UNITED NATIONS ENVIRONMENT PROGRAMME

REGIONAL SEAS

Proceedings of the ROPME Workshop on coastal area development

UNEP Regional Seas Reports and Studies No. 90

ROPME Publication No. GC-5/006

Prepared in co-operation with

REGIONAL ORGANIZATION FOR THE PROTECTION OF THE MARINE ENVIRONMENT

UNEP 1988

PREFACE

The United Nations Conference on the Human Environment (Stockholm, 5-16 June 1972) adopted the Action Plan for the Human Environment, including the General Principles for Assessment and Control of Marine Pollution. In the light of the results of the Stockholm Conference, the United Nations General Assembly decided to establish the United Nations Environment Programme (UNEP) to "serve as a focal point for environmental action and co-ordination within the United Nations system" [General Assembly resolution (XXVII) of 15 December 1972]. The organizations of the United Nations system were invited "to adopt the measures that may be required to undertake concerted and co-ordinated programmes with regard to international environmental problems", and the "intergovernmental and non-governmental organizations that have an interest in the field of the environment" were also invited "to lend their full support and collaboration to the United Nations with a view to achieving the largest possible degree of co-operation and co-ordination". Subsequently, the Governing Council of UNEP chose "Oceans" as one of the priority areas in which it would focus efforts to fulfill its catalytic and co-ordinating role.

The Regional Seas Programme was initiated by UNEP in 1974. Since then the Governing Council of UNEP has repeatedly endorsed a regional approach to the control of marine pollution and the management of marine and coastal resources and has requested the development of regional action plans.

The Regional Seas Programme at present includes ten regions[1/] and has about 130 coastal States participating in it. It is conceived as an action-oriented programme having concern not only for the consequences but also for the causes of environmental problems through the management of marine and coastal areas. Each regional action plan is formulated according to the needs of the region as perceived by the Governments concerned. It is designed to link assessment of the quality of the marine environment and the causes of its deterioration with activities for the management and development of regional legal agreements and of action-oriented programme activities[2/].

During its fourth session in 1976 the Governing Council of UNEP approved the preparatory work for convening a Regional Conference on the Protection of the Marine and Coastal Environment of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and the United Arab Emirates. Subsequently, on the basis of a fact-finding mission sponsored by UNEP and supported by several United Nations agencies, a draft action plan dealing with the scientific and socio-economic aspects for the protection and development of the marine environment of the region was prepared and reviewed by a series of technical meetings of Government-nominated experts.

1/ Mediterranean Region, Kuwait Action Plan Region, West and Central African Region, Wider Caribbean Region, East Asian Seas Region, South-East Pacific Region, South Pacific Region, Red Sea and Gulf of Aden Region, Eastern African Region and South Asian Region.

2/ UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. UNEP Regional Seas Reports and Studies No. 1. UNEP, 1982.

In April 1978 a Regional Conference of Plenipotentiaries was convened in Kuwait for the purpose of reviewing, revising and adopting the action plan and related legal instruments. The Conference adopted on 23 April 1978 the Action Plan for the Protection and Development of the Marine Environment and the Coastal Areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates[3/]. The Action Plan has subsequently become known as the Kuwait Action Plan.

Within this Action Plan, the Governments have approved a number of projects and assigned priority to some of them. UNEP has provided its technical backstopping and support for the implementation of these projects, in co-operation with a number of specialized agencies as appropriate. In this context, the Oceans and Coastal Areas Programme Activity Centre (OCA/PAC) of UNEP closely co-operated with the Secretariat of ROPME in the planning for and convening of ROPME's Workshop on Coastal Area Development (Kuwait, 19-23 August 1987).

In addition to the presentations made by ROPME's regional experts on issues related to the coastal zone management and development in ROPME Sea Area, four UNEP senior experts from outside ROPME Area presented case studies from other regions of UNEP's Regional Seas Programme, namely the Mediterranean, East Asian Seas, Caribbean and South Pacific regions. The workshop was thus an excellent opportunity for the exchange of information and experience between experts working in fields related to the coastal zone management problems.

The present report includes the full text of all the papers which were presented at the Workshop, and were made available to ROPME and UNEP for publication.

3/ UNEP: Action Plan for the protection of the marine environment and the coastal areas of Bahrain, Iran, Iraq, Kuwait, Oman, Qatar, Saudi Arabia and United Arab Emirates. UNEP Regional Seas Reports and Studies No. 35. UNEP 1983.

FOREWORD

The Kuwait Regional Convention emphasized in Article VIII the need to control one of the most damaging coastal activities in the Region which is land-filling and dredging operations so common in our Sea Area. This Article states that "the Contracting States shall take all appropriate measures to prevent, abate and combat pollution of the Sea Area resulting from land reclamation and associated suction dredging and coastal dredging".

Since the skills of environmental management are learned through experience, the Plenipotentiaries of the Kuwait Conference thought of sharing the wisdom gained through mistakes and success stories in Workshops, such as this, to develop the principles and guidelines for coastal development and management.

Having participated in some of the Workshop Sessions and through the examination of the papers presented, it is apparent that the Workshop topics were well-organized into the basic topics beginning from identifying the natural characteristics of our coastal ecosystems over which our coastal development and management plans will be laid; the public health factors and demands by other sectors which compete for and influence our ability to implement those plans and, finally, the planning and administrative aspects of coastal zone development and management. It was interesting to learn about the experiences, lessons and success stories of other Regions which would certainly help us towards setting our own plans for coastal development and management into an environmentally sound framework. I would have wished to see more of the experiences from our Region being presented, especially on the measures already taken to develop plans for coastal zoning and development. However, this Workshop has set the stage for the future Workshops where we can still utilize more of our own experiences to draw the principles and guidelines for coastal development and management within a framework of a ROPME strategy aimed at the development of our natural resources along with conservation and enhancement of our national habitats.

I believe that I would be expressing the sentiments of ROPME Member States by complimenting all those who have contributed towards the organization of the Workshop, presented papers and participated in the discussion. UNEP's assistance and contribution towards this Workshop is especially appreciated.

April 1988

Dr. Abdul Rahman Al-Awadi
Acting Executive Secretary of ROPME

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SESSION I

CHARACTERISTICS, ASSESSMENT AND MANAGEMENT OF MARINE AND COASTAL HABITATS IN ROPME SEA AREA

THE BAHRAIN MARINE HABITAT SURVEY: A STUDY OF THE MARINE ENVIRONMENT OF BAHRAIN USING REMOTE SENSING AS A RAPID ASSESSMENT METHODOLOGY.

by

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ABSTRACT

To monitor the effects of coastal development and to apply coastal resource management recommendations to the State of Bahrain, an inventory of the distribution and condition of all marine resources around Bahrain was undertaken. Satellite remote sensing was used, this being the latest and most efficient methodology available although having yet to be proven for this particular application. Such a full and detailed assessment of marine resources using remote sensing has never been achieved before. The satellite images created were reinforced and tested by helicopter and sea-truthing. Detailed studies of over 200 intertidal and subtidal habitats were undertaken. Species lists were evolved for all the major taxonomic groups. A final, detailed report was submitted to ROPME (The Regional Organisation for the Protection of the Marine Environment), Kuwait. This report also included management recommendations for Bahrain's coastal resources; a database carrying physical, chemical and biological data for all the sites visited; a series of charts showing the distribution of all the intertidal and subtidal habitats along with areas of sensitivity and areas recommended for protection or development.

INTRODUCTION

To assess or predict the effects of coastal development on the environment and to produce realistic management recommendations for its protection, it is necessary to know:

A. What naturally constitutes that environment i.e. what habitats are present and how they relate to the biological communities which they support.

B. What controls the distribution and welfare of those habitats i.e. temperature and salinity ranges, substrate-type, etc.

C. What types of stresses that environment receives both naturally and artificially (man-made).

D. What further stresses are likely and how much more the environment can absorb before irreparable damage is done.

With a view to achieving this end, the Bahrain Marine Habitat Survey set out to:

1. Identify and characterise all of the major marine habitats within the territorial waters of Bahrain.

2. Map the area and distribution of these habitats.

3. Determine the principal physical, chemical and biological parameters expressed within those habitats as a means to identifying biological community types and to understand the distribution of these habitat types.

4. Assess the importance of each habitat type to the scientific, economic and cultural welfare of the state of Bahrain.

5. Produce a series of environmental recommendations and management plans for the waters of Bahrain, identifying the major problems both present and potential and suggest methods for alleviating any pressures on the environment.

Within this framework the biggest single problem from the point-of-view of time, manpower and geographical area is the mapping and characterisation of the different habitat types. The State of Bahrain has a marine Exclusive Economic Zone (EEZ) of some 12,000 sq. km. So most of this survey was restricted to the actual territorial waters. These still constitute some 3,000 sq. km. (see Fig. 1 for main island and reef areas around Bahrain). Such an area presents logistical problems using standard methods of aerial photography and 'ground surveying'. The amount of time and manpower which would be required to cover such an area in order to map and characterise the marine habitats accurately would be realistically and economically prohibitive.

Satellite remote sensing is a very young field of science and its applications within the marine environment are still being experimented with, however, it was felt that this approach might solve the problem of mapping such a large area. This technique has been used before to identify single habitat types or on small scale projects, but no-one had yet managed to successfully and accurately map the complete territorial waters of a country or to identify the many different habitat types using this method. Therefore, this was very much a pilot project to assess the viability of such a rapid and relatively inexpensive methodology. If this worked then its applications throughout the ROPME Sea Area and, indeed, anywhere else in the world would be invaluable.

METHODS

Satellite remote sensing techniques:

The acquisition and processing of the satellite data was handled by the Environmental Remote Sensing Applications Centre (ERSAC) at Livingstone in Scotland, U.K.

The satellite imagery used was obtained from Landsat 5. This satellite was launched on the 1st March, 1984 into a near-polar, sun synchronous orbit at a distance of 705 kilometres above the Earth. Landsat 5 achieves a complete coverage of the Earth's surface between 81 N and 81 S every 16 days having an orbital period of 99 minutes and crossing the equator at 0945 hours local time. The satellite is the latest platform in the Landsat series and is equipped with a 4-channel Multispectral Scanner (MSS) capable of gathering imagery data in the visible and near-infrared spectrum (0.5-1.1 um) and 7-channel scanner called a Thematic Mapper (TM) which scans visible reflected light as well as the near, mid and thermal infrared spectrum (0.45-12.5 um). The TM scanner is capable of higher resolution (30 x 30 metres) in six out of its seven bands than the MSS (80 x 80 metres). This higher resolution allows images to be produced as a photographic map down to a scale of 1:50,000 beyond which the image breaks up into its individual pixels (pixelation). MSS imagery on the other hand can only resolve down to 1:200,000 before pixelation occurs.

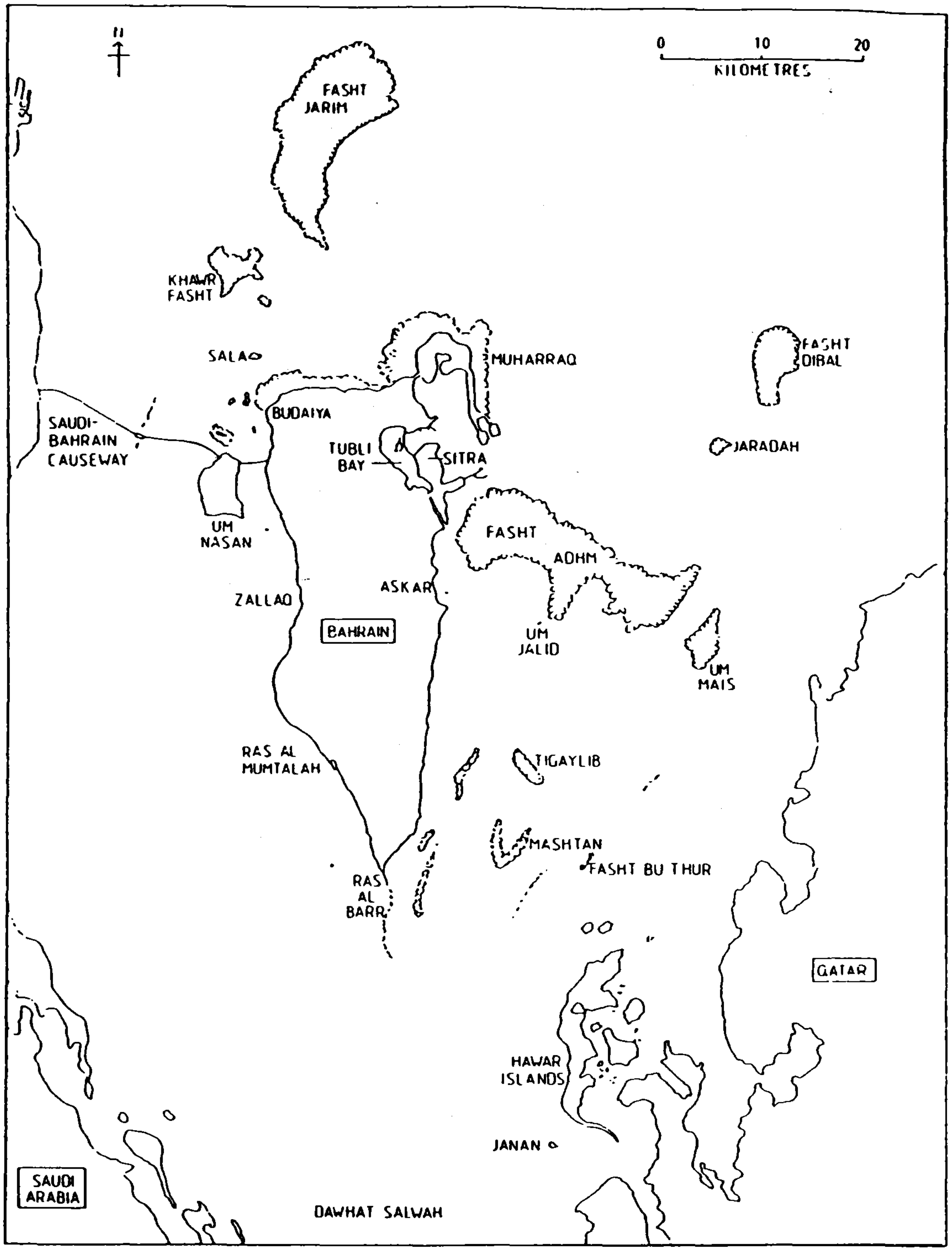


Figure 1. Map of Bahrain showing main Islands and Reef areas.

A further advantage to using TM rather than MSS imagery is the greater sensitivity of the TM to the slightly shorter blue-green light reflectance wavelengths allowing for greater penetration of the water column. This obviously makes it more applicable to seabed studies of this nature.

The digitised data is transmitted to Earth from the satellite and recorded on magnetic tape. It is then fed into a computer for analysis and imagery extrapolation. This service was provided by ERSAC using a Prime/Gems computing/image processing unit which converts the digitised data into a pictorial screen image.

The TM data from the Landsat series of satellites covers 7 parts or 'bands' of the electromagnetic spectrum (see Table 1). The individual bands may be analyzed or portrayed separately as black and white images. Alternatively a false colour composite can be created using principal component analysis on a combination of any three of the available bands and combined onto colour film with exposures made through blue, green and red filters respectively to produce a simulated colour image. Because different bands enhance different physical phenomena dependant on their reflectance, various details will be enhanced in each colour. This retains the original information contained within the black and white imagery but substitutes the grey tones for a combination of colours which are more easily differentiated by the human eye. This is called a false colour image as it only uses certain bands of reflectance and not the whole spectrum.

Two approaches were taken for the analysis and image projection of the satellite scene. The first was to create a false colour image of the area and the second was to extrapolate this to an image predicting habitat types.

1. **False colour image. (see Plate 1)**

To produce the false colour image used during this survey, the initial digital scene was subdivided into land and sea. TM bands 1, 2 and 3 (Table 1) were then extracted for the sea and enhanced to give details of depth, sediment movement, water flow etc. TM bands 2, 3 and 4 were used to enhance the land information and then the two were recombined to achieve the final image. Due to the curvature of the Earth and the angle of the scanner at the time of recording, the image will be distorted when generated as a flat picture on screen or photograph. To overcome this it is necessary to geometrically correct the data and the first step in this correction is the location of ground control points. Once these control points have been established on the image, regression analysis is used to transform the Landsat coordinates to a desired map projection (In this case Universal Transverse Mercator), and to realign the image to correspond to the control points.

2. **Habitat characterisation image. (see Plate 2)**

To create an image depicting habitat types it is necessary to feed the computer with accurate information on areas of known habitat. The principle involved is simply a matter of comparison between the pixel data generated by the satellite and the actual habitat types known to be present for that corresponding area on the 'ground'.

Table 1. Landsat specifications and capabilities.

Sensors:

Multi-spectral Scanner (MSS)

	Wavelength (μm)	Resolution
Band 1	0.50-0.60 (green)	80m
Band 2	0.60-0.70 (red)	80m
Band 3	0.70-0.80 (red-near IR)	80m
Band 4	0.80-1.10 (near IR)	80m

Thematic Mapper (TM)

	Wavelength (μm)	Resolution
Band 1	0.45- 0.52	30m
Band 2	0.52- 0.60	30m
Band 3	0.63- 0.69	30m
Band 4	0.76- 0.90	30m
Band 5	1.55- 1.75	30m
Band 6	10.40-12.50	120m
Band 7	2.08- 2.35	30m

Both sensors provide image data with 185 x 185km coverage, with 5.4% forward overlap and 7.3% side overlap at the equator increasing at higher latitudes.

Launch:

Landsat 4: 16 July 1982

Landsat 5: 1 March 1984

Orbital parameters:

Orbit:	near polar sun synchronous
Altitude:	705km
Inclination:	98.2°
Coverage:	81°N to 81°S
Period:	99 minutes, crossing the equator at 9.45hr local time
Repeat cycle:	16 days

Applications

The main characteristics of the satellite and the MSS and TM sensors are shown in the table, while some of the primary potential applications of the TM are listed below:-

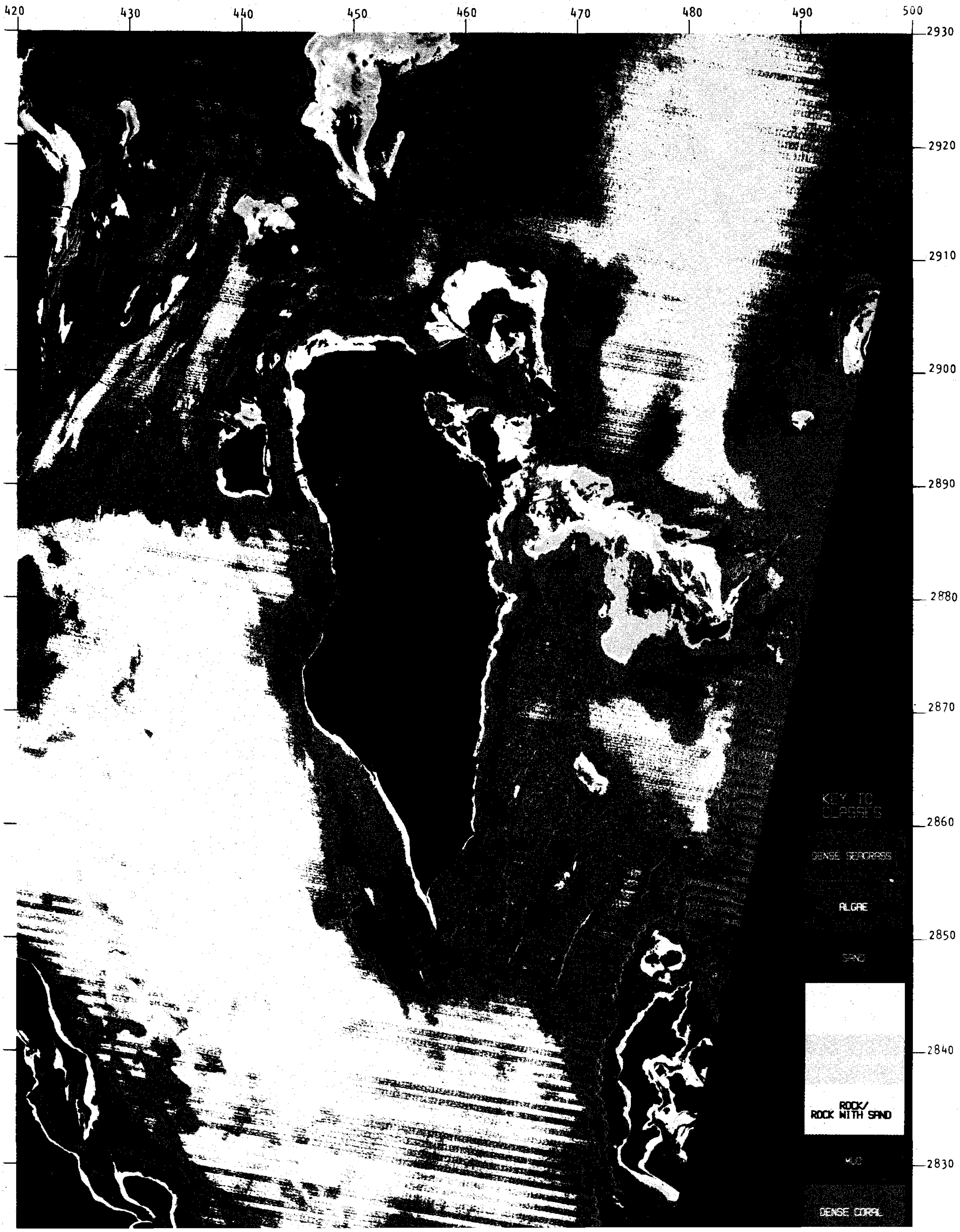
Band	Potential Applications
1	mapping of coastal waters; differentiating soil and vegetation; separating coniferous and deciduous species
2	measurement of visible green reflectance peaks to assess vigour of vegetation
3	discrimination of plant species through measuring chlorophyll absorption
4	delineation of water bodies; determination of biomass content
5	measurement of vegetation and soil moisture; differentiation of clouds and snow
6	thermal imaging and mapping; plant heat stress analysis; determination of soil moisture
7	discrimination of rock types; hydro-thermal mapping.


ERSAC LTD

CENTRE 26.00N 50.55E 163/42 16FEB85 BAND 123 SUN AZ 135 EL 39 ORBIT 5120

TRANSFORMED UTM 39 TOP LEFT 420030 2930009 PIXEL SIZE 30 30

Plate 2 - Marine Habitat Characterization (Satellite Image of Bahrain)



Several areas of training data are required for each habitat type that is to be mapped. For example, to classify areas of seagrass throughout the image it is necessary to feed the computer with the accurate positions of several areas of good seagrass that have been previously identified in the field. The computer can then scan the image for identical pixel types and assign them to the seagrass category. Any areas that do not fall immediately into one of the habitat categories are given a 'maximum likelihood' designation and assigned to the nearest (most similar) category.

To generate our habitat characterisation image only bands 1, 2 and 3 were used, as information for the land was not required. These bands are the most useful as they are more capable of penetrating water. The seas around Bahrain are generally turbid due to high sediment loads. This presented a problem as it reduced the penetration of all three bands, therefore limiting the depth to which habitats could be identified and possibly upsetting the accuracy in some areas of the image. Obviously, the accuracy of the information received by the satellite can also be upset by climatic factors such as sea state and cloud-cover, both of which can affect the penetration and back-scatter of light..

Bearing in mind the limitations imposed by these factors it was necessary to include a deep water element in the habitat classification. By comparing the accuracy of the satellite-predicted habitat types against the 'field-truthed' habitat types this deep water classification was fixed to include all depths of water greater than 12 metres (although penetration may be better than this in some parts of the image depending on localised values for suspended sediment).

Once all the categories had been filled the computer could then be programmed to assign each category of habitat with a colour to produce the final image.

Site selection

The selection of study sites was achieved using a combination of the results from the remote sensing data, helicopter overflights and previously-acquired local knowledge. The initial results from the remote sensing data were poor and the image had to be rerun after further field work had been undertaken (see conclusions).

Helicopter overflights were essential in order to assist in the selection of field study sites. During the helicopter flights, two photographers were positioned one on either side of the helicopter with a voice-recorder in the middle. Each photographer was given a code and signalled a number to the recorder after each exposure. The number was marked in over the relevant position on a chart (assisted by onboard Loran 'C' position fixing equipment and compass). The final prints from this photography were developed in a continuous role so that it was easy to follow the sequence of shots. This method proved to be very effective in identifying differences in the benthic habitat types. During the later surveys the system was even further improved by linking the observers to the recorder via the helicopters onboard intercom system which was also channelled into a cassette recorder. After each observer had recorded his observation on tape the recorder could add a Loran 'C' position fix, compass bearing, air-speed and height.

By analysis of the photographic material along with the initial returns from the satellite imagery and knowledge gained by the local scientists on the project over the last three years it was possible to select the sites. Emphasis here was two-fold, firstly, to recover useful comparative data from known habitat types under potentially different physico-chemical constraints e.g. to look at seagrass beds around the island in different depths, salinities or current and tidal regimes and secondly, to identify those habitats in areas which were unknown or uncertain. Intertidal sites were selected more on the basis of local knowledge which was considerable by this time.

On-site

Intertidal methodologies

Some fifty sites on the coast of Bahrain and its islands were visited and sampled during July and August of 1985. In addition, observations were made at other sites as the opportunity presented itself. These sites were chosen either because they had already been used as monitoring stations, or to give a representative example of each habitat type under different environmental constraints. The physical characteristics of each major site were noted. This involved measurements of the intertidal profile, collection of sediment samples, air and water temperatures, salinity and tidal range. Replicate collections of macrobiota (those retained by a 0.5mm mesh-size sieve) were taken for identification where this was not possible on-site. Wherever possible quantitative estimates of the dominant intertidal biota were made using 0.25 m^2 quadrats or 78.5 cm^2 core-samplers, the methodology employed depending on the substrate-type encountered. In addition, snorkel surveys were made to characterise the immediate sublittoral. Due to the small tidal range present in the summer months, much of the lower intertidal zone at the survey sites was flooded so that it was necessary to complete some of the survey work by wading. Habitat photographs were taken at all sites. Sediment samples taken at all major sites were frozen until processed. Each sample was then washed in fresh water to remove the salt content and oven-dried at 100^{o}C for 24 hours before sieving in a standard sieve series according to ROPME's Manual of Oceanographic Observations and Pollutant Analyses Methods, MOOPAM, (ROPME, 1983). Weights of sieved fractions were recorded and, after correcting to a standard total weight subjected to grain-size analysis.

Subtidal methodologies

Coralline hard substrates

The presence and cover values of each coral species found at each site were recorded *in situ*, and then an associative analysis was employed in which the coral assemblage at every site was compared to that at every other site by means of a similarity index. This method determined which of the sites or groups of sites were similar to each other and which were significantly different. By this means it was possible to estimate the number of general coral assemblages in Bahrain.

This created somewhat of a constraint here as there were so many areas of subtidal habitat which required surveying. Coral reef habitats are enormously time-consuming in comparison to the area covered due to their relatively high diversity and three-dimensional nature.

First, any topographic discontinuities or features were used, if present, to define the boundaries of a survey site. The majority of reefs in the area are shallow and so the reef slope was surveyed at two or more points of the compass around a reef area with each point being counted as one site. Very small patch reefs, such as those found at Fasht Bu Thur and Ad Dur, were treated as a single unit. In cases where different depths occurred on a reef front (e.g. Fasht Adham, near the 'half-tanker' site), different depth zones were treated as different sites. In all cases, the site boundaries were designated by physical or geographical parameters and not by the presence of biological zones.

A coral species list was compiled for each site. Recording was carried out over a lateral distance of at least 50 metres and more usually 100 metres. Sites were covered until no more species were recorded for at least 10 minutes, this procedure usually taking between 20-30 minutes and sometimes less at low-diversity sites.

At each of these sites species were either coded with a 1 if they could only be accurately recorded as 'present' or assigned a percentage cover value where this could be reliably estimated by eye.

Overall coral cover was also estimated for each site as was algal cover and type and any soft substrate cover present e.g. coral sand. Other significant substrates or relevant faunal features, such as zoanthids were also recorded if present.

A cluster analysis was performed on the data to identify patterns in coral assemblages. A Bray-Curtis (1957) quantitative similarity index was used to calculate similarity coefficients between sites. This data was then used to create a similarity matrix for every pair of sites. Then a simple hierachical clustering of sites and groups of sites followed where two sites, once matched, were used to form a composite site or centroid. Correlation values of the centroid then replaced those of its component sites in the matrix; these were determined as the arithmetic mean of the individual coefficients. The procedure was continued until all 32 sites were fused.

The groupings or clusters were then defined as the groups which appeared at a similarity level of about 0.33. In other words, each cluster is only one-third similar and at least two-thirds dissimilar from each other cluster.

Hard, non-coralline substrates

The standard methods adopted for the intertidal zone are generally applicable to the subtidal zone also. The water column was recorded for temperature, surface salinity and depth and, on a site-selected basis, for dissolved oxygen, pH and conductivity. Bottom cover was assessed using repetitive quadrats (0.5 m^2 and 0.25 m^2) and samples were taken from within these quadrats for analysis of percentage cover/standing crop. General collections were also made so as to develop the species lists. Underwater recording was done on white perspex slates with a cord-attached pencil.

Soft or mobile substrates

All parameters were recorded as above but infauna were collected using a 78.5 cm^2 corer made from plastic gutter pipe with a bevelled edge at one end and a stainless steel rod as a handle at the other end. Corers were also used to collect samples for grain-size analysis. In seagrass beds, the estimated percentage cover and average blade length of each seagrass species were also determined.

General collections

All samples were placed in plastic, sealable bags or plastic bottles formalised using 10% formalin, stained where required with a pinch of Rose Bengal to assist in sorting the smaller organisms and labelled using a reversed date code for easier computer analysis (A.R.G. Price, Personal Communication). Using this reversed date code, August 25, 1985 would read 850825. A letter was suffixed to this code to identify the site (a = first site surveyed on that day, b = second site etc.), followed by a number indicating the sample number at that site. Therefore, at the first site visited on the 25th of August, 1985, two core-samples followed by a general collection would read 850825a1, 850825a2 and 850825a3 respectively. This methodology proved invaluable at the desk-top data analysis stage. Furthermore, photographic records were kept of all habitat types for inclusion in the final report using a Nikonos 4a camera with attached flash and interchangeable close-up and wide-angle lenses.

Site positions were recorded using Micrologic Loran 'C' position - fixing equipment. This achieved an accuracy of between 100 and 150 feet (30 - 45 metres) and all positions were later transcribed to a large chart as well as being converted to U.T.M. (Universal Transverse Mercator).

Plankton tows were undertaken during the winter/spring period using a standard Plymouth net of 142 um mesh size, 46 cm diameter mouth and a Kahlsico flow meter. This was towed for 5 minutes following which plankton samples were formalised in 5% buffered formalin. The meter was calibrated on site. Methods for plankton study can be found in ROPME's Manual of Oceanographic Observations and Pollutant Analyses Methods (MOOPAM, 1983) and in Marine Zooplankton (Newell and Newell, 1973).

In all cases, temperatures were recorded to 0.5^{o}C using a mercury thermometer. Salinity measurements were taken to 0.5 with calibrated, temperature - compensated refractometer (American Optical Corporation)

Laboratory samples

All samples were preserved in alcohol, sorted to phyla and either identified to species in the Environmental Protection Technical Secretariat's (EPTS) laboratories by the available taxonomic experts or packaged and shipped for indentification by local or international taxonomists. Core samples were sieved through 0.5m mesh sieves for their infaunal component and grain - size analysis through a standard series (See MOOPAM, 1983).

Museum collection

All samples collected and identified were sorted into duplicate specimen sets (one for Bahrain EPTS and the other for ROPME). These were processed for preservation and labelled with taxonomic identification, site, date of collection, name of collector, etc. Corals were bleached, washed, sun-dried and tagged with the name for any further sampling and monitoring work.

RESULTS AND DISCUSSIONS

Intertidal survey

The intertidal areas of Bahrain show very few single (pure) habitat shores. There are some exceptions with pure sandy beaches being found on some of the offshore islands and pure muddy coastlines in some of the sheltered bays but by far the greater area of the intertidal zone consists of mixed habitat types often forming a longitudinal zonation down the shoreline. Also there are very few undisturbed shores around Bahrain except to the south and on the offshore islands. The rest of the coastline of Bahrain shows the effects of coastal development and the oil and petrochemical industry.

The general physical characteristics of Sea Area shores together with their biota are briefly described below. Examples of rock, sand and mud are all present within the study area although the latter is rare. The rocky cliffs of the Hawar island group are the only example of an extensive classic rocky shore as most other rocky areas consist of mixed habitats or rock and sand. Whilst summer temperatures are high, their effect on the intertidal zone is ameliorated to some extent by the small tidal range during the hottest months and the occurrence of the spring tides during the night-time. Salinities show a north - south gradation with a range of 42* to 58*. However, the salinities vary diurnally with the state of tide by as much as 7. (see figures 2 and 3.). Higher values often occur intertidally and in lagoon areas and almost certainly fluctuate with seasonal changes in temperature. Sand beaches are rarely typical, often consisting of only a thin veneer of sand over rock for most of the intertidal zone. Exposed sand beaches are best developed on the small offshore islands, while sheltered sand beaches are more typical in the southern section of the main island of Bahrain. True muddy shores are restricted to a small section of the open coast and Tubli Bay as well as some of the inundated sabkha flats among the Hawar group.

*Following the new Practical Salinity Scale (UNESCO, 1981), the Salinity is a dimensionless quantity.

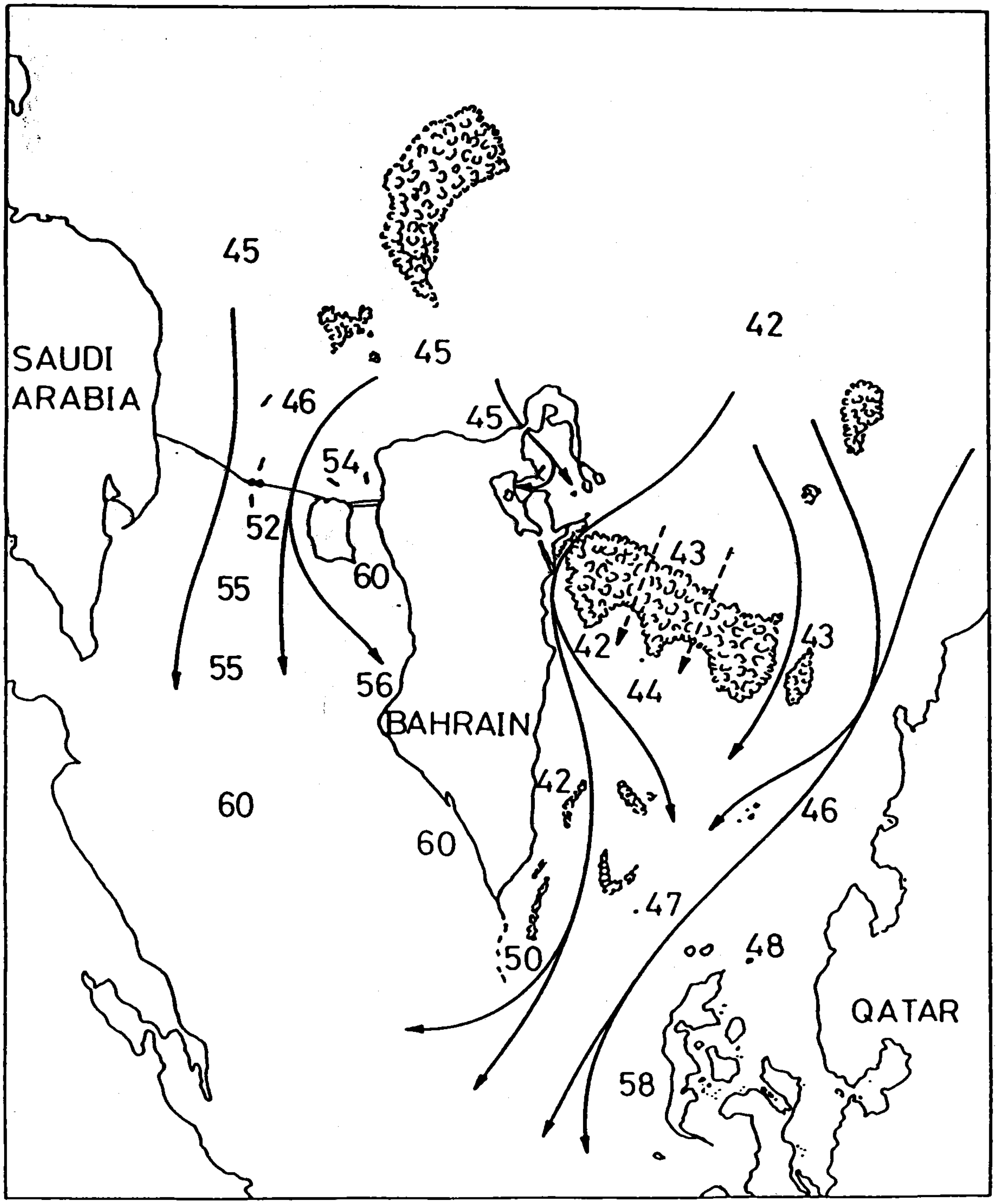


Figure 2. Mean salinity levels around Bahrain approaching slack water on a rising tide (taken from Vousden, 1985).

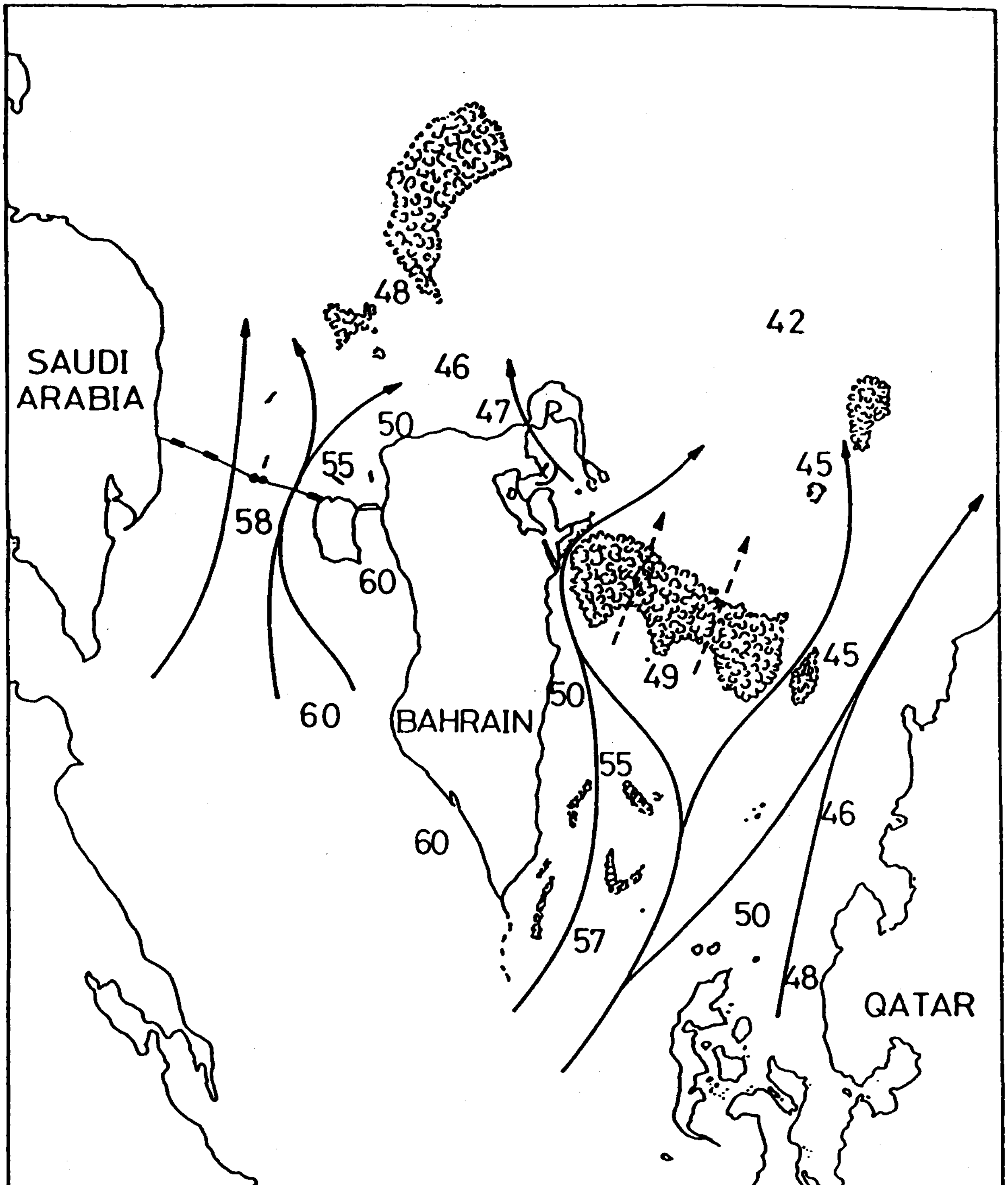


Figure 3. Mean salinity levels around Bahrain approaching slack water on a falling tide (taken from Vousden, 1985).

Despite the restrictions placed on the intertidal biota by a limited distribution of habitats, narrow tidal range and extreme temperature and salinity, it is possible to characterise the shores and intertidal habitats of Bahrain by their biota. Zonation patterns are present on most shores and characteristic species are listed in the tables in the Bahrain Marine Habitat Survey report for each level of each type of intertidal habitat. A comparison is made between the shores of the same habitat type in Bahrain as well as with the same habitats elsewhere in the Sea Area. Examples of undisturbed reference habitats are identified together with those shores influenced by human interference. The shore habitats of Bahrain are characterised and examples of each category are also listed within the report. Used together with key species lists it is hoped that it should be possible to evaluate the effects of perturbation on these shores in the future.

It is concluded that the lower shore levels and immediate sublittoral are regions of high productivity with food webs based on macroalgae, seagrasses and blue-green algae, all of which are involved in supporting various stages in the life-cycles of a number of commercially-important fisheries species. Recommendations include more detailed survey work to establish more precise annual ranges of intertidal biotic variations and detailed studies on food-web links.

The impact of new coastal structures upon benthic productivity and increased habitat diversity requires evaluation, as does the effects of habitat deterioration due to infill and other perturbations. Tubli Bay, an area of high productivity supporting fisheries and containing unique habitats, is now in urgent need of protection. As elevated salinities appear to reduce biotic diversity it is recommended that salinity and temperature tolerances of key intertidal species be determined so that their response to changes in these two parameters can be predicted.

There are several reviews of the physical and biological characteristics of the shores contained within the ROPME Sea Area all of which have been summarised recently (Jones D.A., 1986). More detailed discussions of the coastal ecology of Bahrain and its physical and biological aspects also exist (Price et al, 1984; Vousden,1985; Vousden and Price, 1985). These papers emphasize that the wide annual temperature range together with the high salinities over much of the Sea Area act to limit biotic diversities. In addition, the horizontal and almost featureless coastal topography found in the western Sea Area region further depresses diversity by producing large areas of relatively similar, flat intertidal habitat, providing less ecological niches in comparison to a more three-dimensional shoreline. Small tidal ranges and the absence of oceanic wave also serve to reduce the exposure gradients that are otherwise seen on open Indian Ocean shores. For these reasons it is often difficult to isolate the classic biota which characterise rocky, sandy and muddy shores elsewhere as they often occur mixed together on the same shore within the ROPME Sea Area.

Human modification of the existing coastline by infill and harbour construction, as well as pollution, has further blurred the distinction between shores of differing physical characteristics. Thus it is not uncommon to find areas of soft mud on the surface of rock or sand flats and this may often be as a result of leaching and outwash from recent local reclamation areas. Present intertidal habitats now include the following categories.

Rocky shores

Natural rocky shores are rare due to the soft, eroding nature of the recent neogene sedimentary limestone which makes up most of the coastline in the western ROPME Sea Area (Evans, 1985). Limestone cliffs reaching a height of 10-15 metres are a unique feature of the Hawar islands. Elsewhere in Bahrain rocky shores are characterised by occasional, small rocky islands (e.g. Jazirat ash Shayk and Jazirat Yasuf), by the odd outcrop of rock protruding through a veneer of sand, or by scattered boulders. The mixed sand/rock habitats dominate the coast of Bahrain and its islands, and their rather unique effect on biotic communities is discussed in more detail in the subtidal section on mixed sand and rock habitats within the Bahrain Marine Habitat Survey.

However, becoming increasingly more common are the artificial intertidal rocky habitats associated with the coastal rock armouring used in the building of causeways, as anti-scour protection and in the construction of harbours and marinas.

Sandy shores

Although sand is the most common intertidal substrate throughout Bahrain it is usually too thinly spread over the surface of beach rock to support a typical burrowing macrofauna. Characteristically, a sand beach forms the upper fringe to many shores, but at the low water mark there is often a transition to beach rock covered by a few millimetres to a few centimetres of sediment. Thus, it is common to record sand beach biota from the upper shore and rocky biota from the lower shore where the rock surface is exposed, but a somewhat mixed biota in the transition zone. True sandy beaches are mainly restricted to the south and south-west of Bahrain and to many of the islands where they occur as spits or cays. Occassionally, sandy beaches have been created by reclamation processes where a sacrificial (gently shelving) sand slope has been laid down by the engineers as an alternative to rock anti-scour protection. Examples of such slopes can be seen at Budaiya, Sanabis and the south end of Sitra. These slopes often provide a soft, mobile substrate on a shoreline which is otherwise distinctly different. This substrate in turn offers an increased diversity of habitats to burrowing forms and their predators such as wading and crabs. Here is an example of how coastal development can be beneficial to the environment when suitably planned and controlled.

Muddy shores

The relatively smooth, flat coastal topography of Bahrain and the absence of rivers tend to limit the development of bays and inlets. The scarcity of these sheltered, low-energy environments makes the occurrence of muddy shores and mud-flats rare. True muddy shores only occur in the semi-enclosed Tubli Bay, patches of the coast near Askar and Ras Al Mumtallah and in sheltered bays within the Hawar island group. However, the high incidence of coastal reclamation and infill is causing the development of protected bay and inlet areas in which mud-flats are now beginning to form. Examples of such areas are noticeable at the southern end of the Al Hidd reclamation strip between the Arabian Ship Repair Yard and the Arabian Iron and Steel Company, on the edges or recent reclamation zones as can be seen at Sanabis and Budaiya and around the northern edge of Un Na'san in the area of the work island servicing the Saudi-Bahrain causeway. These areas are already becoming rapidly colonised by pioneer species and attracting large numbers of migratory birds such as flamingo and smaller waders.

Biota

The general features of the intertidal biota of the western ROPME Sea Area are now well-documented (Basson et al., 1977; Jones, 1986). It is recognised that the ROPME Sea Area supports elements of both warm temperate and tropical biota and that these are impoverished in comparison with the Indian Ocean biota due to the presence of physical stresses which restrict the biotic diversity and species distribution around Bahrain. These physical stresses on the marine environment are mainly due to its position in the Gulf of Bahrain at the mouth of Dawhat Salwah. This area of shallow seas and restricted water movement encourages high temperatures and salinities.

Subtidal survey

Subtidally, the soft or mobile habitats (muds, sands and gravels) tend to be mixed with each other and with hard substrate types. Evidence suggests that such mixed habitat types may support a number of 'commuter' species, i.e. Those fauna that live within a three-dimensional, hard substrate habitat for shelter and protection but which move out, often at night, to feed in the soft substrate areas. Within the classification of soft substrate types, the seagrass and sand habitats showed up very distinctly on the satellite image and this revealed the presence of a major, hitherto unknown grassbed on the west coast covering an area of some 40 sq. km. By comparison, between the distribution of the grassbeds as depicted on the satellite image and bathymetric charts we can now see that it is not salinity which is limiting the extent of the seagrass (as was previously supposed) but depth (assuming that the correct substrate is present). This is probably more obvious when considering the photosynthetic requirements of the seagrasses. The cut-off point for grassbed development (between 12-14 metres beyond which only scattered clumps of grass exit appears to be closely related to the depth to which the satellite can classify habitats and beyond which we define as the 'Deep water' zone. There may indeed be good reason for this apparent close relationship between the ability of the satellite to 'read' the seabed due to light penetration and the ability of the seagrasses to photosynthesise. Below the 12-14 metre depth contour most of the soft substrates consist of silts, muds and shelly gravels depending on current velocities. In the shallows the grassbeds may extend right up into the intertidal depending on wave action and substrate type. Biologically, the grassbeds serve a twin role as a major source of primary productivity and as a three-dimensional habitat acting as a shelter and substrate for attachment. The grassbeds around Bahrain provide an important substrate during the Pearl Oyster (Pinctada spp.) spat-fall in the late summer as well as a major food source for the Green (Chelonia midas) and Hawksbill (Eretomechelys imbricata) Turtles. They are probably more famous for the large herds of Dugong or Seacows (up to 700 animals recorded in February 1986) which they support. These animals have now been given protected status by the Government of Bahrain. The subtidal muds and sands also play an important role in the life-cycle of commercial species e.g. shrimp.

Within the definition of subtidal hard substances we have the coral reef areas, the ex-coral (historic coral reef that is no longer viable but still provides a three-dimensional habitat) and exposed rock.

In the waters around Bahrain coral growth is severely limited by physical constraints such as high water temperatures and salinities which often exceed the tolerance limits of most, if not all, coral species. There is very little complex reef community as such and coral species diversity is low. However, there is a wide variety of reef development and structure around Bahrain. The range of reef topography shows that there is current reef growth in some areas along with substantial past reef growth in others. This suggests that some areas which historically supported coral development have ceased to do so presumably due to alterations in surrounding physical characteristics. The conditions for reef development are borderline. It is likely that under the already over-stressed physical regime all these reef systems are undergoing a natural sequence of mortality followed by recovery. Temperature is almost certainly the major constraint, especially the low winter values (12-14^{o}C). Salinity imposes geographical limitations and high turbidity is retaining development. The whole area is marginal for coral growth with the most favourable conditions to be found in the northeast of the region where salinities are low (generally less than 43) and temperatures are buffered by the open water of the ROPME Sea Area. As a consequence the healthiest reef systems are to be found in this northeastern region. Cluster analysis of the coral communities isolated five clusters. Three of these were clearly defined by the dominance of an Acropora or a Porites species, a fourth assemblage had fewer species and no dominants and the fifth was species-poor and represented a highly stressed reef flat assemblage. Two sites did not fall into any of these clusters. One site represented a very turbid reef area where the main reef-building species was, in fact, not coral at all but the bivalve mollusc, Chama pacifica. Coral cover at this site was less than 3%, the other exception was a site at which the salinity was recorded as 50% and only three species of coral were present. The satellite proved to be very effective at identifying coral cover of greater than 20.

Certain hard substrates in Bahrain are non-coralline because local temperature, salinity or turbidity levels are too extreme for coral survival. There is very little pure, exposed rock. Where it does occur, its surface will be colonised depending on the current velocities. In lower velocity water the surface of the rock will be covered with algae while in higher velocities it is the filter-feeders such as sponges and tunicates which dominate. The Sargassum/Hormophysa algal beds play an important role in the life-cycle of commercial fisheries providing protection for young shrimp and fish as well as a further source of settlement for the oyster spat. The ex-coralline structures, although no longer supporting corals, still provide an important three-dimensional habitat for shelter and attachment and as such are still of importance to diversity and fisheries.

Interpretation of the false colour image

Although the principal reasons for employing satellite remote sensing was to create a Habitat Classification image, the value of the False Colour image should not be ignored. This image provides a very good representation of the geology and sediment regime around Bahrain. Looking at the main island itself it is possible to identify some of the historic geological features associated with past coastlines. Various sea levels that have existed in the past can be defined and agree closely with work done by geologists in this area (Doornkamp, 1980). General trends of accretion and erosion around the islands are apparent. Evidence of longshore drift down the western coastline is obvious from the image. The sand spit at Ras al Barr is very clearly marked on the imagery along with a number of other sand formations around the island. These all show the predominantly north-south current in this area.

To the south-west of the image, stretching up the coast of Saudi Arabia and across most of Dawhat Salwah it is possible to see the shape of large sand formations on the sea bed. These are the remains of sand dunes which once covered this area of the Gulf of Bahrain when it was a desert and before the waters flooded it during the late Holocene. These have become compacted and stabilised on the sea bed by the action of carbonate muds. Small dune formations and sand ripples have been seen underwater off the west coast of Bahrain during field trips. Part of their present day stability is determined by the presence of seagrasses growing on the taller ridges of the dunes and ripples, thus preventing their erosion. Between the dunes and the ripples there are often areas of exposed rock and this combination provides for quite an unusual habitat.

Throughout the image the shallow reefs and sand banks show up well. In fact, they are even clearer in the habitat classification image. Channels and intertidal flats are also very obvious mainly due to the high turbidity of these waters. Because of this high turbidity it is easy to pick out zones of erosion/accretion and also areas of recent dredging and reclamation. The recently reclaimed sites on the north coast at Sanabis and to the north-west at Budaiya stand out as regular grey areas and the effects of siltation caused by these reclamations can be seen along the adjacent coastline, especially at Sanabis. At Al Hidd, where there is a recently reclaimed causeway to serve the shipyard and the iron and steel mills, the area offshore, which was dredged to provide sand, can be clearly seen in the form of a cross.

Below Fasht Adhm, on the south eastern side, is an area of curious sedimentary characteristics. The water, here, appears to be very turbid and this is confirmed by helicopter observations. On the satellite image there appears to be some form of eddying effect which may be related to the meeting of currents due to a tidal time lag.

Another curious phenomenon is the presence of very regular grid lines across Fash Jarim, Fash Adhm and off Tighaylib. These appear to be the result of petrochemical exploration using a magnatometer and it is the first time that these features have ever been detected from satellite data.

Perhaps one of the best uses of the false colour imagery, then, is the detection of these geological and sedimentary phenomena. These also serve to highlight the current regime of the area as is immediately apparent when first observing the image. The direction of flow around the north end of the island and between Saudi Arabia and the northwest of Bahrain, as well as around Fasht Adhm and south down into Dawhat Salwah, stands out very clearly.

Interpretation of the habitat classification image

The overall accuracy of the classification image was assessed by comparing the satellite predictions for a known area with the on-site field records for that area. Over 235 field sites were visited during the course of the survey. The site positions were given to ERSAC who then supplied the precise satellite predictions for those areas. This actual/predicted site comparison showed the method to be extremely reliable, returning a satellite accuracy of between 87% and 93%. Realistically, the total accuracy across the image is probably slightly less than this as the survey sites were originally chosen for ecological rather than statistical reasons and are, therefore, not representative of the whole image area. Despite this, most of the unsurveyed areas would have fallen into a 'Deep water' category and the total image accuracy can be estimated as being greater than 80%.

The habitat classification image has classified 100% of the scene. What should be remembered is that 20-25% of this classified image represents deeper water (>12-14 metres). This does not present a problem when extrapolating to the final habitat map as the bottom types in these deeper waters are generally well known and probably of less significance from the point of view of protection as they are outside of the sphere of industrial influence.

There is a pattern of close correlation between depth contours and habitat predictions which is a logical one. In fact, because of the turbid waters in the area and the generally shallow nature of these waters, the majority of the habitat types do tend to be closely correlated with depth. This is probably true of most coastal communities, bearing in mind their dependence on primary productivity. But in these particular waters, where benthic productivity has been shown to be so much more important than phytoplanktonic productivity, this situation will be even more exaggerated. The distribution of the seagrass beds with respect to depth limitations has already been discussed in a previous section, suffice to say that it is their very dependence on sunlight for photosynthesis, along with the high levels of suspended sediment reducing light penetration, that helps to cause this depth-dependence. The grass beds are also substrate-dependent and this can also be related to depth. In areas where they are not recorded either in field observations or on the classified map it is often due to the fact that the substrate is not suitable. On the west coast the depth of sediment inshore is too thin to support seagrass. It is not until the 6-7 metre mark that there is sufficient substrate and at this depth out to 12-14 metres the grassbeds are prolific. It can be seen, in fact, that seagrass does not follow bathymetry perfectly by comparison of areas classified as seagrass. Around Tighaylib, Mutarid and Mashtan the colour code for seagrass stretches from 2 metres down to 14 metres when compared with local hydrographic charts. In other areas it is restricted to between 3-6 metres and between 8-12 metres depending on substrate types. So, the general trend is for substrate classifications to follow the contours of bathymetry, which can be seen to be reflection of depth and substrate-related dependence.

The classification of 'Rock/Rock with Sand' seems to represent very shallow, almost intertidal areas with this substrate type (i.e. <1.5 metres deep). the black 'Land' areas represent extremely shallow (i.e. <0.5 metre) probably mostly intertidal areas and dry land. Once again the 'Rock/Rock with Sand' classification can be seen to be depth-dependent. Exposed rock is a rare habitat subtidally due to the high levels of sediment in the water column. It is only in the intertidal and very shallow waters that it will remain exposed, mainly due to the effect of wave action. Even in these areas it may support a thin veneer of sand.

To the south of the image there is a very sharply defined edge between mud, seagrass and algae off the coast of Um Janan. A similar sharp edge can be seen off the south-west coast of the mainland between sand and seagrass before dropping away into deep water. Inspection of the bathymetry on hydrographic charts reveals that these two areas do, in fact, have quite a steep gradient moving west. It is possible that this may be a relic of either an old historic shoreline or it could be a reflection of a down-faulting episode which occurred in Dawhat Salwah several thousand years ago.

The submerged dune structures in the southern Gulf of Bahrain and Dawhat Salwah, that were apparent in the false colour image, are equally obvious in this classified image due to the presence of seagrass on the tops of these structures. These appear to extend right across the southern edge of the image but this may be noise from the banding effects of the satellite imagery and would need field verification.

The classified image is even more accurate than the false colour image in picking up areas of reefs and shallow waters. In a number of cases on the image reef structures are quite clearly defined where local bathymetry charts only have them marked as a spot-position of 'Shallow waters'. In the south-east area of the image, to the north of the Hawar islands and south-east of Mutarid, is an area that is shown on the most recent bathymetry charts as 6 spot-depths of between 2.0-2.5 metres. On the classified image this area represents a significant sand bank which fits quite accurately over the spot-depths and gives a defined shape to an otherwise obscure shoal. For this reason both the False Colour and the Habitat Classification images have been carefully studied by the Ministry of Housing, Survey Directorate's Hydrographic Section for inclusion of such details on their bathymetric charts.

To the north of this the classified image predicts another sand shoal and careful inspection of the hydrographic charts shows a line of three spot-depths of between 1.8-2.4 metres in waters otherwise 5-6 metres deep, once more proving the accuracy of this imagery. In both cases the shoals appear as 'ghosts' on the false colour image.

Therefore, not only does the classified imagery predict habitat types with exceptional accuracy but it would also appear to be major aid to bathymetry and the potential for such hydrographic applications may be much greater than this.

CONCLUSIONS

The habitats

From the previous description of the shores of Bahrain and its islands and with the further detail encompassed within the Bahrain Marine Habitat Survey report it was possible to categorise the intertidal habitats. It is noticeable that several shores appeared under more than one category due to habitat overlap. For the same reasons no attempt has been made to identify habitats using cluster analysis techniques. Whilst these methods might separate the obvious (e.g. mangrove from rock) it is unlikely that they would be able to delimit grades of mixed sand and rock biota.

When all the data returns have been received from the various taxonomic consultants it may well prove useful to undertake a cluster analysis not so much to identify habitat types as to investigate faunal/floral community types. As with some of the subtidal habitats it may be the case that a mixed habitat supports a significantly different community to those communities found in the various component habitats (i.e. rock with a sand veneer may well support a different biotic community than would be the case if one was simply to add together the two communities associated with rock and sand respectively).

A list of those habitats already modified by human agency ranging from oil or sewage pollution to infill and the modification of natural habitats was also included in the report. Examination of detailed site data shows that such perturbation has been greatest along the north coast of Bahrain, to such an extent that it is not possible to find any example of an unmodified shore. Undisturbed shores were usually found to the south and west of Bahrain and on offshore islands, particularly the Hawar group.

For this reason it is necessary to use caution in defining the effects of the north-south salinity gradient on intertidal biota. The rocky shore algal diversity appears to be highest in the Hawar islands where salinities ranged from 48 to 50 or more. Similar clean rocky habitas were absent in the north of Bahrain where salinities were at their lowest (42). Certainly on the west coast of Jazirat Hawar eulittoral communities were dominated by a single tunicate species. However, this may simply reflect the admixture of sand and rock at these sites.

Higher salinity ranges are probably responsible for the sparse biota found on soft substrate shores in the Hawar island group. Pirinella conica is an excellent indicator of salinity stress and its appearance as a replacement for Cerithidea cingulata may be taken to show that salinity levels are too high for most of the typical sand and mud biota. Thus, salinity levels may well explain the absence of the mangrove, Avicennia marina, from otherwise suitable sites in these islands, although there is some uncollaborated evidence that very reduced stands of mangrove may have once existed on the bays on the east coast of Hawar and that a few plants may still be struggling to survive there. It is worth noting that P. conica also dominates communities in the Al Jasrah area where raised salinities are an important feature.

Despite perturbation, the lower shore and immediate sublittoral regions around Bahrain are zones of high productivity with macroalgae, seagrasses and cyanophytes all contributing to food webs supporting commercial fish and shrimp species. The importance of benethic rather than planktonic primary productivity in the waters around Bahrain has been identified in previous studies (Price et al., 1984; Vousden, 1985) and is a research area that is certainly in need of further attention. There is growing evidence that these habitats are essential to some stages in the life-cycles of many commercial species.

Remote Sensing Techniques

After analysis of the data returns from this tehchique, the accuracy was shown to be extremely good and it is safe to say that one can reliably predict the average habitat type for any one area around Bahrain. However, in the process of arriving at such a reliable method, many problems had to be solved. In retrospect the whole process could be undertaken more economically both financially and from the point of view of man-hours. In this respect, there are a number of lessons to be learnt from this study as well as observations that can be made in hindsight, which may be of use to people wishing to develop this technique for their own use.

Any reduction in discrepancies in position-fixing must be an advantage and the use of more accurate positioning gear, such as a trisponder network, should be a consideration. This would reduce on-site position error to a few metres at most. However, this has to be considered in direct relation to the increase in cost. Furthermore, such expenditure may be considered unnecessary as pin-point accuracy is not essential for a general habitat survey (a seagrass bed is not really a seagrass bed if it only covers a couple of square metres!) Where the accuracy is necessary is for 'proving' the satellite predictions. To this end, a reduction in the RMS (geometric correction) error on the satellite image would be an advantage. The best way of achieving this is with a reliable network of ground-control points.

One of the original mistakes made during this survey was to commission the habitat classification image based on poor ground-truthing data i.e. before sufficient data was available on which the computer could base its habitat prediction. The original intention was to use the satellite imagery to select the field-sites, but it became obvious that this approach was the wrong way around. As a result, the first habitat classification image only classified between 10-15% of the original area which, although of some use in site selection, fell far short of original expectations. This was rectified by ERSAC's generous agreement to re-run the habitat classification after the field-survey and based on its results. This produced the significantly more accurate second image from which to create the final habitat maps.

To achieve good ground-truthing data, therefore, one should select good examples of high-cover, widespread, habitat types. To feed the computer reliable examples of, say seagrass distribution, one needs to identify a number of good sites supporting 60% (or greater) cover of seagrass stretching over as large an area as possible with as few interruptions by other habitat types as possible. Some examples of borderline habitat types may also be useful for accuracy assessment (i.e. low percentage cover seagrass tending over a mud-type habitat).

It is quite probable that the more habitat types one tries to squeeze out of the imagery, the more likelihood there is of classification overlap as was the case in some places between seagrass and algae. It is reflection on the reliability of this method that the computer did seem capable of distinguishing between fine sand, mud and silt with reasonable accuracy, a distinction that is often missed in the field by the eye of the human observer. It should be pointed out that a certain amount of balancing is necessary to achieve the best possible accuracy. Often the accuracy of one habitat type has to be sacrificed in order to gain a better understanding of the distribution of another, less well-known habitat. This was the case with the final image produced for this study in which the seagrass classification to the north-east of the image was sacrificed in favour of the algal classification. During the generation of this image several different expansions and contractions of training areas were attempted to try and rectify this. However, it became apparent that it was not possible to achieve a superlative degree of accuracy for both these classifications. The sacrifice of some of the distribution data on the seagrass habitats was considered justified in the light of the considerable information already known about this habitat type and its distribution.

One should also bear in mind that the penetration of light, and hence the depths at which the satellite can 'see' the benthos, will be unpredictable and certain to vary from one geographical area to another mainly due to water clarity, but also probably affected by salinity and temperature.

Having created a reliable habitat classification image, the next step is the production of a series of charts showing not only the distribution of the various marine habitat types around Bahrain, but also incorporating information stored in the database, and identifying areas of vulnerability, habitats of specific importance to commercial fishery species such as shrimp, pearl oysters and fin-fish and to endangered or threatened species such as the Dugong (Seacow). Following on from this we will be able to select areas requiring protection or special management considerations. Furthermore we are now in a position to advise the government and local industry on the siting of new developments and any necessary precautionary measures that we feel should be taken into consideration. But of equal importance and returning to one of the original specific drives behind this survey we are now able to start selecting realistic monitoring areas. This must now be one of our priorities especially in view of the continuing emphasis that local industry and government are placing on coastal development. But perhaps of equal priority now is for Bahrain to develop a realistic and effective legislation in order to execute its management policies and conservation requirements.

The information made available from the satellite imagery, extrapolated to a series of charts and used in conjunction with an accurate, flexible comprehensive database should give us a considerable advantage in protecting the fragile and finely-balanced environment in these waters. Bahrain is moving ahead to consolidate a national conservation strategy. Already we have designated the main area of mangrove as a protected marine reserve and it is hoped that such protection can be extended to other sensitive areas such as some of the offshore islands.

In conclusion, we are now convinced that basic coastal and shallow water habitat prediction by remote sensing is a potentially viable and accurate technique. The development of more sophisticated remote sensing platforms with improved data reception facilities and greater resolution should provide the potential for better accuracy in projects of this nature. Hopefully, with further research into the use of satellites for coastal planning and management, it should be possible to answer some of the questions arising from this survey and refine what amounts to a very useful and time-saving method of mapping the shallow coastal seas.

With the generation of further imagery of this nature from other areas and countries using remote sensing it will be possible to build up a clearer understanding of its limitations and its flexibilities. In any case the feasibility of using such remote sensing for marine environmental research and monitoring would now seem to be beyond dispute.

RECOMMENDATIONS

The following comprises a complete list of the recommendations that were made in the Bahrain Marine Habitat Survey report.

The selection of marine monitoring sites and coastal areas requiring protection

The selection of fixed, marine environmental monitoring sites for the regular measurement of water quality, currents and biological characteristics must be placed at the top of the priorities list. This remains as the major impetus behind the need for initiating the Marine Habitat Survey of Bahrain in the first instant. It is hoped that with the wealth of information now available such monitoring and conservation sites can be selected in confidence on the basis of meaningful and significant results. Although monitoring sites were initially set up during the first ecological survey of the coastal waters of Bahrain (Price et al., 1984) it has since been recognised that environmental marine monitoring can only be effective in the presence of reliable and widespread baseline data (Vousden, 1985). Before allocating areas such as monitoring sites, marine reserves or parks it is necessary to achieve some knowledge of the different habitat types available, their relationship both to each other and to the chemical and physical parameters controlling their distribution, as well as a firm understanding of their biological characteristics (i.e. their diversity, what species they support, any natural cycles in dominance or species fluctuations, etc.). Only when armed with such background data is it possible to select sites for monitoring that will return information of significance to scientists endeavouring to maintain the balance and well-being of the marine environment as a whole or to aid in selecting representative sites for conservation.

Representative sites should be given protection, both to preserve their integrity as genetic reservoirs and to provide controls against which the effects of perturbation can be measured. The status of the mangrove habitat in Tubli Bay is critical. Without immediate protection the only example of this habitat in Bahrain will completely disappear together with its associated biota.

Tubli Bay itself contains a rich variety of sheltered muddy and rocky shores and supports artisanal shrimp and fin fisheries as well as an algal harvesting industry. Tubli Bay has already lost most of its highly-productive mangrove due to industrial development despite having been shown previously to be of major importance to local fisheries. Such classically bad management of natural resources should be avoided at all costs in the future if they are to survive. Further surveys have shown the existence of unique, subtidal rocky areas. Studies are now being conducted to establish the food webs between primary food sources such as seagrass, algae and mangal and the commercial fisheries species. The results can be used to evaluate the effect of habitat deterioration upon renewable biotic resources.

The Hawar island group presently enjoys an unofficial 'protected' status due to the security restrictions imposed on the main island. However, recent construction in the area may be having a deleterious effect on this, one of Bahrain's unique collections of habitat types. The construction of a road across the mouth of one of the largest bays on the east coast of Hawar has closed off the tidal channel which could have disastrous effects on the inner bay flora and fauna. There is some evidence that the more remote coastal areas on the east side of Hawar could support mangrove. This has yet to be confirmed, but if found to be true would strengthen the need to protect this unique piece of Bahrain even more. Hawar, along with Tubli Bay, should be given official 'protected' status whereby any further development work of this nature should be previously discussed with environmental and conservational experts.

Research into seasonal changes in the biological environment to improve the efficiency of the monitoring programmes

Seasonal changes in the biota at selected sites have been investigated in February and March of 1986. The results of this winter season survey along with the main study undertaken in the summer reveals considerable annual variation in the community types supported by the various habitats. It follows from this that more detailed monitoring should be undertaken to establish annual cycles of variation. An area of particular concern here would be to identify the cause of the apparently cyclic mortalities amongst the coral communities. This would clear up any existing controversy over whether these mortalities have been induced by man-made stresses, such as dredging and reclamation, or are a result of natural stresses such as temperature extremes. This sort of information is essential for the accurate interpretation of data from the marine monitoring programme.

The use of further Landsat imagery to assist in the identification of seasonal variations in habitats as well as supplying biological oceanographic data for the whole area

Having proved the accuracy of satellite imagery and recognising it as a powerful aid to fast, economic field data collection, it would undoubtedly prove worthwhile to employ this method again to assist in the understanding of the afore-mentioned seasonal variations in the marine environment. To this end, it would be necessary to request a fly-over by Landsat 5 on a specified date in the summer. Because of the need to specify a date in the request, there could be a number of advantageous spin-offs from such a project. By knowing which day the satellite is to collect the imagery data it would be possible to prepare several field teams in boats whose objective would be to collect real-time data from the waters around Bahrain on the same day. By using this field data to calibrate the data from the satellite it would be possible to acquire valuable information on such parameters as sediment loads in the water column, temperatures and chlorophyll-a concentrations. Also, it would supply useful information about the capabilities of penetration of the water column by the satellite's sensors. Finally, it would be of great use to hydrographic charting institutes as bathymetry can also be measured accurately using the available data.

Further oceanographic studies as a component of the marine monitoring programme

A detailed oceanographic survey of Bahrain's waters is currently underway. Further work is essential in the area of oceanography particularly water currents and water quality. Current meters have already been deployed at some sites and the data returns from these are expected to be very useful in the further analysis of temperatures, salinities and water movements around the islands. Turbidity and sedimentation are also areas of concern and deserve a study of their own. Hopefully, such a project can be initiated in the near future and possibly be run in conjunction with research into the effects of dredging and reclamation.

Identification of all key species and their distribution and tolerance levels

It is clear that many species are close to their thermal and salinity tolerance limits in Bahrain. The present survey indicates that certain species are absent from the south of Bahrain and from the Hawar islands and that biotic diversity probably declines as a result of elevated salinities. It is recommended that the salinity and temperature tolerance of key intertidal species be measured so that their distribution and response to artificially-induced salinity changes (e.g. infill, dredging and any general coastal development impeding or increasing water movement) can be predicted. In parallel to this work, further field measurements of coastal salinites and temperature trends around Bahrain would prove invaluable in improving the understanding already achieved from the data collected to date. Such measurements are already underway in the form of a programme of current meter deployment at selected sites around Bahrain.

The identification of key species for each habitat type is an important step towards monitoring the welfare of those habitats. A key species usually holds a position of dominance within a community because it is better adapted to surviving in the conditions which prevail over that community. It is, therefore, obvious that any detrimental changes within that community as might result from man-induced impacts are likely to show up in the balance of dominance and, therefore, in the distribution of the key species making them an important monitoring parameter. Furthermore, it has become apparent from the intertidal surveys undertaken during the course of this study that certain flora and fauna, which are highly representative of the intertidal of other ROPME countries, are missing from Bahrain. The reasons for this absence need identifying as a further understanding of the stresses imposed on the local biota.

Further studies into the parameters controlling the distribution of each habitat type

We now have a much better understanding of the distribution of the various marine habitats and what controls that distribution. However, to provide a powerful advisory capability it is necessary to understand the balance of controlling factors for each habitat and to what extent this balance can be disturbed before it becomes irreversibly unstable.

The seagrasses are an obvious case in point. There appears to be a very deliberate distribution of the three species with regard to depth, substrate and, possibly, salinity. The reasons for this distribution are not fully understood but should not prove difficult to elucidate using proper scientific analysis. The effects of such parameters as salinity, temperature, depth and substrate type are of importance both for advisory/protective purposes and for the understanding of results from monitoring programmes. For example, if one were not aware that certain species of seagrass tend to die-back in the winter months it would be an easy mistake to suspect a major man-induced impact was occurring within the environment.

Research into the relative productivity of the various marine habitats around Bahrain

Much has been discussed in the literature about the relative productivity of certain habitats. It is generally accepted that mangrove communities, seagrass beds and coral reefs are areas of critical importance due to their high productivity and diversity. However, there is an increasing body of opinion which feels that other habitats of less obvious importance may, in fact, be just as productive if not more so. Certain areas of extensive, intertidal, mud flats may well support as much primary productivity and as many juvenile commercial species as the mangrove and there is evidence available that subtidal sands can often display a richer diversity than the seagrass beds (Basson et al, 1977). This is an area that is now receiving attention. If such habitats such as intertidal mud-flats do indeed prove to be as important to the well-being of the environment, then their protection should be given a priority, especially in view of the fact that it is these very areas that so often come under the bulldozer during reclamation projects.

Analysis of the direct or indirect commercial importance of each habitat type

Each habitat type so far identified should be assessed for its commercial importance, i.e. does it support a major fisheries species or is it an indirect contributor to the food-chain of a commercial species or does it support a stage in the life-cycle of such a species? A full identification of the key species goes a long way towards answering such a question, but further studies are also underway within the planktonic component of the environment as well as a more detailed approach to understanding the various links in the food chains.

Study of new areas which may prove to be highly productive

The above may also be true of certain areas which have yet to be studied for later inclusion in the Habitat Survey. These include certain old, historic beach formations in the subtidal off the west coast of Bahrain. Some of these show relatively steep profiles on the local charts and on echo-sounder and local fishermen consider them to be very productive although they often have difficulty in locating them.

Further north, well out into the Exclusive Economic Zone allocated to Bahrain, there are certainly areas of importance. These include the pearl-oyster beds which are presently undergoing a study with a view to re-exploiting their commercial potential. Also in the same area are coral reefs and one, in particular, is proving to be of some interest. This is Abu ath Thamah some 90 kilometres north north-west of Muharraq. With respect to quality, this reef appears to be in a much better state than those further south around Bahrain. The water here is much clearer which probably accounts for improvement in quality. Most of the reef is in deeper water probably due to the water clarity. Salinities, although not yet measured, are likely to be less. Also because of the deeper water, the coral is more likely to be buffered against temperature extremes. This is an area which is used by the local fishermen and also represents a potential re-seeding stock should the reefs further south ever become impacted beyond the point of recovery. More detailed studies of this reef should be carried out in the near future as a comparison to our near-shore reef complexes.

Research into the harmful and beneficial effects of coastal development with a view to setting standards and advising on methodologies

Once annual cycles of biotic variation and production are established for intertidal habitat types, these can be compensated for in any evaluation of the effect of new coastal developments upon production and diversity. It is possible that marine construction such as harbours and marinas may actually enhance productivity provided water circulation is not impeded.

Such construction often produces a wider range of habitats than originally existed. The frequency of coastal development around the islands of Bahrain offers a unique opportunity for study and research into the establishment of new techniques and methodologies for such development. These techniques and methods could be designed in such a way that not only would they incorporate all the best approaches for imposing the least damage on the environment but they could also attempt to improve the environment by creating new habitat types where none previously existed. It is recommended that surveys be conducted into the biota colonising such coastal developments and structures such as harbours and marinas so that their impact may be evaluated. Studies should also be undertaken to identify better techniques of landfill and reclamation with a view to fulfilling those recommendations laid out above. Such studies should include direct measurements of the sediment plumes produced at the cutter head and at intervals down-stream along with analysis of the effects on down-stream biotic communities. Further studies into the problems of siltation at the delivery end where the reclamation takes place would also be beneficial. The need to cut down on the volume of fine sediments entering the water column is a priority. After evaluation of these problems it should be possible to develop standards for inclusion in future legislative policy.

Research into the potential for habitat enhancement by artificial inducement

The 'Oasis' effect of increased diversity due to increased habitat niche, as described in the main text of the 'Habitat Survey' report, has important consequences with regard to the possibilities of habitat enhancement. The improvement of certain stretches of coastline by careful development has been noted already with much evidence in the local environment of increased productivity in such areas as marinas and around the Saudi-Bahrain causeway. Offshore, there are possibilities for artificial reefs to supplement the productivity of a mixed habitat (such as sand and rock) and the sum of the individual components as pure habitats may well prove the former to be of greater significance to the environment as a whole. The mangrove habitats which are presently under severe threat could be aided and enhanced by the creation of new mangrove in suitable areas. This would require research into their physical tolerance levels, substrate requirements, etc.

Geological studies with the emphasis on sedimentology to assist in the selection of sites for coastal development

Further studies into the marine geology/geomorphology of the area would be valuable. At present, most of the geological information for Bahrain concentrates on the land with very little study having been pursued beyond the intertidal zone. Such a study would be useful not only as an aid to habitat protection but also to the planners and coastal engineers. The distribution of sediment types and their transportation around the coast obviously has its importance to those wishing to protect marine habitats, especially with regard to the effects of any physical changes in the environment and how these might be reflected in the water column and benthos. But, it should also be considered that any changes to the physical environment which cause alterations in the distribution of sediment types and their erosion, transportation and deposition may have drastic effects on water quality vis-a-vis the local industries which require that water in their processes. If the reclamation of a certain area of coastline caused changes in local current regimes, these in turn might initiate changes in the balance between erosion and accretion of the coastline. The net effect of such changes could be a significant increase in suspended sediments adjacent to the water intakes of an important industrial concern. This is just one example of a number of equally harmful scenarios which could occur.

A detailed study of the local sediments would also be of use to those requiring good high-grade, low-silt deposits of sand for reclamation purposes. This could parallel the interest of the environmental planners as they would be in a position to recommend areas for sand-winning well away from sensitive habitats.

The regular monitoring of industrial input at source

The continued monitoring of industrial input to the marine environment is essential. This can be further improved by inclusion of data from the fixed environmental monitoring sites which we are now in a position to select. However, monitoring of the industrial sector is useless without some form of control and that is why it must become a priority to set fixed standards of discharge.

The development of management policy and legislation

It should be realised, however, that no matter how much research has been done and how many recommendations have been made regarding the levels of pollutants entering the water column, the effects of coastal development, the need for monitoring, the design of effluent emission standards and the designation of protected areas, none of this is of any use whatsoever unless there is Government legislation to support it. If there is no legal backing from the Government to enforce the implementation of realistic standards which support the protection of designated areas then an environmental protection agency as a government body is powerless.

In order to undertake a coastal management strategy it is necessary to have a management policy which is both flexible enough to assess each situation on its own merit but firm enough to insist on conforming to standards when necessary. Often it is useful to develop an atmosphere of productive compromise between the developers and industries and environmental body and this is a realistic approach. However, in the final analysis the environmental body representing the Government needs to have the capability to insist on certain standards which it feels are beyond compromise.

ACKNOWLEDGEMENTS

Acknowledgements are due to the specialists/consultants, employed by ROPME at the Environmental Protection Technical Secretariat (EPTS) in Bahrain, who provided input to both the field-work and the text of the Bahrain Marine Habitat Survey in their relative areas of specialisation as follows: Dr. D.A. Jones (Intertidal ecology and Arthropod taxonomy); Dr. C.R.C. Sheppard (Coral ecology and taxonomy); Dr. A.R.G. Price (Subtidal soft benthic ecology and Echnoderm taxonomy); Dr. P.W. Basson (Algal taxonomy); Dr. A.L.S. Sheppard (Molluscan taxonomy); Dr. A. Nelson-Smith (Annelid taxonomy); Dr. D. Lane (Tunicate taxonomy); Dr. W. Clifford-Jones (Sponge taxonomy).

Further to this the author wishes to acknowledge the input of Mr. Walter J. Vreeland, Mr. Shaker Khamdan and staff of the Environmental Protection Technical Secretariat, Bahrain. Also the following institutions:

Environmental Remote Sensing Applications Centre, Livingstone, Scotland, for providing the satellite imagery and enhancement.

The School of Ocean Sciences, University College of North Wales, U.K. for the use of the library and other facilities. The Directorate of Survey, Ministry of Housing, Bahrain for charts and the use of their hydrographic vessel.

Finally the author would like to thank ROPME for their financial assistance and encouragement without which this survey would never have taken place.

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MARINE COASTAL AREA OF KUWAIT - AN OVERVIEW

by

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ABSTRACT

An overview of the general meteorological, oceanographic, geomorphic and urban characteristics of the coastal area of Kuwait is discussed in the paper together with examples of potential interaction between these characteristics. The paper addresses four topics: (1) Basic characteristics of the coastal area; (2) Distribution of urban density and potential sources of pollution along the coastline; (3) Examples of human encroachment on the coastal environment; and (4) Potential impacts of pollution on subsequent human development and utilization of the coastal area.

INTRODUCTION

The coastal area (air, water and land mass) is potentially subject to different interactions, not only between these parameters, but also in regard to the human population inhabiting the area. The interaction between these elements can be generally described as follows:

1. At any particular time, the natural environment will restrict man's capability to inhabit or exploit the coastal area, depending on his level of technological advance.

2. Establishing a human settlement with a wide variety of activities causes certain changes in the coastal environment.

3. The combined action of the basic natural constraints and the patterns of human exploitation may eventually limit the suitability of the coastal area for certain future developments.

This paper uses Kuwait as an example to study these interactions by addressing three main topics:

1. The basic environmental characteristics of the coastal area of Kuwait and the surrounding air, water and land mass.

2. Urban settlements and examples of potential human effects on the marine environment.

3. Potential effects of the existing conditions on possible future development of the coastal area.

In addressing these topics, it is inevitable that there is a bias towards using data generated at the Kuwait Institute for Scientific Research (KISR), with which the author is most familiar. An attempt is made, however, to use data from other sources whenever possible.

BASIC ENVIRONMENTAL CHARACTERISTICS

Atmospheric environment

Seasonal variation in air temperature, rainfall, and water evaporation rates (Fig. 1) suggest an extremely arid environment throughout most of the year, particularly in summer. This aridity and the predominance in the area of northwesterly winds (Fig. 2) blowing from desert areas to the north and northwest of Kuwait significantly contribute to a variety of suspended dust phenomena, ranging in intensity from mild haze conditions to severe dust storms.

Available data suggest that levels of air-suspended solids and rates of dust fall-out in Kuwait are probably the highest in the world. Mean monthly concentrations of suspended solids may reach up to 1400 $\mu g\ m^{-3}$ in summer decreasing to 250 $\mu g\ m^{-3}$ in winter (EPD, 1984). In comparison, the primary air quality standard for suspended solids in the United States was set at 75 $\mu g\ m^{-3}$ annual average and 260 $\mu g\ m^{-3}$ daily average. A similar elevation is observed for dust fall-out rates throughout the year although these rates vary with season and with location on the mainland, for example, ranging from 5 to 1250 tons $km^{-2}\ month^{-1}$ in 1984 (EPD, 1984). This fall-out is potentially derived from a number of local and regional sources including local desert playa and coastal sabkha[1/] deposits, muddy sediments covering the lower Mesopotamian flood plain, and other surface deposits in northern Kuwait and southern and western Iraq (Al-Kadi et al., 1981; Khalaf and Al-Hashash, 1983; Khalaf et al., 1985).

1/ Sabkha: a coastal flat area of clay, silt or sand occurring just above the level of the normal high tide. Its surface could be wet throughout the year (wet sabkha) or dry during summer (dry sabkha).

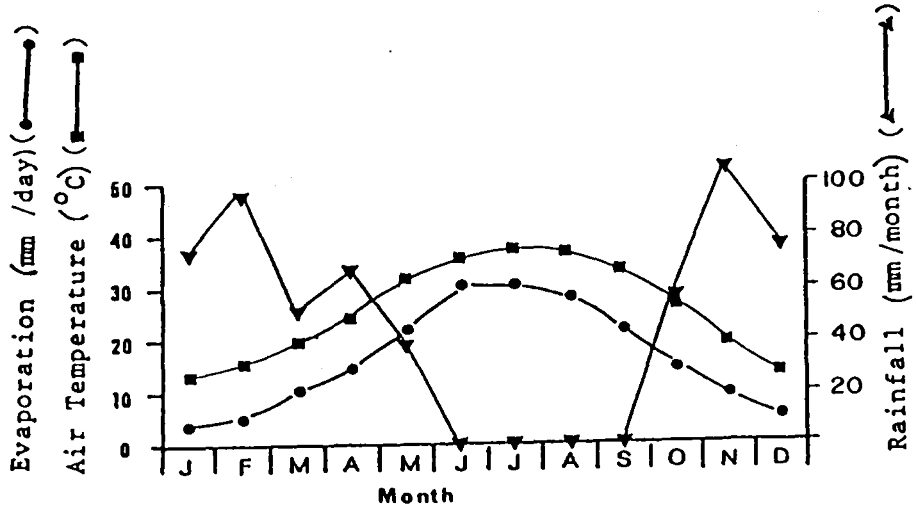

Figure 1. Mean monthly evaporation rate, air temperature and rainfall (after Al-Kulaib, 1984; Safar, 1985).

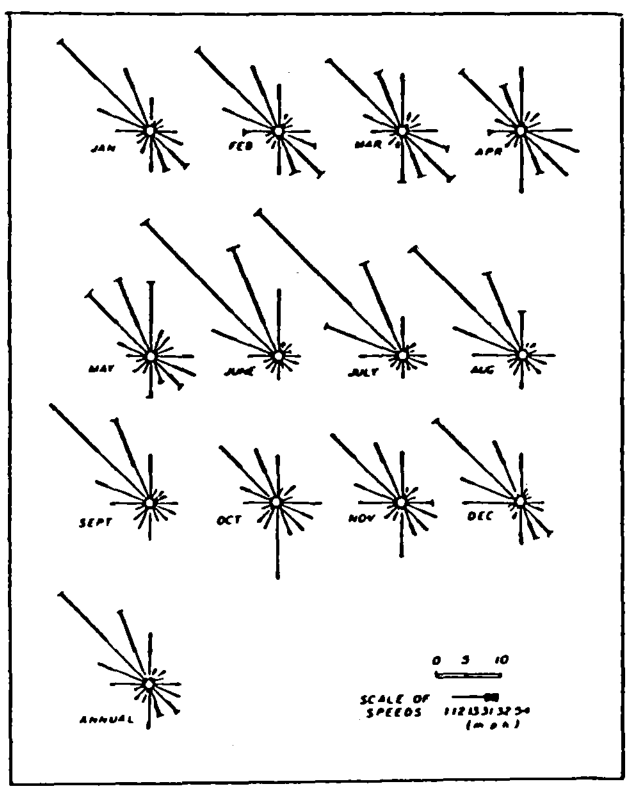

Figure 2. Frequency of wind speed and direction at Kuwait International Airport, 1957-1973 (after Al-Kulaib, 1984).

A dust storm originating in the Mesopotamia region usually has a NW-SE axis (Fig. 3) and may travel a great distance over the northwestern part of the ROPME Sea Area. Unlike the situation on land, where dust particles are kept suspended by an equilibrium between processes of gravitational deposition and aeolian uplifting, particles settling on water surfaces will be trapped and will not be able to be uplifted. This causes a dust cloud advancing over a water surface to gradually settle with the quantity deposited decreasing by distance from the shoreline. Using a mathematical modeling technique, Foda et al. (1982) estimated that dust storms deposit about 5 mm yr^{-1} at the Iraqi coast, about 2 mm yr^{-1} 30 km off the coast and about 1 mm yr^{-1} 60 km off the coast; averaging over 200 km off the Iraqi coast, which includes the Kuwaiti coastal area, the sedimentation rates averaged 0.8 mm yr^{-1}. An estimate of 1 mm yr^{-1} along the Kuwaiti coast was obtained by extrapolation from sedimentation rates measured on the mainland (Khalaf and Al-Hashash, 1983). These estimates are substantially higher than the average rate of dust deposition on the world's oceans, which range between 10^{-3} and 10^{-4} mm yr^{-1} (Judson, 1968).

Terrestrial environment

The extreme aridity of the local environment and the predominance of northwesterly winds also cause a NW-SE migration of mobile sand from different sand belts on the Kuwaiti mainland (Fig. 4). Of particular significance to the marine environment, are the sand movements at Ras Al-Subiya and the southern coastal areas, which have been estimated to contribute a total of 20,000 and 170,000 m^3 yr^{-1}, respectively, to the marine environment (Foda et al, 1984).

Marine environment

The Kuwait marine environment is generally shallow with broad flats to the north, a gentle to steep shelf slope along the southern coastline, and a relatively deep trough in between (Fig. 5). The depth of the water column at the shoreline increases gradually with distance offshore in northern Kuwait Bay, but increases more rapidly along the southern coastline. Three coral islands (Kubbar, Qaru, Umm Al-Maradim) and several submerged coral reefs are also present in the area.

The sea floor is mostly covered with fine sediments (mud, silt, sandy mud), except along the coastline from Ras Ajuza to the southern border where the sea floor is covered with sand, and except for a few locations in the Kuwait Bay trough, which are rocky in nature (Fig. 6). Mineralogical and textural examinations of recent marine sediments suggest that their main potential sources, in approximate order of importance, are: (1) dust fall-out originating from southern Iraq and surface deposits of Kuwait, (2) abraded material from local coastline sediments, (3) direct biochemical precipitation from seawater, (4) river-borne sediments from Shatt Al-Arab, and (5) submerged ancient sediments occupying the bottom of Kuwait's offshore area (Al-Bakri et al., 1984).

High tides approach the Kuwait marine environment from the east. Tidal cycles at different locations along the coastline occur in phase, but their amplitude gradually increases towards the north. The generated tidal currents are the strongest currents in the local environment, with their directions, in the near-coastal area modified by the coastal and bottom topography (Fig. 7). In general, water flowing into Kuwait Bay during flood tides moves successively into northwesterly, westerly and southwesterly directions, whereas the opposite occurs during ebb tides for water leaving the Bay (i.e., in northeasterly, easterly and southeasterly directions). Because of their oscillatory nature, however, tidal currents do not affect the net transport of seawater-suspended materials. The latter are affected by residual currents that are mostly generated by the interaction of tidal currents with bottom topography, and which also constitute

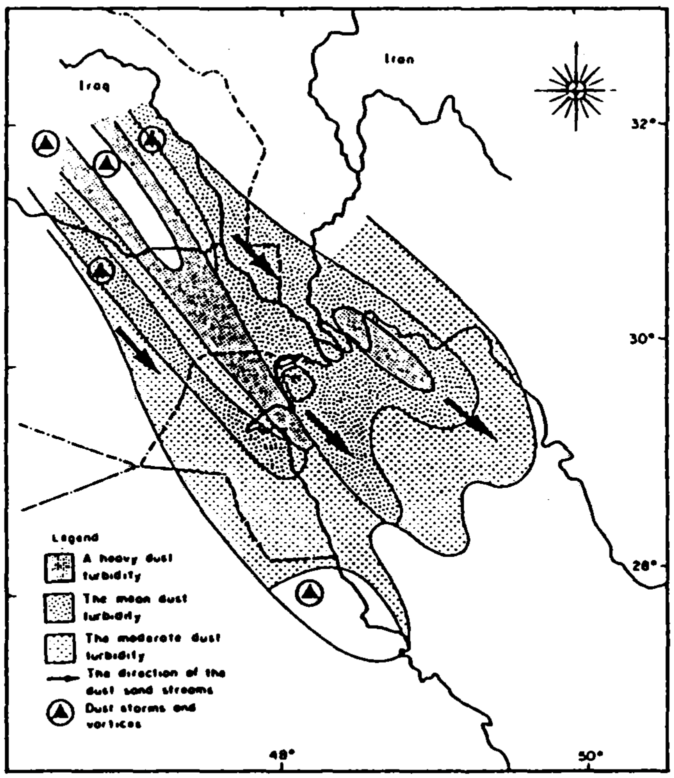

Figure 3. TV image of the dust storm structure over Mesopotamia lowland and northern ROPME Sea Area (after Vinogradov <u>et</u> <u>al</u>., 1973).

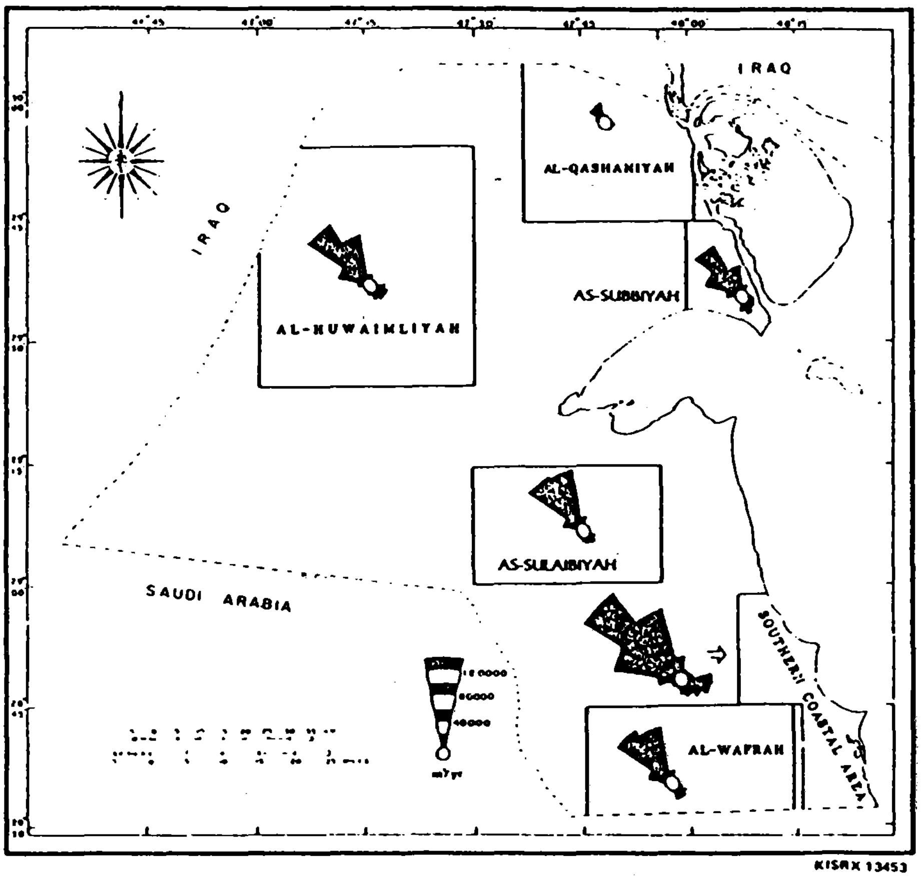

Figure 4. Annual rates of sediment transport in areas vulnerable to sand encoachment in Kuwait (after Foda et al., 1984).

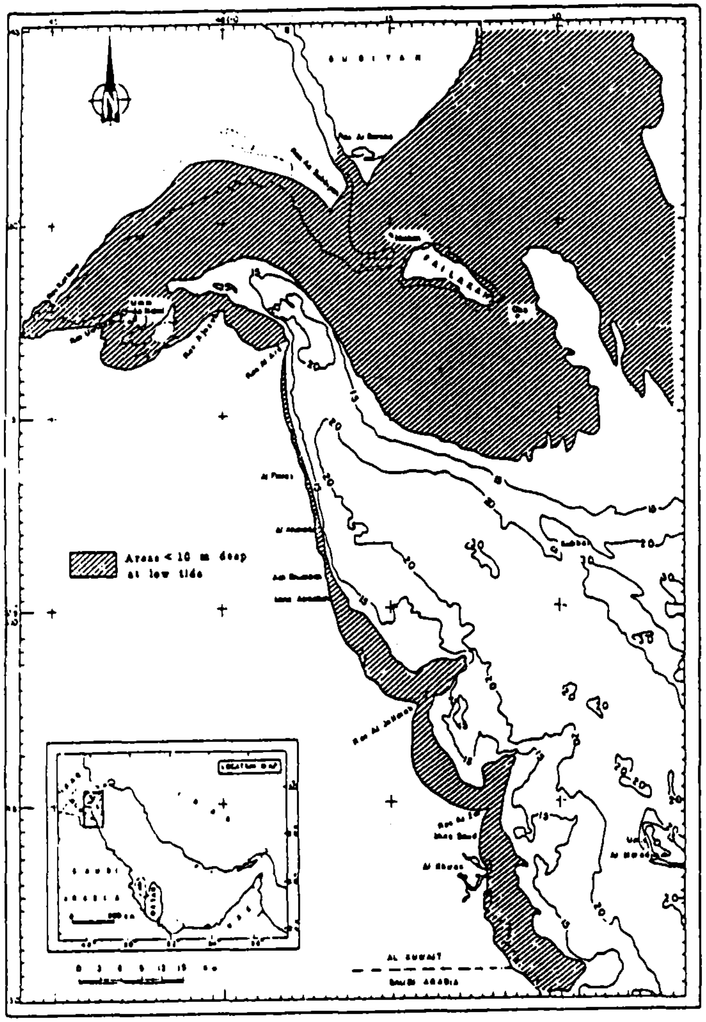

Figure 5. Bathymetry of the Kuwait marine environment.

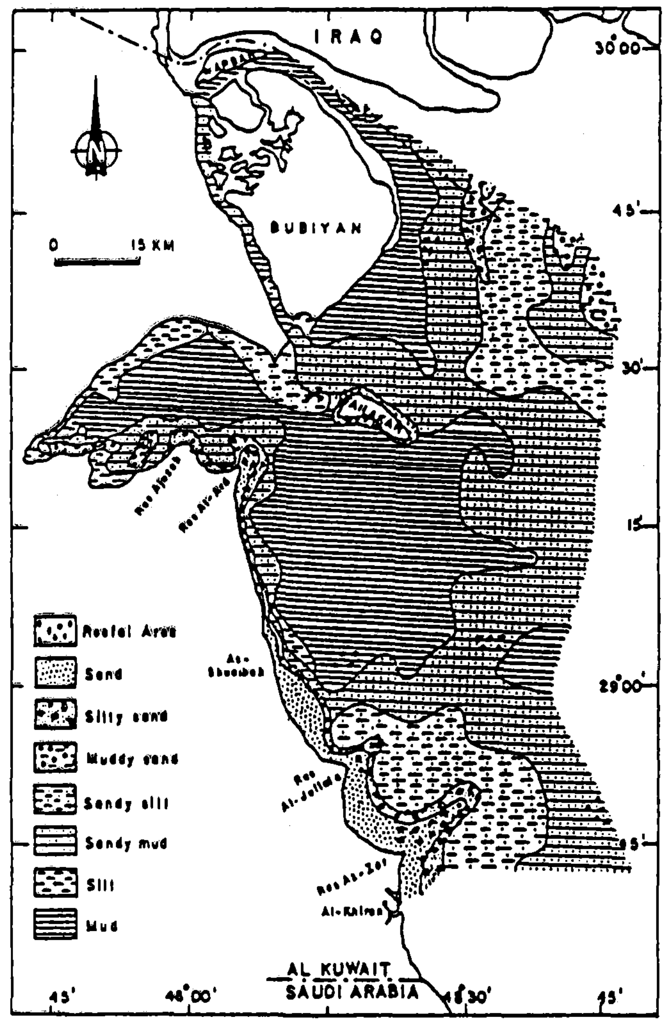

Figure 6. Spatial distribution of various sediment textural classes in the Kuwait marine environment (after Khalaf et al., 1986).

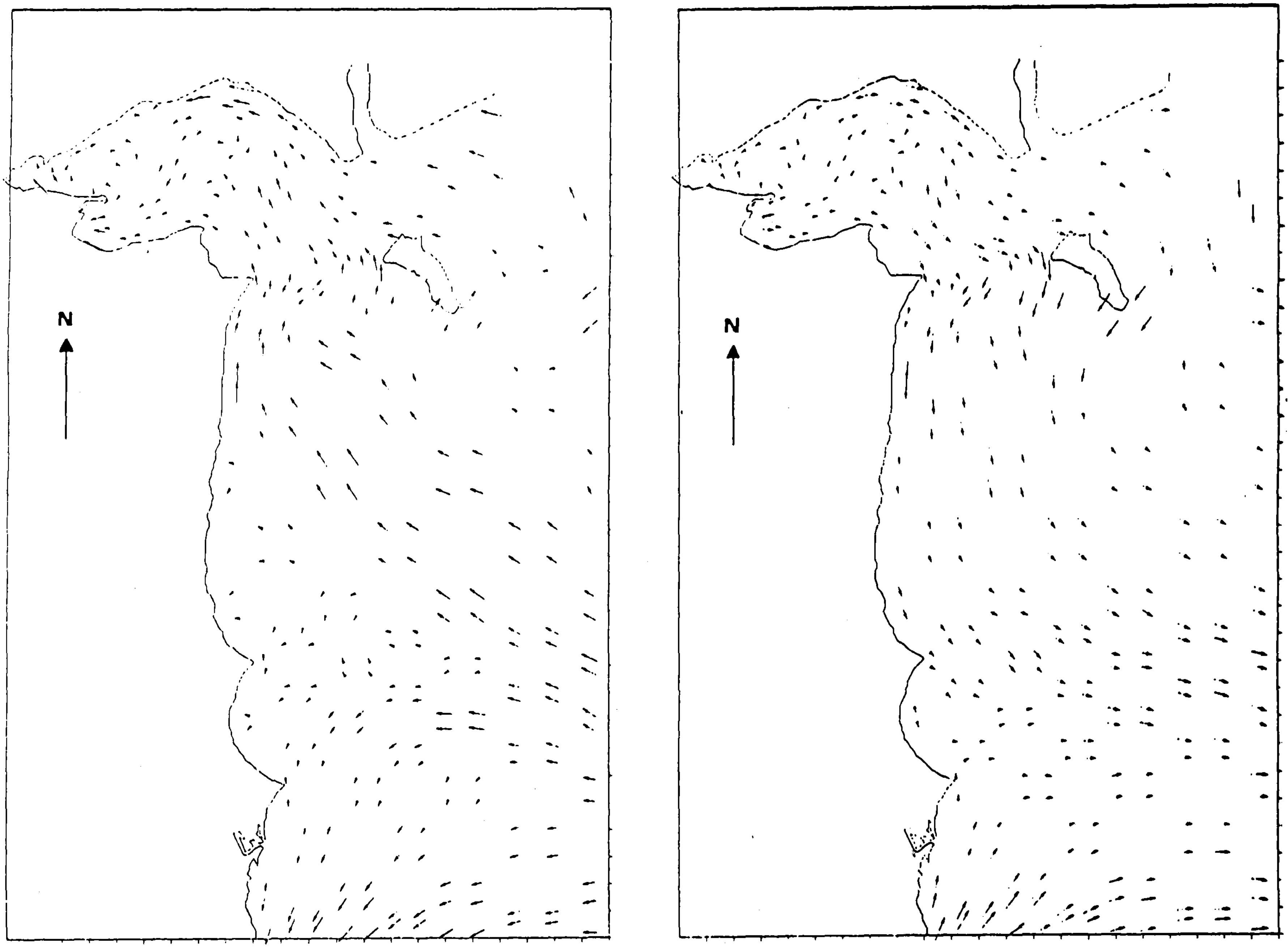

Figure 7. Computer simulations of the tidal currents in Kuwait during (a) flood and (b) ebb tide phases (after Samhan et al., 1986a).

an integral component of the residual current movement in the ROPME Sea Area (Fig. 8). Residual currents may have different directions at the surface and bottom of a water column (Fig. 8a). The interaction of these currents with high rates of dust fall-out and mobile sand encroachment indicate potentially high rates of littoral sediment transport.

The chemical and physical characteristics of seawater may vary with location and with season. Seasonal fluctuations in air temperature, for example, are accompanied by similar, but slower, changes in seawater temperature so that the former is higher than the latter in summer and lower in winter (Fig. 9a). Higher air temperatures, higher evaporation rates and lack of rainfall in summer (Fig. 1) also cause seawater salinity to be higher in summer than in winter (Fig. 9b). Salinity in winter is further reduced by a higher rate of fresh water inflow from Shatt Al-Arab, which is usually highest between December and April.

Coastal environment

Interactions of the atmospheric, terrestrial and marine environments exert their effects on all aspects of the coastal area including its geomorphology and sedimentology. Khor Al-Subiya has a narrow muddy intertidal zone that is successively fringed land-ward by wet sabkha, dry vegetated sabkha and sand drifts. Wet sabkha, dry sabkha and sand drifts also occupy the backshore at the northern side of Kuwait Bay and its western corner. A broad and muddy intertidal flat occurs seaward along these parts of Kuwait Bay as well as in Sulaibikhat Bay. Dry vegetated sabkha, active sand sheets and coastal sand drifts also occupy the backshore along the coastline south of Mina Abdullah, fringed seaward by a narrow rocky/sandy intertidal flat. A similar intertidal flat occurs along the coastline from Shuwaikh port to Mina Abdullah, but this coastline is extensively modified landward by human construction and filling activities.

HUMAN SETTLEMENTS AND POTENTIAL HUMAN EFFECTS

Human settlements

The extensive aridity of the land and the lack of agricultural resources traditionally forced people of Kuwait to concentrate on the coastal zone. Among other factors, the coastal geomorphology was instrumental in forcing them to settle in particular locations. The extensive sabkha and intertidal mud flats to the west and north of Kuwait Bay, for example, prevented and continue to prevent urban occupation of these areas. Today, the urban population of Kuwait is concentrated along the southern coastline of Kuwait Bay between Jahra and Ras Al-Ardh, and extends southward along the coastline to Fahaheel. The area immediately south of Fahaheel is occupied by the enlarged Shuaiba Industrial Area and other industries, whereas only the coastal strip of the area further south is inhabited, mostly by private beach houses.

The coastal area between Jahra and Shuaiba receives the majority of urban waste and industrial effluents: four oil-loading terminals at Shuaiba; petrochemical and other industries at Shuwaikh and Shuaiba; power plants at Doha, Shuwaikh and Shuaiba; and numerous storm water/sewage outfalls throughout the area. The area between Ras Al-Zor and Al-Khiran is also becoming increasingly populated, now having an oil loading terminal, two power plants, and a large recreational complex. These human activities affect the nearby coastal environment, for example, by introducing various organic and inorganic pollutants. The following are examples of potential human effects on the environment.

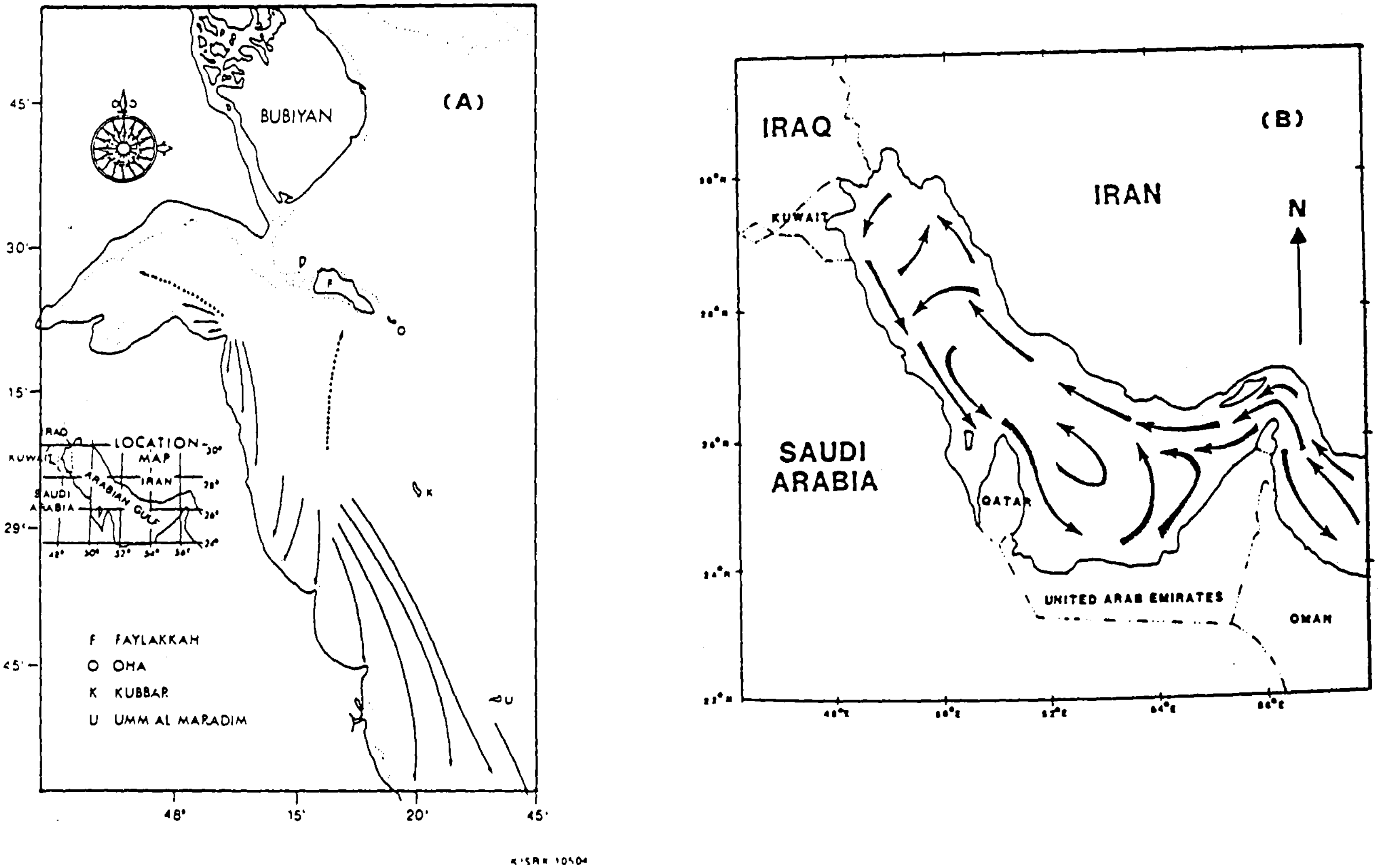

Figure 8 (a). Surface (——) and bottom (- - - ->) local residual currents (after Lee, 1983) and
(b). Mean current pattern in the ROPME Sea Area (after Pickett et al., 1984).

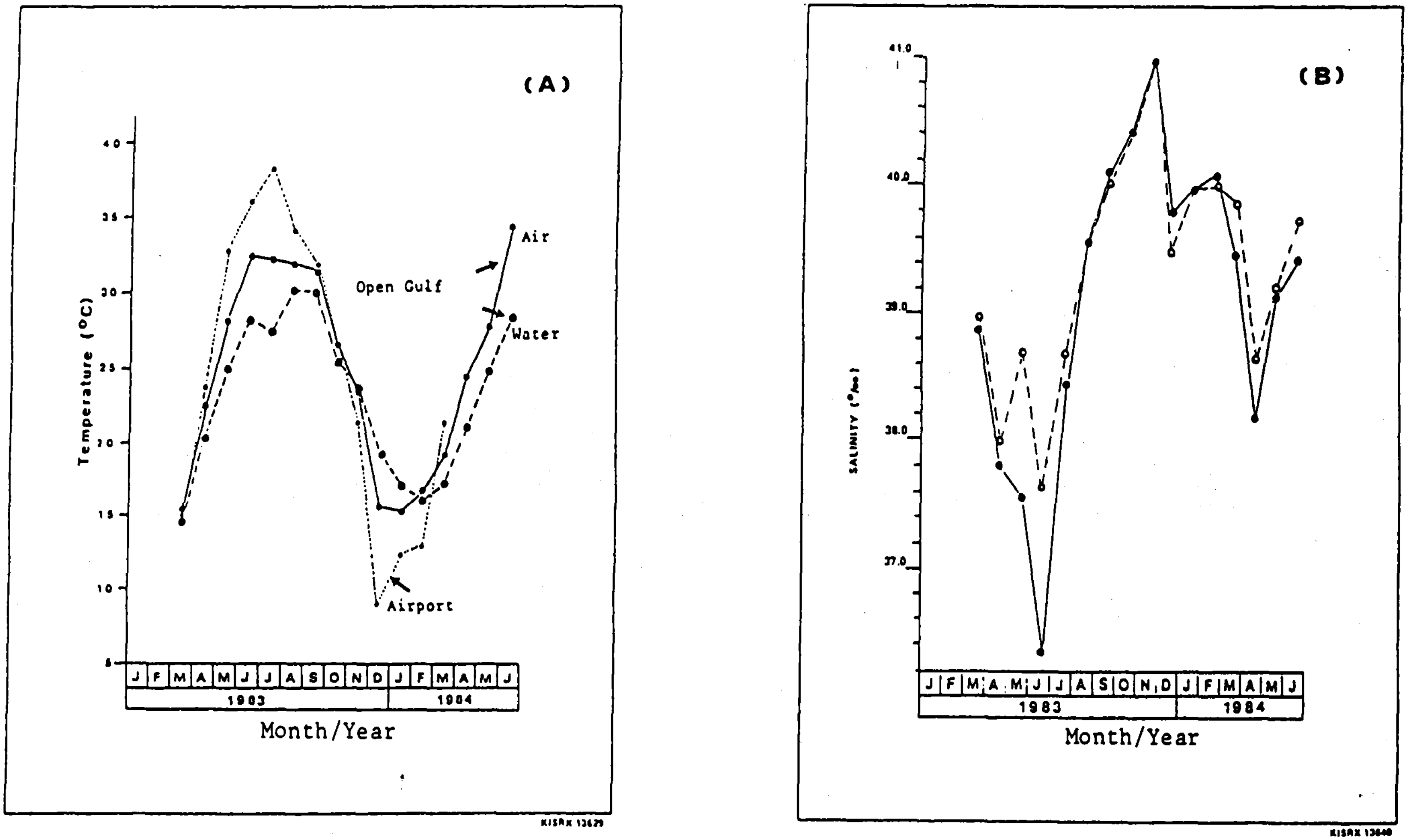

Figure 9. Seasonal changes of (a) seawater temperature,, air temperature over the Gulf, and air temperature at the Kuwait International Airport, and (b) surface (——) and 10 m deep (- - - -) seawater salinity (after Literathy *et al*., 1985).

Oil pollution

The majority of oil spill incidents in Kuwait occur near oil-loading terminals at Shuaiba and, to a lesser extent, at Ras Al-Zor (Fig. 10). These spills and harbour activities at Shuwaikh and Shuaiba contribute to the spatial distribution of petroleum hydrocarbons in marine sediments (Fig. 11). Together with the direction of the surface residual currents (Fig. 8), the frequency of these spills contributes to the low beach tar density at Ras Al-Ardh and a gradually increasing density towards Ras Al-Zor, where the highest tar ball densities are usually observed (Fig. 12). These spills may also affect the biota in the region. For example, levels of petroleum hydrocarbons in oysters (Pinctada margaritifera) at Mina Abdulla were about ten times higher than at any other location studied (Al-Hassania, Finaitees, Fintas, Ras Al-Zor, Ras Bard Halq; Anderlini et. al., 1981b).

Industrial pollution

Oyster samples were also analyzed for polychlorinated biphenyls (PCBs). These are synthetic organic compounds that do not naturally occur in the environment. Results of analyses showed that the highest concentrations in oysters occurred at Mina Abdulla (71 ng g^{-1} dry weight) because of the heavy industrial activity in that location. Furthermore, PCB's concentrations in oysters at locations north of Mina Abdulla were higher (29-38 ng g^{-1}) than at locations to the south (3.8-5.2 ng g^{-1}). This is probably due to an additional contribution from domestic waste and storm water discharges to the north of Mina Abdullah.

Industrial effluents may also contain inorganic pollutants. For several years, for example, a salt and chlorine plant at Shuwaikh was believed to contribute significant quantities of mercury to the nearby marine environment. Results of water, sediments and biota analyses (Fig. 13) indicated a localized source of mercury pollution in that area. Discharges from this plant have recently been stopped.

Power plants

Power plants may produce a variety of chemical pollutants in addition to thermal pollution. For example, halomethanes are produced by the reaction of hydrocarbons in effluent seawater with chlorine that is added as a biocide to kill marine biofouling organisms. Halomethanes thus produced are discharged with the effluent seawater into the receiving water bodies where they may exert negative environmental effects. Their dissipation away from the discharge outlet will be controlled in part by the prevailing currents (Ali and Riley, 1986). For example, dissipation of halomethanes at the Shuwaikh power plant seemed to be more enhanced by ebb tide conditions than by flood tide conditions (Fig. 14).

Atmospheric fallout

The atmosphere is an important medium affecting the transport of pollutants away from urban, industrial or agricultural areas. Pollutants may be emitted directly into the atmosphere (e.g., from industrial emissions or aerial application of pesticides), or they may be initially deposited on land surfaces from which they are picked up either by volatilization or particulate aeolian uplifting.

The potential for atmospheric transport of pollutants in this area is enormous because of the high air temperatures, extreme aridity, and the frequent occurrence of dust storms. Processes affecting the aeolian transport of particulate matter (Fig. 15) may affect the transport of

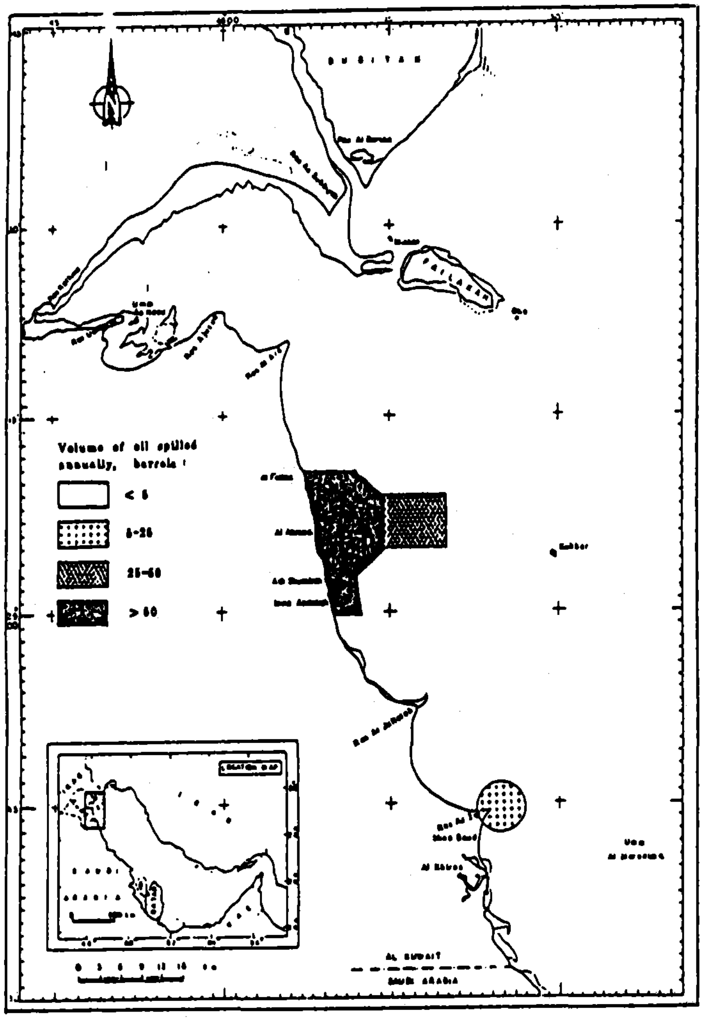

Figure 10. Volume of oil spilled annually into the marine environment, 1979-1985 (after Samhan *et al*., 1986a).

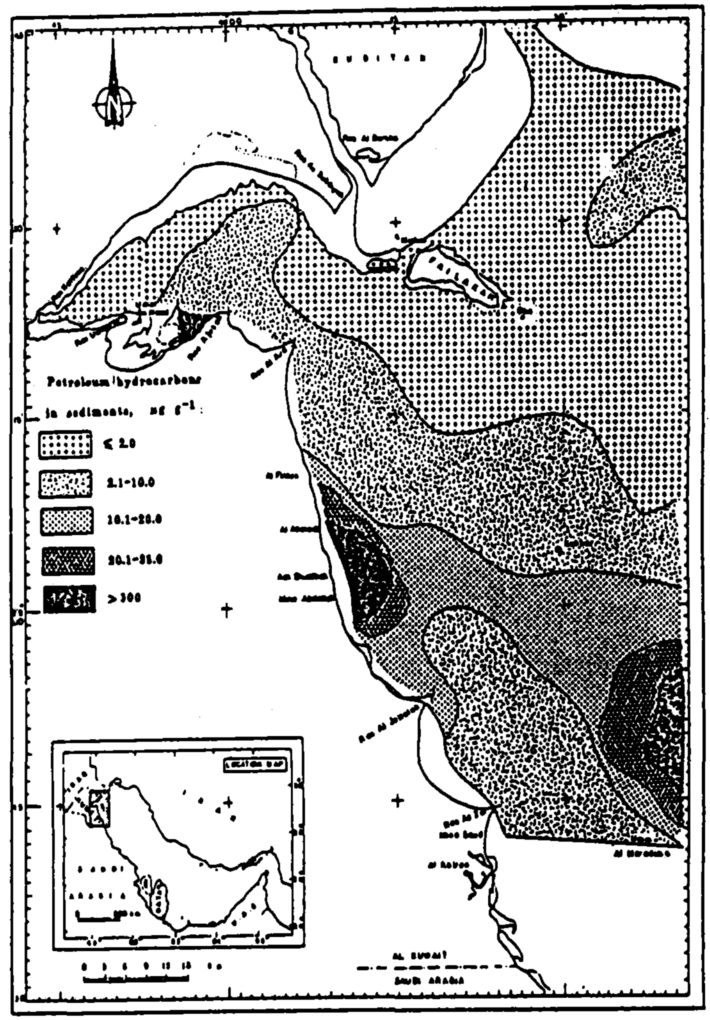

Figure 11. Spatial distribution of petroleum residues in marine sediments (after Zarba *et al*., 1985a).

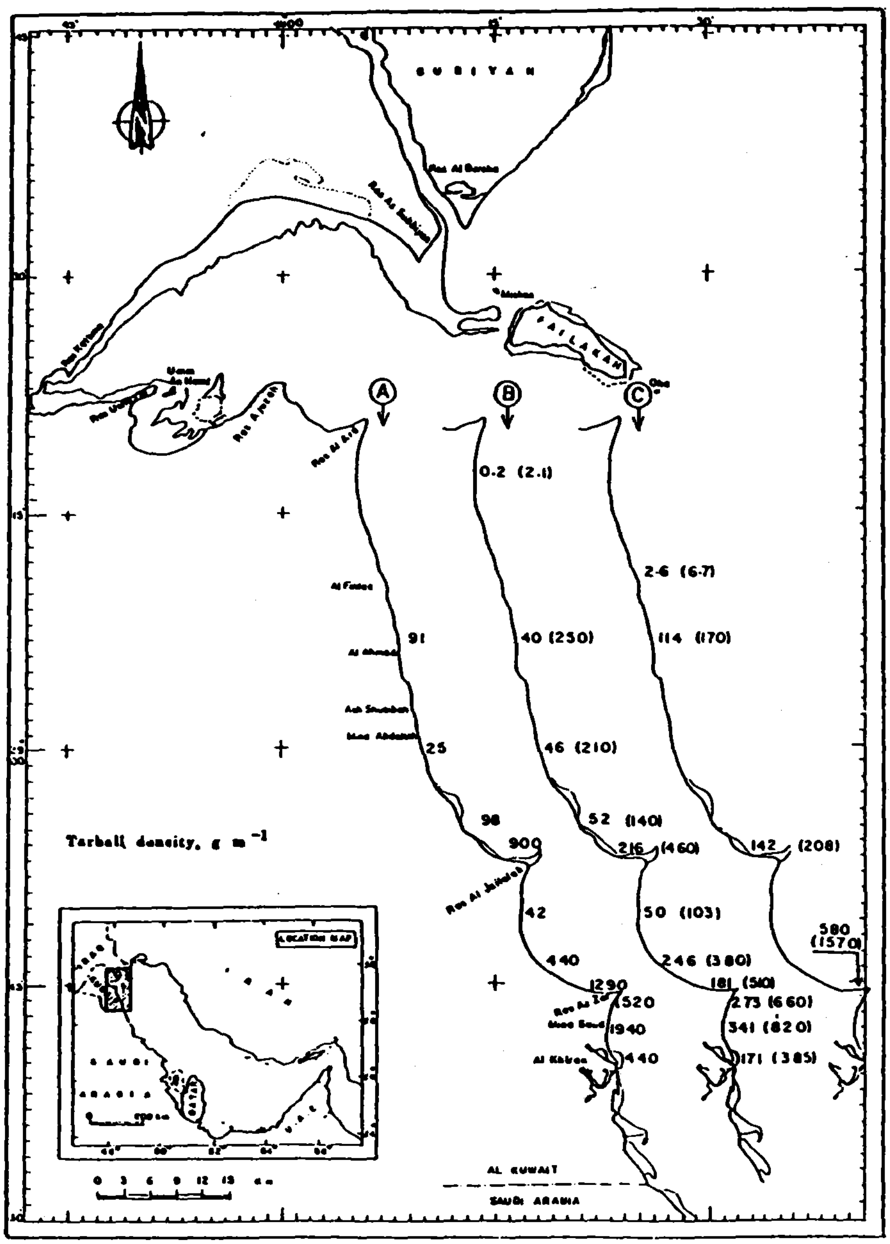

Figure 12. Distribution of tar ball density along the coastline of Kuwait: (A) Anderlini and Al-Harmi (1979), (B) Anderlini <u>et</u> <u>al</u>., (1981a), (C) Literathy <u>et</u> <u>al</u>.,

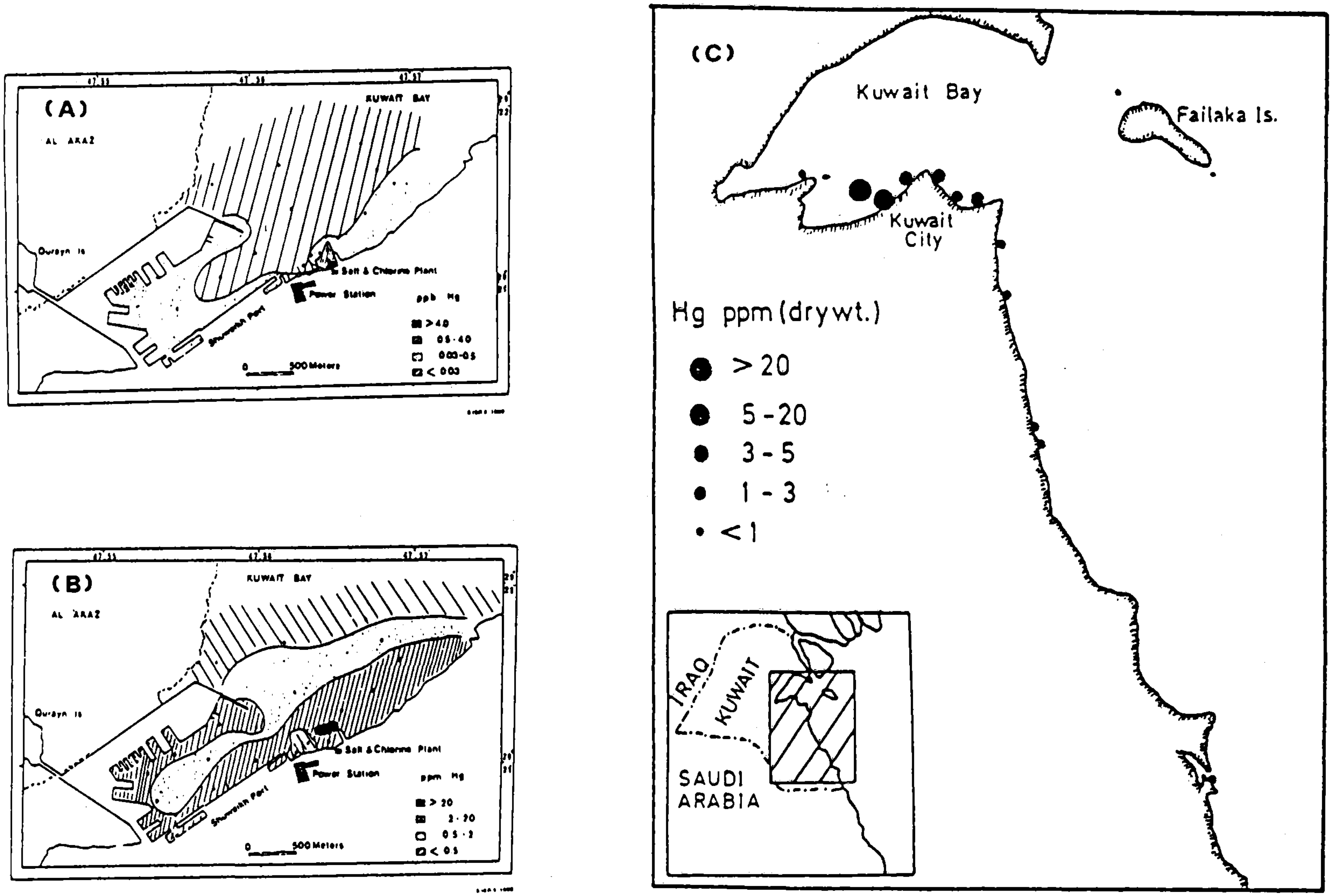

Figure 13. Distribution of mercury in (A) seawater and (B) marine sediments at Shuwaikh and (C) in clams along the coastline of Kuwait (A, B, after Zarba et al., 1981; C, after Anderlini et al., 1982).

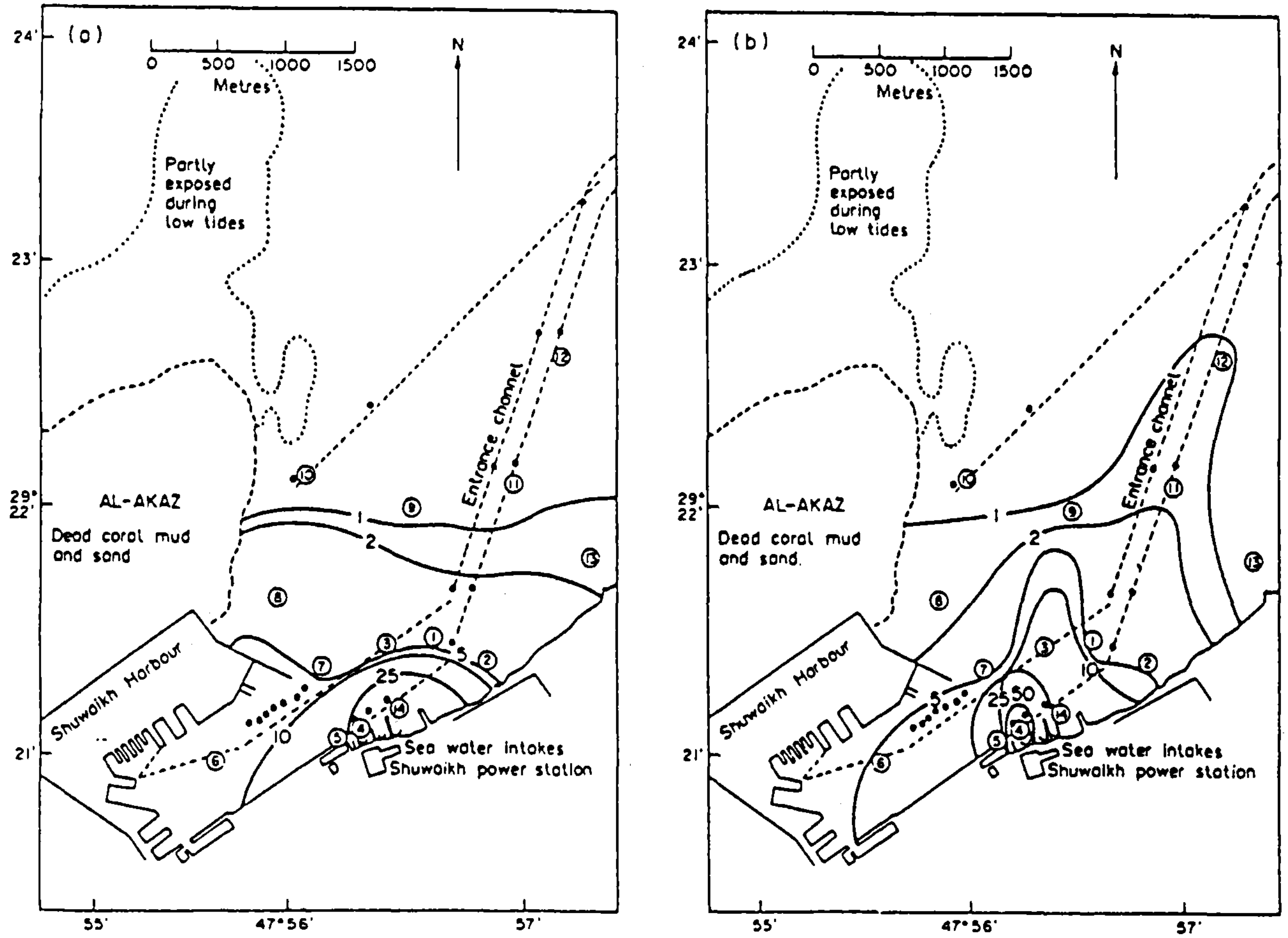

Figure 14. Distribution of halomethanes ($\mu g\ l^{-1}$) in seawater off Shuwaikh during the ebb (a) and flood (b) phases of the tide (after Ali and Riley, 1986).

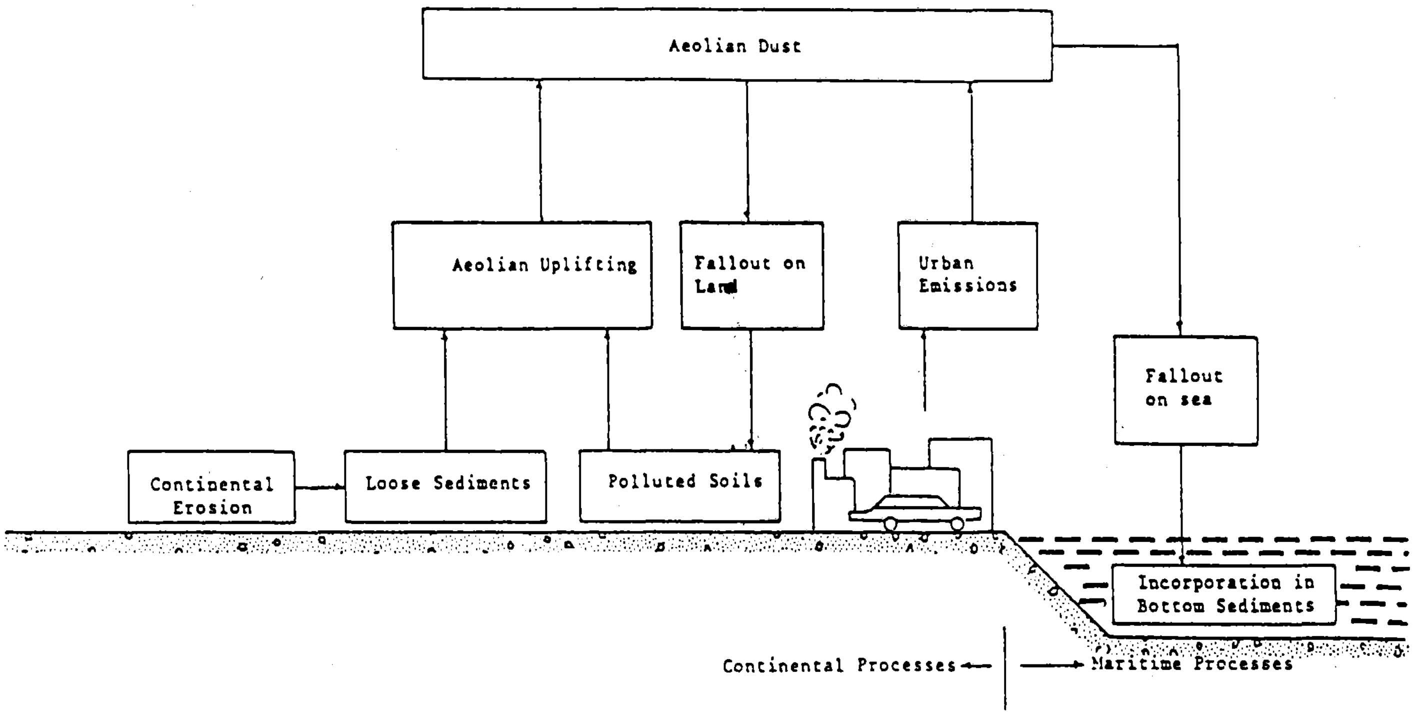

Figure 15. Processes affecting the aeolian transport of natural and anthropogenic particulate matter from terrestrial to marine environments (after Samhan et al., 1986b).

pre-contaminated soils from the urban and industrial centers of Kuwait to the marine environment. Contaminants in these soils may be derived from a variety of sources, for example, lead from car exhaust emissions. Levels of lead in local soils have been found to be higher in the immediate proximity of a busy street than in soils only a few meters away (Zarba et al, 1985b). However, lead and other pollutants may also enter the marine environment from more distant sources, for example, pesticides from agricultural lands in the Mesopotamian region.

EFFECTS OF EXISTING CONDITIONS ON FUTURE DEVELOPMENTS

The basic environmental requirements of coastal developments may vary. Offshore aquaculture, for instance, requires sufficiently deep water, good water quality, and reasonably strong currents. A power plant requires a large quantity of influent seawater, efficient water circulation patterns, and remoteness from certain sources of pollution, for example, oil spills. A recreational beach should be clear of tar balls, odors, floating garbage, pathogenic organisms, or toxic substances. Therefore, decisions regarding the siting of these or other activities should take into consideration both the basic environmental characteristics of the area and the distribution of human density and activities along the coastline.

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SESSION II

CHARACTERISTICS OF MANGROVES, CORAL REEFS, ESTUARIES, ISLAND ECOSYSTEMS AND OTHER CRITICAL HABITATS

CHARACTERISTICS AND ASSESSMENT OF CRITICAL AND OTHER MARINE HABITATS IN THE ROPME SEA AREA AND THE RED SEA

by

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ABSTRACT

This paper considers aspects of recent marine habitat surveys, particularly in the ROPME Sea Area of Saudi Arabia, as well as in the Saudi Arabian Red Sea. Emphasis is given to the range of methods used to characterise different habitats, from the use of Thematic Mapper (TM) satellite imagery to quantitative in-situ observations on habitat biota. Included are semi-quantitative techniques, whose value is becoming increasingly recognized as a means of assessing extensive tracts of coastal habitat. Selected results on habitat characteristics and distribution are also given to illustrate the methodology used. In addition, the use of habitat and other resource information in coastal planning and management is highlighted, and includes a brief discussion of databases and habitat maps. The paper is concluded by consideration of habitat ecology, particularly those aspects which are of relevance to coastal management.

INTRODUCTION

Countries bordering the ROPME Sea Area and Red Sea value development as a means of enhancing the prosperity, dignity and well-being of their people. Managed development and environmental planning are seen as the approach for the future, and are among the key elements of ongoing national and regional development plans. Within this context, maintenance of coastal and marine resources is of fundamental importance not only to coastal people, but to virtually the entire population of the region. Fishery products and drinking water from desalination plants are but two examples of renewable resources that are of major significance to coastal and inland people alike. In addition, the coastal environment is now of very great recreational value. These and other renewable coastal and marine resources can be utilised or enjoyed from one year to the next only if managed on a sustainable basis, for example in the context of a national or regional coastal zone management programme.

Marine habitats occupy virtually the entire intertidal and subtidal zones of a coastal area. Together with their associated plant and animal species, habitats provide a renewable resource base of appreciable diversity and value. Knowledge of marine habitats is therefore of fundamental importance to coastal resource management (IUCN, 1980; Salm and Clark, 1984). As such, habitats can be usefully regarded as ecological 'foundation stones'. All coastal and marine

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species depend ultimately on habitats for their occurrence. Habitats and associated biota are often termed biotopes, which interact with one another to form integrated ecosystems.

Certain coastal and marine habitats are considered to be 'critical' (IUCN, 1976), and may be more important than others in sustaining the renewable nature of natural resources. Examples of critical marine habitats are mangroves and other coastal vegetation, coral reefs and seagrass beds. The attributes of critical habitats include: high productivity, or a source of nutrients and productivity for adjacent areas; areas particularly rich in species and areas essential for conservational interest, and areas of special scientific interest.

During resource assessment studies, attention often focuses on critical marine habitats. However, all habitats and species must contribute in some way to the overall integrity of a region, such as the ROPME Sea Area, or the Red Sea. Future research may well reveal some ecological or other value of the seemingly less 'critical' habitats (e.g. sand beaches, subtidal and mud and even artificial structures). Accordingly, these resources should not be completely disregarded, misutilised or destroyed, but instead safeguarded for possible future use.

This paper aims to summarise aspects of recent studies conducted on critical and other marine habitats in Saudi Arabia, principally in the ROPME Sea Area (IUCN, 1987a; Price et al., 1987a), but also in the Red Sea (Dawson Shepherd and Ormond, 1987, IUCN, 1987). The information presented here is based principally on these works. Emphasis is given to the methodology used to assess and characterise the different habitats.

The information obtained on habitats (and other coastal resources) provides the context and setting for identifying conflicts and compatibilities between the various resources (e.g. habitats) and resource uses (e.g. fishing, ports and urban developments). In this way, managers and decision makers can identify key areas, issues and priorities for planning and management. The investigations were undertaken by the Meteorology and Environmental Protection Administration (MEPA) of Saudi Arabia in collaboration with the International Union for Conservation of Nature and Natural Resources (IUCN) and consultants from York University's Tropical Marine Research Unit (TMRU). Together, they form the basis of an overall National Coastal Zone Management Programme for Saudi Arabia (MEPA/IUCN, in preparation).

RESULTS AND DISCUSSION

Summarised below are some of the methods used to assess and characterise shallow water habitats during recent studies in the ROPME Sea Area and the Red Sea. Consideration is also given to the overall approach. The results of the study are not given in detail, except as a means of illustrating the survey methodology.

Biophysical features of habitats

Overall Approach

Habitat assessment and characterisation represent one component, usually the initial phase, of coastal zone management assessment. It is increasingly recognized that coastal zone management is most effective when undertaken by a multi-disciplinary team. The tasks of the marine biologist assessing marine habitats and associated resources therefore need to be carefully co-ordinated and integrated with the activities of other team members, such as the fisheries specialist, ornithologist, coastal planner and any other personnel.

Ground-truth

The nature, distribution and abundance of habitats was determined using several methods, following the general guidelines of ROPME (1983). Initially, LANDSAT 5 Thematic Mapper (TM) was used in the ROPME Sea Area for obtaining a synoptic overview of subtidal habitats. The use of TM imagery represented a major advance over most earlier studies. It was particularly valuable as aerial photographs for the region are not generally available. Preliminary ground-truthing was undertaken during helicopter overflights. On both coasts, virtually the entire shoreline was inspected and further ground-truthed using a 4-wheel drive vehicle. In addition, data on habitat abundance (and associated species and impacts) were collected from the intertidal and shallow subtidal zones at selected sites. Spot dives and transects were undertaken offshore to confirm, clarify or distinguish benthic habitat types and boundaries are recognized from the TM imagery and during coastal overflights. The methodology used for recording habitat abundance is discussed further below.

Habitats were classified and characterised according to their main biophysical features. Physical features recorded included substratum type (e.g. rock, sand, mud, coral, seagrass) and details of the shore profile at intertidal sites. In mangrove areas, for example, knowledge of substratum type (e.g. mud or rock/coral) has great significance to the ecology and mangrove communities (Por and Dor, 1984; Price et al., 1987b). Biological features used for classifying the habitats were just the major characteristic groups/organisms, while detailed taxonomic surveys were not attempted. Details of the different habitats were mapped on Admiralty and other charts, and also recorded on data sheets (see below). In addition, the nature and magnitude of impacts and threats to habitats were also recorded at each site (see Dawson Shepherd and Ormond, 1987; Price et al., in press), but are not considered in the present review.

Sampling was undertaken at up to three or more levels of intensity, as indicated below.

(i) Semi-quantitative shore site observations

At every site visited, semi-quantitative observations were made in a 'site inspection quadrat' on habitat abundance, associated species (and impacts). Each quadrat comprised an area 500 m x 500 m bisecting the beach, thereby covering both the intertidal and shallow subtidal zones. Within each sample area of 250,000 m2 (500 m x 500 m), the abundance of habitats and associated dominant biota was recorded using a semi-logarithmic scale (0-6) as follows:

Abundance Score (semi-log scale)	Areal Extent (m^2) : Habitat or No. of Individuals : Associated Biota (equivalent arithmetic range)
0	0
1	1-9
2	10-99
3	100-999
4	1000-29999
5	30000-99999
6	100000+

An example of a completed sheet for the ROPME Sea Area is given in Annex 1. This presents information within the sample area on the physical features of each habitat, as well as details of the commoner species or species/groups. Habitats, biota and impacts outside the sample area are merely recorded as present (+) or absent (o). NR denotes no record. It will be noted that in addition to strictly marine species, details of animals such as birds were also recorded. Since many bird species are of conservational interest, much attention was given to this animal group, particularly in the ROPME Sea Area, where more detailed counts were made by ornithologists along the shore (e.g. intertidal flats). Detailed observations were undertaken to determine bird densities, particularly of waders, and their habitat preference. During the survey in the ROPME Sea Area, it was estimated that a quarter of a million waders winter in coastal habitats of Saudi Arabia, while for the whole ROPME Sea Area the number may be as high as 1-2 million. The survey similarly revealed that ROPME Sea Area provides the breeding area for a large part of the world population of Lesser crested terns.

(ii) Semi-quantitative underwater observations using REEFWATCH forms

Semi-quantitative observations on habitats containing coral reef were made and recorded on REEFWATCH forms (Annex 2). Observations include basic information on reef structure, diversity, quality and impacts, as well as details of reef fish diversity and abundance. The observations take about 15 minutes to complete. In addition to the main data sheet, additional data sheets can be completed for selected reef fauna (e.g. butterflyfish, triggerfish, pufferfish and sea urchins). Further details of the REEFWATCH scheme are available in the literature (Ormond et al., 1984).

(iii) Quantitative observations (intertidal and subtidal)

This method, orginally termed 'rapid study sites', involves quantitative observations taking several hours at each site (Ormond et al., 1984). During the present surveys, sampling of habitats and associated biota was undertaken along 100 m transects. In the case of mangroves, bush height and density were determined by recording the frequency of plants of different height classes along each transect to a distance of 5 m each side, i.e. in a band 100 m x 10 m. This provided information on mean height and density (number of plants per unit area). Larger surface biota (> 2 cm) associated with mangroves and other habitats, and particularly also biota not sampled within transects below, were recorded along each transect to a distance of 2.5 m each side, i.e. within a band 100 m x 5 m. Other surface fauna were collected at 10 m intervals along each transect from quadrats of 1 $(m)^2$ or, for smaller organisms, of $0.25(m)^2$ (see also Ormond et al., 1984; Price et al., 1987b). Only limited sampling of the infauna was undertaken. Coral reefs were assessed using these methods, and other techniques (Sheppard, 1985).

(iv) Detailed quantitative observations (intertidal and subtidal)

This method, originally termed 'detailed study sites', involves more intensive, quantitative observations along transects, taking about a week at each site (Ormond et al., 1984). The method was used in the Red Sea but not in the ROPME Sea Area (due to time constraints). Sampling was undertaken at several depths: 1 m, 1.5 m, 3.0 m, 6.0 m and 12.0 m in the case of coral reefs. In addition, all the transects were photographed in stereo and are currently being analysed. Stereo-photography greatly facilitates in situ identification of corals, and can be a valuable means of monitoring coral communities over time. In addition to corals and other habitats, associated invertebrates and fish were sampled in detail, again principally along transects. Based on these and other methods, considerable information is now available on coral reef communities, both in the Saudi Arabian Red Sea, (Roberts, 1985, 1986, Sheppard, 1985; Sheppard and Sheppard, 1987) and ROPME Sea area (Basson et al., 1977; Burchard, 1979; McCain et al., 1984).

Sampling strategies

The value of rapid, semi-quantitative methods for surveying extensive tracts of coastal habitats is becoming increasingly recognized in marine biological assessment work (Dawson Shepherd & Ormond, 1987; Price et al., in press). These methods are particularly useful when characterisation of habitats at a broad level is required (Price et al., in preparation). In this paper, inclusion is therefore made of semi-quantitative methods (i & ii above). While the more detailed quantitative methods [(iii) and (iv) above] clearly provide more information, for example on species abundance, such methods are at the same time more time-consuming.

Consequently, detailed quantitative sampling can only be undertaken at a limited number of (perhaps unrepresentative) sites. In practice, it is often found desirable to use a combination of semi-quantitative and quantitative methods depending on the specific objectives of the survey (Dawson Shepherd and Ormond, 1987; Price et al., in preparation).

Databases and maps

Site information on habitats and associated resources can readily form a computer data base. Such databases are not only of great ecological interest but also of considerable value to resource managers. The information can be used to assess the current environmental state and also to predict the likely effects of environmental changes. In addition, information from data bases can be easily summarised to provide, for example, an estimate of the extent (or abundance) of major intertidal and subtidal habitats. This is shown in Annex 3 for the ROPME Sea Area of Saudi Arabia. This kind of information is considered to be fundamental to coastal planning and management.

Information on habitats is particularly useful to planners when compiled on maps. Maps showing the distribution of particular habitats can of course be combined. For example, it might be desirable for coastal planners to determine the distribution and extent of all critical marine habitats (or other resources, e.g. fisheries), and to show their areas of concentration on a single map. Areas where these critical habitats (together) overlap with areas of heavy coastal use denote conflict areas, and these represent priority areas for management. Conversely, areas of little or no overlap between critical habitats and resource uses represent compatibilities. Accordingly, in the latter areas the need for management initiatives may not be quite so pressing. Information from maps can also be digitised and incorporated into a Geographical Information System (GIS).

ECOLOGICAL CONSIDERATIONS IN HABITAT ASSESSMENT

In addition to characterisation of habitats according general biophysical features (i.e. substrate type and associated species), certain aspects of habitat ecology were considered during the present investigations. Special emphasis was given to those aspects of ecology of likely relevance to management and planning, and are considered below.

Systems ecology and natural processes

Our appraisals of the coastal and marine habitats of Saudi Arabia have included a system approach (Mann, 1982), whereby habitats and associated resources were assessed in terms of the natural systems of the regions. By relating the distribution of habitats to the natural (physical and biological) processes that control their occurrence, portions of the coast can be managed within the context of each region as a whole. It is of great significance to management that natural processes, and hence habitats, can be modified by human activities. Financial or time constraints may preclude collection of detailed oceanographic data. Nevertheless, basic information on oceanographic conditions and natural processes is available for many regions in the literature. Such information can then be used to determine, if only in a general way, how the overall (eco)system functions, and how the different components (habitats) interact with each other. For example, it is known that the offshore islands in the ROPME Sea Area represent major nesting areas for several species of birds (terns) and turtles, in addition to supporting well-developed coral communities. From a management perspective, it is particularly significant that these islands are actually formed and sustained by calcium carbonate production from coral reefs. This graphically illustrates how a terrestrial environment can depend for its very survival on continued sustainability of a marine environment.

Habitat preference of selected organisms

A consequence of marine and coastal development is often degradation, or even complete loss of one or more different habitats (IUCN, 1980; IUCN/UNEP, 1985; Vousden and Price, 1985). For some developments and activities (e.g. building of ports) the choice of suitable area may be very limited, while for others (e.g. dredging, reclamation, effluent discharge) some choice of location may be available. Knowledge of habitat preference of animals is therefore of appreciable significance to coastal planners (Salm and Clark, 1984), particularly for species of known commercial, scientific or cultural importance. It is assumed that organisms occurring in several different habitats ("habitat generalists") are probably less vulnerable to the effects of disturbance to any single habitat than organisms inhabiting just one or a few habitats ("habitat specialists").

Data on the number of major habitats occupied by five selected groups of invertebrates and vertebrates were determined for the Saudi Arabian coast of the ROPME Sea Area. The total number of habitats available is assumed to be eleven. The groups were chosen on the basis of their known ecological, commercial, cultural or conservational importance. Organisms associated with a broad spectrum of habitats ("habitat specialists") include pearl oysters (7 habitats), commercial shrimp (6 habitats) and the brittlestar, Ophiothrix savignyi (9 habitats). Organisms recorded in fewer biotopes, and therefore probably more vulnerable to the consequences of biotope degradation, include the lobster, Thenus orientalis (2 habitats) and dugong, Dugong dugon (2 habitats).

Of major significance, however, is whether or not certain habitats are critical at some stage of an organism's life cycle. In the case of pearl oysters, grassbeds have been shown to be the preferred substratum for attachment of spat in Saudi Arabian waters (Basson et al., 1977). However, recent studies in Bahrain (Vousden et al., in preparation) have shown that pearl oyster spat may settle on certain macroalgae (e.g. Hormophysa triquetra). This suggests that pearl oysters may not be such 'habitat specialists' as had previously been assumed.

The degree of dependency of juvenile commercial shrimp (Penaeus semisulcatus) on seagrasses is also not completely resolved. The earliest benthic juvenile stages have been found in thickets of macroalgae (Hormophysa and Sargassum), both in the Saudi Arabian part of the ROPME Sea Area and further north in Kuwait. In Saudi Arabian waters, older juveniles are no longer found among macroalgae but in seagrasses, whereas in Kuwait seagrasses are only of limited occurrence. This suggests that the Kuwait populations may be able to complete their life cycles without the need of seagrass: in this sense, therefore, seagrass seems not to be a critical habitat. Alternatively, juveniles in Kuwait may perhaps be transported by water movements to the northern Saudi Arabian waters where some fairly extensive seagrass beds occur, suggesting that seagrasses could be important.

In summary, consideration of habitat preference of organisms can provide useful information for planners. However, some caution must be exercised in interpreting results, since certain habitats are thought to be critical in the life cycles of some "habitat generalists" (IUCN, 1976; IUCN, 1980; Salm and Clark, 1984; IUCN/UNEP, 1985; Price et al., 1987a).

Similarity of habitats according to species composition

Knowledge of the similarity of habitats is also valuable to coastal planners, particularly if a system of priority needs to be established for habitat conservation. For example, if open rock beaches and rock tidal flats are very similar habitats, the need for active conservation of both habitats will probably be less important than if each habitat supports very distinctive biological assemblages. Again, however, factors other than species composition (e.g. food, shelter) may assume ecological importance and characterise habitats in some way.

The similarity and relationships of the various major habitats in the ROPME Sea Area of Saudi Arabia have been compared by means of cluster analysis on the extensive species composition data available (Basson et al., 1977). According to the analysis using Ward's method (presence-absence data), the habitats fall into a number of more or less distinctive clusters (Price et al., 1987a). Cluster I consists of all sedimentary intertidal habitats, with mud flats and sand flats showing greatest affinity. Cluster II is represented by several hard-bottomed habitats (rock beach, subtidal rock, artificial structures and possibly also rock flats). Cluster III constitutes a single habitat, coral reef, and appears to support a fairly distinctive assemblage. The remaining cluster (IV) is made up of all sedimentary subtidal habitats, including seagrasses. These form another, but less distinctive grouping. Greatest habitat similarity within this cluster is shown between subtidal sand and subtidal mud.

From a management and scientific perspective, it would be valuable to determine whether or not each of the major clusters above forms a functional grouping, or perhaps even a useful management unit. However, this idea cannot easily be tested due to lack of certain data, such as more detailed productivity estimates and measurements of nutrient fluxes.

Other ecological considerations

During present surveys, it was recognized that certain coastal and marine areas may, either immediately or subsequently, need to be considered as candidate sites for special management or protection. Such sites were selected using a number of objectives and criteria as indicated below:

(i) Areas that are the finest examples of the region's coastal and marine habitats or other outstanding natural features according to diversity, naturalness, uniqueness, representativeness, integrity and significance.

(ii) Areas that are critical to species of economic, conservational, scientific or cultural importance according to importance to species, dependence of species and productivity.

(iii) Areas considered to be of greatest value in maintenance of ecological processes and biological productivity and overall importance of role in a biotope or ecosystem. It will be seen that these and the above-mentioned criteria match very closely the attributes of critical marine habitats. In addition, there are numerous other factors, such as economic and social considerations; for example, the degree and nature of threats from human activities, public need, competing uses for the area, the size and availability of the area and public acceptance of the proposed area. Further details of the factors needing consideration in selection of protected areas are available in the literature (e.g. Salm and Clark, 1984; Usher, 1986).

ACKNOWLEDGEMENTS

The information presented here represents the results of work undertaken by the Meteorology and Environmental Protection Administration (MEPA) of Saudi Arabia in collaboration with the International Union for Conservation of Nature and Natural Resources (IUCN), Switzerland, and consultants principally from York University's Tropical Marine Research Unit (TMRU), UK. Thanks are also due to the input from other consultants involved on the projects, in particular James Dobbin Associates at Alexandria, USA. Enhancement of the Thematic Mapper (IM) imagery used on the ROPME Sea Area project was undertaken at UNEP/GRID in Geneva, Switzerland, whose staff are also acknowledged with thanks.

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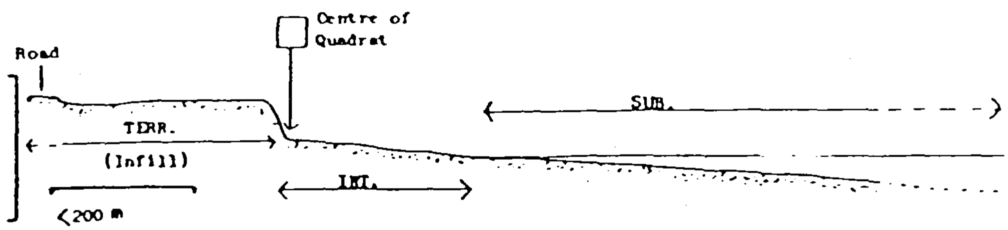
Annex 1. Example of data collected at site inspection quadrat during survey of Saudi Arabian coast of ROPME Sea Area.

SITE INFORMATION

Latitude	Longitude	Source	Nearest name on map/chart	Sector Code	SAGS/1
AP/TV Researcher	Details of Location			Date Code	860201A

PROFILE

TERRESTRIAL: Rubble/sand infill extending 250m from road to intertidal; halophytes;
SUPRALITTORAL: Absent;
INTERTIDAL: Very gently sloping anoxic mud extending 200+m; algae; seagrass; invertebrates;
SUBLITTORAL: /*/ very gently sloping sandy mud, depth <1m, 250m from shore; int./sub. boundary not obvious; algae; invertebrates.



FLORA	Mangroves	0		0
	Seagrass	+	INT: (2) H. UNINERVIS litter (+); drifting H. OVALIS (1).	0
	Halophytes	3	Sparse, covering infill 2 dom. spp. (3); /*/ continuing to road.	+
	Algae	6	INT: thick blue-green algal mat (6), also filamentous greens (3); INT/SUB: extensive blue-green mat (3); ENTEROMORPHA SP. (2) and other greens (+) /*/ continuing outside quadrat.	+
	Freshwater vegetation	0	/*/ small palm trees lining corniche road.	+
	Other	NR		NR
FAUNA	Reefs and corals	0		0
	Birds	+	200+ gulls (3); 200+ small waders (3); 300+ flamingo (3).	+
	Turtles	0		0
	Mammals	0		0
	Fish	0		0
	Invertebrates	+	INT: CERITHIDEA CINGULATA (5); CERITHIUM SCABRIDIUM (5) dom. SUB: as for int.; also hermit crabs in cerithid shells (5); bivalve (?CIRCE SP.) (860201A/2) mostly dead.	+
	Other	NR		NR
IMPACTS	Construction	+	Infilled pier (+); extensive landfill (+) /*/ continuing to N and S, especially to N; /*/ corniche road to N.	+
	Fishing/ Collecting	0	/*/ locals seen collecting halophytes.	+
	Pollution	+	(0) beach oil (d); (5) human litter, scrap iron, tyres etc. (+); (?) wood litter (+); sewer outlet under pier (+) probably responsible for large bird population.	+
	Other	NR		NR
OTHER	Oceanography	+	Surf. temp. 21°C int. sub.; salinity 39‰ (N.B. diluting effect of sewage effluent).	+
	Meteorology	NR		NR
	Other	+	Sediment sample 860201A/1; sub. bivalves 860201A/2	+

<u>Annex 2</u>. **REEFWATCH form as used in survey along Saudi Arabian Red Sea coast.**

	REEFWATCH	Your Ref. No.

COUNTRY	REGION	LOCALITY	REEF	FACE N/E/S/W

LATITUDE			LONGTITUDE			DATE		
deg.	*min.*	*sec.*	*deg.*	*min.*	*sec.*	*day*	*month*	*year*

POSITION ACCURACY	*Completely certain*	*Fairly certain*	*Slightly uncertain*	*Very uncertain*

N? SKETCH LOCATION OF REEF — SCALE	N? SKETCH MAP OF REEF — SCALE

Sea Level

SKETCH PROFILE OF REEF

5m

10m

15m

20m

25m

30m

35m

metres

Estimate bottom depth	1–4	4–8	8–15	15–30	30–50	50–80	>80

Annex 2a. (cont'd)

DATA BASE NUMERICAL INDEX	1	2	3	4	5
Reef Typical	*Among best in area*	*Rather better*	*Typical*	*Rather worse*	*Can't tell*
Attractiveness	*Exceptional*	*Pretty good*	*Moderately good*	*Limited*	*Poor*
Dive Site Rating	*Exceptional*	*Pretty good*	*O.K.*	*Not much use*	*No use*
Hard Coral Cover	*>80*	*60–80*	*40–60*	*20–40*	*<20*
Coral Variety	*Exceptional >30*	*Good 20–30*	*Moderate 10–20*	*Limited 5–10*	*Poor 5*
Soft Coral Cover	*>80*	*60–80*	*40–60*	*20–40*	*<20*
Reef Fish Nos.	*Superabundant*	*Abundant*	*Numerous*	*A bit limited*	*Noticeably few*
Reef Fish Variety	*Incredibly varied*	*Pretty varied*	*Moderate variety*	*A bit limited*	*Noticeably few*
Pelagic Fish Nos.	*Very large nos.*	*Good no.*	*Some*	*Few*	*None*

POLLUTION DAMAGE	*Fishing*	*Spear-fishing*	*Diving*	*Shell collect-ing*	*Broken coral*	*Dead coral*	*Oil slick*	*Beach oil*	*Sedi-ment*	*Sewage waste*
None 1										
Possible/little 2										
Definite/some 3										
Moderate 4										
Extensive/severe 5										

ADDITIONAL COMMENTS

NAME(S)	ADDRESS TELEPHONE

Annex 3. Estimated linear and areal extent of intertidal and subtidal habitats along the Saudi Arabian coast of the ROPME sea area.

Habitat	Extent			
	Linear (km)	Linear (%)	Areal (km^2)	Area (%)
A. INTERTIDAL				
Sand or sand/ rock beach	433	40	5	2
Sand/mud beach	144	13	7	3
Mud flat	84	8	36	18
Mangroves	12	1	4	2
Sand/mud flat	109	10	86	42
Rock flat with sand	190	18	26	13
Rock flat with sand/mud	51	5	4	2
Sand flat	49	5	35	17
TOTAL	1,072	100	203	99
B. SUBTIDAL				
Sand/mud			27,500	95
Seagrass			370	1
Reef corals			390	1
Rock/Algal			700	2
TOTAL			28,960	19

(Note: The linear and areal extent of saltmarsh halophytes was not estimated directly, although this vegetation was recorded at 72% of the shore sites visited).

THE CORAL REEFS AND CORAL ISLANDS OF KUWAIT

by

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ABSTRACT

Kuwait's coral community is a low diversity coral assemblage existing in a healthy, albeit extreme environment. Marked seasonal variations of the environmental characteristics include water temperature change between 13.2°C in winter and 33.8°C in summer. Indigenous coral reef fishes comprise many commercially important species. Sea terns and turtles visit some of the coral islands for breeding. A complete and effective protection of the coral reefs of Kuwait as a unique and rich living resource to the nation, may be realized by overcoming the obstacles which may hinder their conservation. The general lack of awareness and education on the coral reefs and their associated island ecosystem is considered the main obstacle, which should be dealt with as an integral part of a carefully planned coral reef protection and management scheme.

INTRODUCTION

The coral reefs and coral islands of Kuwait occur in the northwest sector of the ROPME Sea Area. Although they are small by comparison to the coral reef systems which occur further south, they represent the most northern regional development of reef corals and are thus of interest not only to Kuwait, but also to other nations bordering the Area.

The Kuwait Institute for Scientific Research (KISR) has just completed a four year study on Kuwait's coral reefs. This included: an assessment of the species of corals making up the reefs; accurate bathymetric charting of the three major reefs surrounding the islands of Kubbar, Qaru and Umm Al Maradem; production of charts showing the distribution of the various corals on the reefs, collection and identification of all species of coral reef fishes, together with detailed photographic documentation; a study of the seasonal variation in species composition and number of fishes found on the reefs over a period of two years; a study of the quality of the reef environment over a similar period of time. This work has been published by KISR in a five volume series (Downing, 1987a,b,c; Downing et al., 1987; and Literathy et al., 1987). Two papers have been published externally (Downing, 1985; Downing and El-Zahr, 1987), and several others are in preparation. This paper is based on the summary of the work (Downing 1987a), with additional comments on the status of the sea terns and turtles which visit some of the coral islands to breed.

THE CORAL COMMUNITY

Three well developed coral islands and their associated reefs exist in Kuwait's waters. They are Kubbar, Qaru and Umm Al Maradem. A number of smaller, platform reefs are variously located both close to shore and at the southern and eastern extent of Kuwait's territorial waters. Kubbar Island, (Lat. 29° 04' 10"N; Long 48° 30' 24" E) is the northernmost coral reef development of any significance in the northwestern part of the ROPME Sea Area.

Kuwait's coral community is a low diversity coral assemblage existing in an extreme environment. A total of 29 species of scleractinia have been identified in 31 genera. One species, Turbinaria frondens, is a new record for the Gulf. The coral community is dominated by the genus Porites, particularly on the reef flat, and the genus Acropora.

It has been observed that the reef flat, which comprises by far the most extensive area, dries out periodically at very low spring tides. When this coincides with low air temperatures the exposed corals will die from chilling. Such an event was monitored during the late winter/early spring of 1985. The reefs are very vulnerable at this period of drying, and would be susceptible to contamination by surface-borne pollutants such as oil.

Large areas of the reef flat Porites are dead, and heavily colonized by the rock-boring sea urchin, Echinometra mathaei. Work was undertaken on the feeding rate of Echinometra which erodes the dead coral surface as it feeds. Over 90% of the urchin's gut contents is coral derived $CaCO_3$, and the rate of ingestion of material is almost one order of magnitude greater than reported elsewhere. The feeding behaviour of Echinometra is likely to reduce the chances of successful coral larval settlement. There is no obvious control on the numbers of urchins, whose density can exceed $100/m^2$.

Reef recovery has been monitored over a four year period. For fast growing species such as Acropora significant recovery has been observed over three years.

For slow growing massive, corals such as Porites the recovery has been obscured by the 1985 coral kill, and is likely to take much longer.

An accurate and detailed hydrographic survey of the seabed, from the reef edge to the island; of the three major reefs (Kubbar, Umm Al Maradem and Qaru) was undertaken. Using a Mini-Ranger Position Fixer with a positional accuracy of + 2 m probable error, it provided precise information on the extent of each reef and its topography. This was combined with data on the types of corals making up the reefs. Charts for each island and its reef have been produced on B1 size sheets, at scales of 1:2000 (Qaru and Umm Al Maradem and 1:2500 (Kubbar).

THE CORAL REEF FISHES

A total of 119 species of fish have been identified from Kuwait's coral reefs, of which 8 species are new records for the Gulf, and 47 species new records for Kuwait. Based on the list published by Kuronuma and Abe (1986), the contribution of the reef fish species to the total number reported from Kuwait is in excess of 50%.

Fish censuses were carried out over a two year period at two locations on each of the main reefs (Kubbar, Qaru and Umm Al Maradem). A marked seasonal fluctuation was observed, with a dramatic increase in the number of fish over the spring and summer months.

The reefs support a number of commercially important species. They are found in the following families: Synodontidae, Serranidae, Carangidae, Lutjanidae, Caesionidae, Sparidae, Bothidae, Rachycentridae, Pomacanthidae, Siganidae, and Scombridae. The most commonly found grouper of the reefs is the shnainew, *Cephalopholis hemistiktos*. The hamoor, *Epinephelus suillus*, is not particularly common. It is more likely to be attracted to artificial reef structures (Downing *et al*. 1985).

A number of species of fish, some of them of commercial importance, use the reefs on a seasonal basis as a breeding ground. Much of the increase in number during the spring and summer appears to be related to the increased breeding activity.

THE REEF ENVIRONMENT

A water and sediment sampling was carried out over a two year period to study the environment in which Kuwait's coral reefs exist, and to provide baseline data on its quality.

Samples were collected over and around five reefs: an inshore platform reef, Qit'at Urayfijan, an offshore platform reef, Mudayrah Reef, and the three major coral reefs, Kubbar, Qaru and Umm Al Maradem. Samples were taken from the reef edge and the reef flat, both from the surface and the bottom. In addition, the reef at Qit'at Urayfijan was sampled during a tidal cycle once each quarter.

The parameters determined in the water column were: temperature, salinity, turbidity, orthophosphate, ammonia, nitrate, silicate, suspended particulate matter and petroleum hydrocarbons. Surface sediment samples were analyzed for total phosphate and nitrate, carbonates and petroleum hydrocarbons.

Generally speaking, the results indicate a healthy, albeit extreme marine environment over and around the reefs. Temperature, salinity and orthophosphate values show seasonal variations. A reef base temperature of 13.2°C was measured in March 1985, and a maximum of 33.8°C was measured on the reef flat in August 1986. The water is always hypersaline. Turbidity has been observed to fluctuate by an order of magnitude and suspended solids were highest around the reef at Qit'at.

The Qita reef is also more influenced by nearshore water and waste discharges. The other reefs are in an offshore zone, controlled by open sea conditions. Based on observations during tidal cycles around the Qita reef, an anthropogenic effect was detected in the variation in concentration of ammonia.

Petroleum hydrocarbons were detected at low concentrations in both the water and sediment around the reefs.

THE SEA TERNS

Four species of sea tern breed each year on Kubbar Island. They are: *Sterna anaethetus*, *S. bengalensis*, *S. bergii* and *S. repressa*. Neither Qaru nor Umm Al Maradem have been used as breeding areas in recent years. The numbers of these terns visiting the Kubbar each year have increased over the past four years, from 1,211 birds in 1984 to 2,648 birds in 1987 (all species, chicks included).

The terns breed at the height of the summer. Protection of the eggs and chicks from the high ambient temperatures is essential to avoid heat stress. However, the parent birds are easily disturbed, and it has been established experimentally that the external temperature of eggs (S. repressa) exposed to the sun at mid-day will increase by approximately 1°C/minute over the first 7 minutes of exposure.

Although there is no evidence of egg collecting, spent shot gun cartridges are often found, together with dead birds, on the island.

THE SEA TURTLES

Qaru Island is the only coral island in Kuwait's waters still regularly used as a breeding area for the green turtle (Chelonia mydas), and probably the hawksbill (Eretmochelys imbricata). The occasional nest is seen on Kubbar and Umm Al Maradem, and one juvenile green turtle was found on the beach south of Ras Az-Zour.

The number of green turtles using Qaru each year is small. Fifty pits were counted in 1984, and 21 in 1986. The island's remoteness probably contributes to the continued breeding activity there, but it is small (approximately 230m in length) and much of the area is taken up by huts and assorted debris. A "security" fence is now being built around the huts, and this will further restrict the area available for nesting.

RECOMMENDATIONS

The coral reefs of Kuwait are a unique, rich and diverse living resource to the nation. They exist in an environment which by most standards would be considered very marginal for coral reef growth. Any additional, man-induced pressure should be avoided.

The general recommendation is one of complete and effective protection.

There are three main obstacles which may hinder the conservation of a living resource:

1. **Dependency** - Those who make a living from the resource in question stand to lose in the short term, although they would benefit in the long term.

2. **Money** - Any well implemented conservation programme is likely to be costly.

3. **Ignorance** - Most people are unaware of the need to conserve a resource.

For the nations bordering the ROPME Sea Area only the last of these obstacles is of any significance. In Kuwait, no one depends on any of the reefs for their existence. Most fishermen who visit them do so as a past time. There are adequate funds available for even the most ambitious conservation requirements. However, most of the population is ignorant of the worth of the coral reefs and their associated islands as a rich and unique renewable living resource. This is true of all strata of society. Nevertheless, the general lack of awareness can be dealt with as an integral part of a carefully planned coral reef protection and management scheme. The role of education, at all levels of the society is crucial to the success of the conservation of Kuwait's coral reef and coral island ecosystem.

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PROTECTION, CONSERVATION AND REHABILITATION OF PHILIPPINE MANGROVE AREAS

by

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ABSTRACT

This paper discusses two major strategies the Philippine government has implemented in the recent past and is implementing at present as means of protecting and conserving the remaining mangrove forest and of rehabilitating degraded coastal and mangrove areas. These are: (1) establishment of mangrove wilderness areas and mangrove forest reserves and (2) afforestation-reforestation of critically degraded mangrove areas.

Mangrove wilderness areas (total of 4,326 hectares) are distributed in 52 small islands in Luzon (4 islands in 2 provinces), Visayas (31 islands in 3 provinces) and Mindanao (17 islands in 2 provinces). Mangrove forest reserves (total of 74,267 hectares) are distributed in 6 islands (Luzon, Masbate, Marinduque, Palawan, Visayas and Mindanao). Reforested-afforested mangrove areas (total of over 1,140 hectares) are located in Luzon (Quezon), Central Visayas (Negros Oriental, Cebu and Bohol) and Mindanao (Sulu and Basilan). Additional degraded areas are being planned to be afforested or reforested in the foreseeable future in 8 important sites: Manila Bay, Tayabas Bay, Lamon Bay and Ragay Gulf in Luzon; Cebu-Mactan, Inabangan-NW Bohol and SW Bohol in the Visayas; and Davao Gulf in Mindanao.

Also discussed are several biological stressors that have been found to affect the mangrove rehabilitation sites. These include (1) attack or infestation of seedlings by barnacles (in Bohol), oysters (in Bohol), Uca and Sesarma crabs (in Sulu), green alga (Enteromorpha) (in Cebu) and (2) attack or infestation of prop roots of adult mangrove plants by woodboring teredo (in Bohol) and of seeds by Poecilips fallax beetle (in Negros Oriental). Of these, infestation by barnacles and oysters is considered a major problem.

INTRODUCTION

Mangroves occupy a highly strategic position in the economy and ecology of not a few of the coastal areas of the Philippines. Economically, they have been, still are, and will be, to many coastal Filipinos, important as aquaculture or fishpond sites, source of forest products (poles and piles, fuelwood, charcoal, tanbark, nipa sap, thatching materials), as fry gathering grounds, sites for saltbeds, sustenance fisheries, commercial and industrial establishments, human settlements, agricultural farms and waste disposal. Ecologically, they are important in nearshore nutrient enrichment, as spawning, breeding, feeding and nursery grounds for economically important species of aquatic life, wildlife habitat and in shoreline stabilization and protection. However, rapidly increasing population growth and technological development over the years have contributed immensely to the intensification of the utilization of mangroves such as those stated above and concomitantly not to small degree of environmental degradation.

Brown and Fischer (1918) placed the area of mangrove swamp forest in the Philippines between 400,000 to 500,000 hectares (average 450,000). The more recent estimate (NRMC, 1978) placed the total mangrove area at 146,139 hectares (Table 1 (a), (b); Figure 1). Subtracting the 1918 estimate (450,000 hectares) from the 1978 estimate (146,139 hectares), the difference comes to about 303,861 hectares representing the deforested mangrove area over the past 65 years. In other words, 67.5% of the total mangrove area is denuded, while only 32.5% is now occupied by mangrove forest. Cabahug et. al. (1986) placed the rate of denudation at 6,321 hectares a year. A large portion of the denuded mangrove area (205,500 hectares) is not devoted to fishponds (Bureau of Fisheries and Aquatic Resources, 1984; Figure 2). It is for this reason that the conversion of mangrove swamps into capital-intensive brackishwater fishponds is considered the more controversial issue in mangrove econosystem management in the country. The increase in areal extent of fishponds and the concomitant decrease in areal extent of mangroves have caused a growing concern that further fishpond development may have negative ecological, economic, social and cultural impacts on the ecosystem of the nearshore waters of the country. Past national and international workshops, conferences, fora and symposia have arrived at a consensus that fishpond development have contributed to the decline in the yield of other mangrove products.

As indicated earlier, the mangrove ecosystem has other functions among which are energy export, nursery ground, breeding ground and feeding ground. All these are important for the maintenance of ecological stability of the ecosystem itself as well as to the surrounding nearshore ecosystems. For conversion uses to function, the developer must change to a great extent the mangroves from a natural to an artificial state. Of the conversion uses, aquaculture has the most potential, and hence, poses the greatest possible danger to the mangrove for area expansion. Once an area is converted into fishpond, it is no longer able to function as a natural system. Thus, as a hectare of fishpond is improved, the same hectare can no longer be counted on to contribute to the productivity of the nearshore ecosystem.

Thus, the continued reduction of mangrove forest area is expected to:

(1) exert a depressant effect on energy export which continues up the food chain to man, i.e., less nutrients means less algae, and less algae means less fish catch by the sustenance and commercial fisherman;

(2) decrease the area available for protection and nursery grounds for seed fish needed for stocking fishponds;

(3) decrease the yield per unit area in mariculture (oyster culture); and (4) expose the shoreline to the action of strong waves during inclement weather (The Philippines experiences an average of 19 typhoons a year).

STRATEGIES FOR PROTECTION, CONSERVATION AND REHABILITATION

In view of the foregoing, the government became greatly concerned and acted accordingly by formulating and implementing measures directed towards the protection and conservation of the remaining mangrove forest areas as well as the rehabilitation of the critically denuded mangrove areas of which the following are here discussed: (1) establishment of mangrove wilderness areas and mangrove reserve areas; (2) reforestation or afforestation of certain critically bare areas; and (3) implementation of other measures.

Table 1(a). Areal measurement summary of mangrove forests.*

	Mangroves (Pure Mangrove)	Low Density Logged-over
Region I		
Pangasinan	-	988.5
		988.5
Region II		
Cagayan	303.6	1,989.7
Isabela	343.4	38.0
	647.0	2,027.7
Region IV-A		
Quezon	5,948.1	2,824.3
Mindoro Or.	439.7	247.9
Mindoro Occ.	-	2,668.8
Palawan	25,934.8	151.1
Marinduque	1,764.3	-
Rombion	505.2	71.1
	34,592.1	5,963.2
Region V		
Camarines Norte	-	2,462.6
Camarines Sur	2,182.8	886.8
Albay	630.8	-
Sorsogon	1,084.0	1,510.5
Catanduanes	25.3	216.7
Masbate	6,191.2	1,086.6
	10,114.1	6,163.2
Region VI		
Capiz	-	2,382.0
Aklan	-	1,266.7
Iloilo	-	1,043.2
Negros Occ.	3,898.3	1,128.2
	3,898.3	5,820.2
Region VII		
Bohol	7,208.2	2,321.4
Negros Or.		811.6
	7,208.2	3,133.0
Region VIII		
Northern Samar	2,633.0	1,085.3

	Mangrove (Pure Mangrove)	Low Density Logged-over
Eastern Samar	190.5	78.7
Samar	8,476.6	1,424.3
Leyte	2,576.5	1,943.0
	13,876.6	4,531.3
Region IX-A		
Basilan	1,684.7	83.7
Sulu	25,171.5	10,754.0
	26,856.2	10,837.7
Region IX-B		
Zamboanga del Norte	596.8	504.4
Zamboanga del Sur	21,394.4	12,094.4
	21,991.2	12,598.8
Region X		
Misamis Or.	762.3	1,411.5
Misamis Occ.	6,745.8	5,671.7
Agusan del Norte	6,265.3	8,641.4
	13,773.4	10,724.6
Region XI		
Surigao	8,606.5	2,145.0
Davao	2,135.1	1,884.9
Davao Or.	-	248.4
Davao del Sur	-	1,498.3
Southern Cotabato	499.9	340.2
	11,241.5	6,116.8
Region XII		
Sultan Kudarat	272.8	1,059.1
Maguindanao	1,668.5	2,925.7
	1,941.3	3,984.8
TOTAL	146.139.9	71,720.8

*This does not include area covered with clouds.
Source: Mangrove Inventory of the Philippines Using Land-sat Data NRMC (1978).

Table 1(b). Estimates of areal extents of forested mangrove areas, denuded mangrove areas and annual rate of denudation of mangrove forest in the Philippines.

Year	Forested Area (Hectares)	(%)	Denuded Area (Hectares)	(%)	Annual Denudation Rate
1918a/	450,000	(100)			
1978b/	146,139	(032)	303,861	(068)	5,064
1983c/	126,171	(028)	323,829e/	(072)	4,982
1987d/	100,564	(022)	349,436	(078)	5,064

a/ Brown, W.H. and A.F. Fischer. (1918)
b/ Bina, R.T., R.S. Jara, B.R. de Jesus Jr., and E.N. Lorenzo (1978): 60 years from 1918
c/ Zamora, P.M. (1983): 65 years from 1918
d/ Howes, J.R. (1987): 70 years from 1918
e/ 205,500 hectares of 63.5% of 326,829 hectares of denuded area constitute

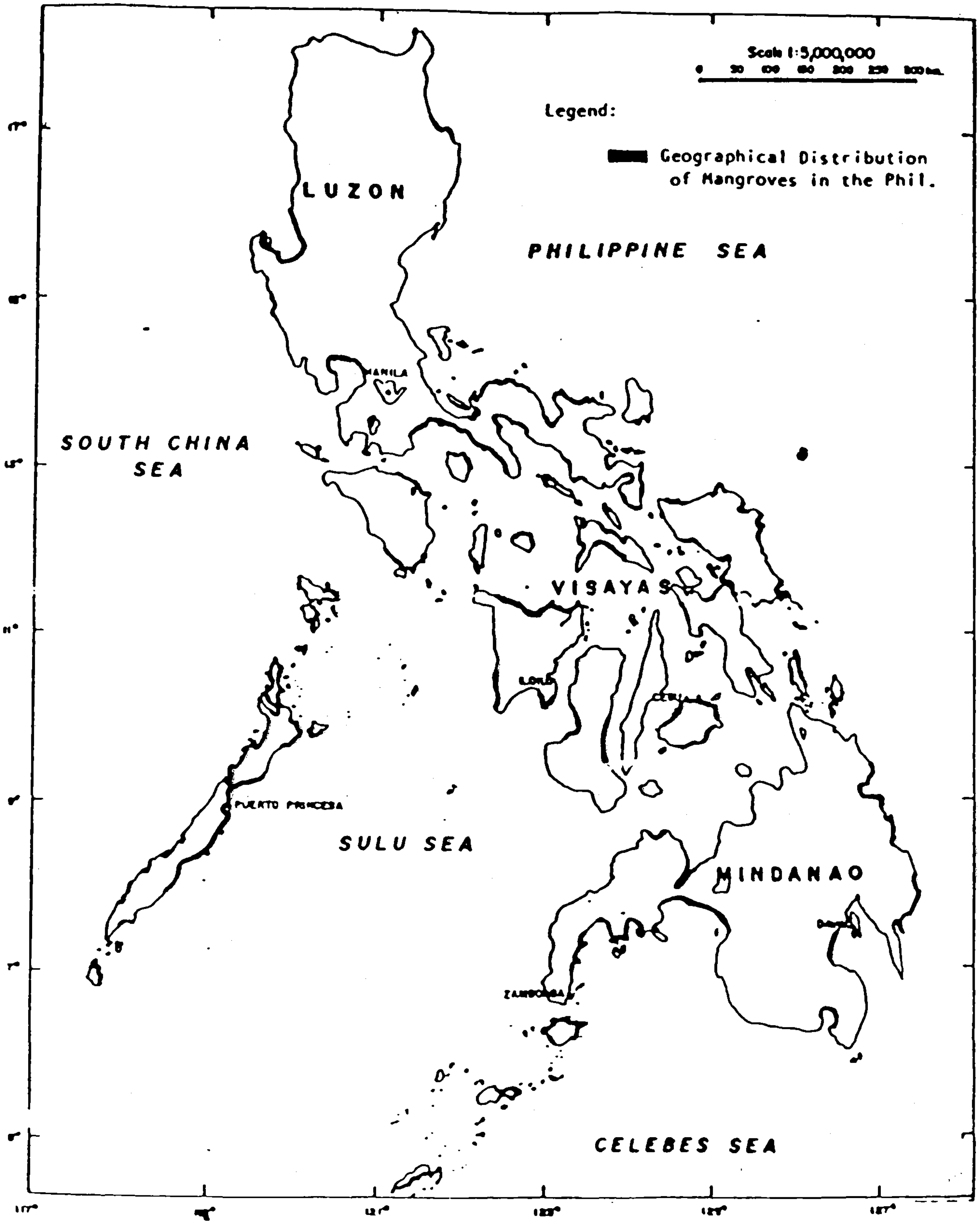

Figure 1. Geographical distribution of mangroves in the Philippines

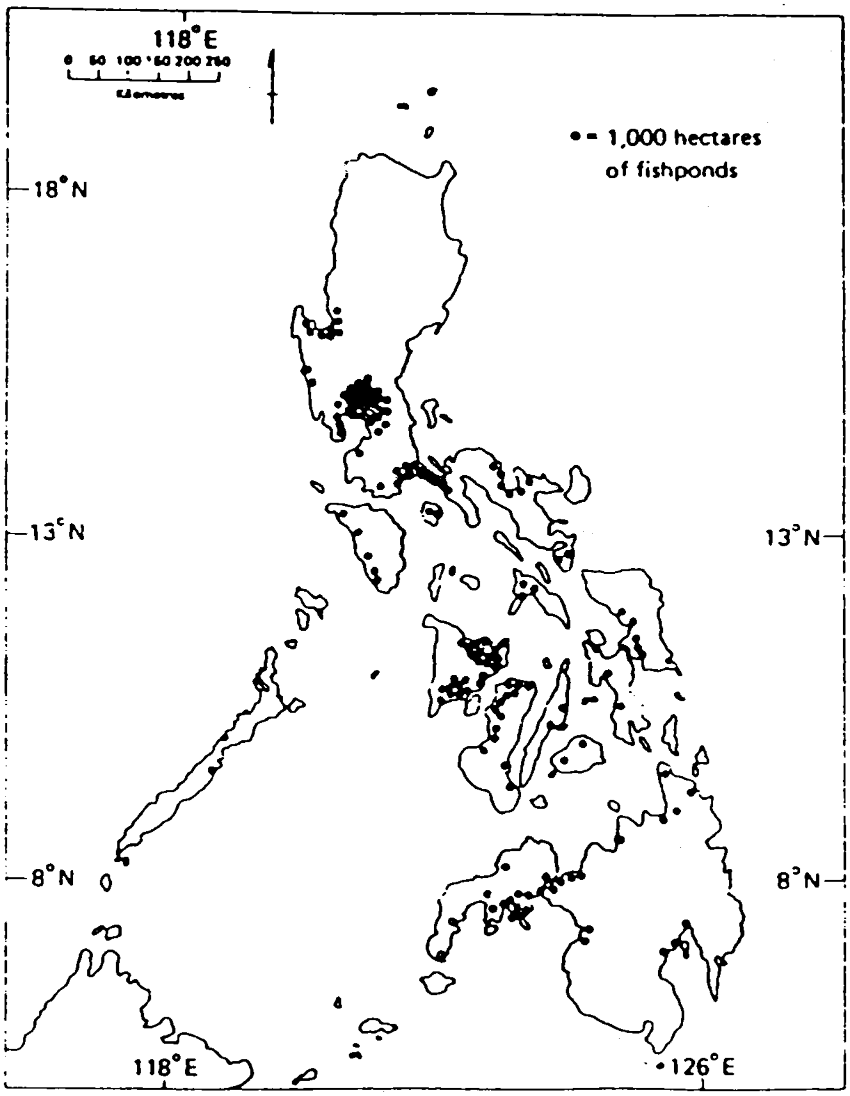

Figure 2. Distribution of fishponds in the Philippines
Source: Chong, Kee-Chai, I.R. Smith and M.S. Lizarondo. (1982)

Establishment of mangrove wilderness areas and mangrove forest reserves.

In 1979, the National Mangrove Committee (NMC) of the Philippines presented to the government two alternatives to consider in respect to mangrove protection, conservation, preservation and rehabilitation of mangrove areas (Figure 3).

Alternative 1. The government may suspend or declare a total ban on large-scale clear-cutting of mangrove forest for fishpond and regulate the dumping of industrial waste in areas occupied by mangrove forest. The salient features of the strategy are:

(1) the suspension should be implemented immediately;

(2) the suspension should be applied to all forested areas; and

(3) the suspension should continue in effect until such time as the necessary research has been evaluated and an allocation plan has been set up, a process that is estimated to last for 5-7 years.

Some interested sectors of society will undoubtedly object to the suspension of development option as economically feasible. However, few, if any, economic problems are anticipated. As the data suggest, logging has become less important annually since 1971; and if this trend continues, then there is almost no active logging in mangrove areas. That being the case, probably logging no longer has an economic interest in mangroves. Land reclamation involving mangrove swamps, while a convenience, is presently not a necessity yet. Also, the probable future cost of trying to keep the land from returning to the sea makes reclamation a questionable mode of development at best. This leads to fishpond development. Although the Philippines developed 87,351 hectares of fishpond from 1952 to 1975, the area developed annually toward the end of that period decreased considerably due probably to the ban on the development of unclassified land. And while the rate of fishpond development has levelled off, the rate of fish production of existing fishpond areas has increased.

Thus, even if fishpond development is suspended indefinitely, fish production in the existing fishpond area should continue to increase, perhaps for many years. This increase in yield should obviate the need to construct more fishponds at the expense of the mangrove forest. While the suspension or ban is in force, a concerted and continuous research effort towards the understanding of the nature of the mangrove resources and the relationships of these to the surrounding environment should be undertaken.

Alternative 2. The second alternative is to allocate the remaining mangrove resources as follows: Proclaim mangrove areas for conservation, preservation or declare as national forest reserves, using the guidelines formulated by the NMC (Figures 4 and 5) for which the NMC has identified a total of 78,393 hectares from the remaining mangrove area for proclamation as conservation and preservation areas. This area, which is 58% of the remaining mangrove forest, will be used for scientific research and educational endeavours to satisfy the ecologists, while the remaining balance will be allocated for conversion of fishpond or released for other uses.

Of the two alternatives, the second one was implemented. In December 1981, the government issued Presidential Proclamation 2151, declaring certain islands and/or parts of the country as wilderness areas (It withdrew mangrove forest from entry, sale, settlement and exploitation of whatever nature or form of disposition) (Table 2) and Presidential Proclamation 2152, declaring the entire island of Palawan and certain parts of the country as mangrove forest reserves (Table 3).

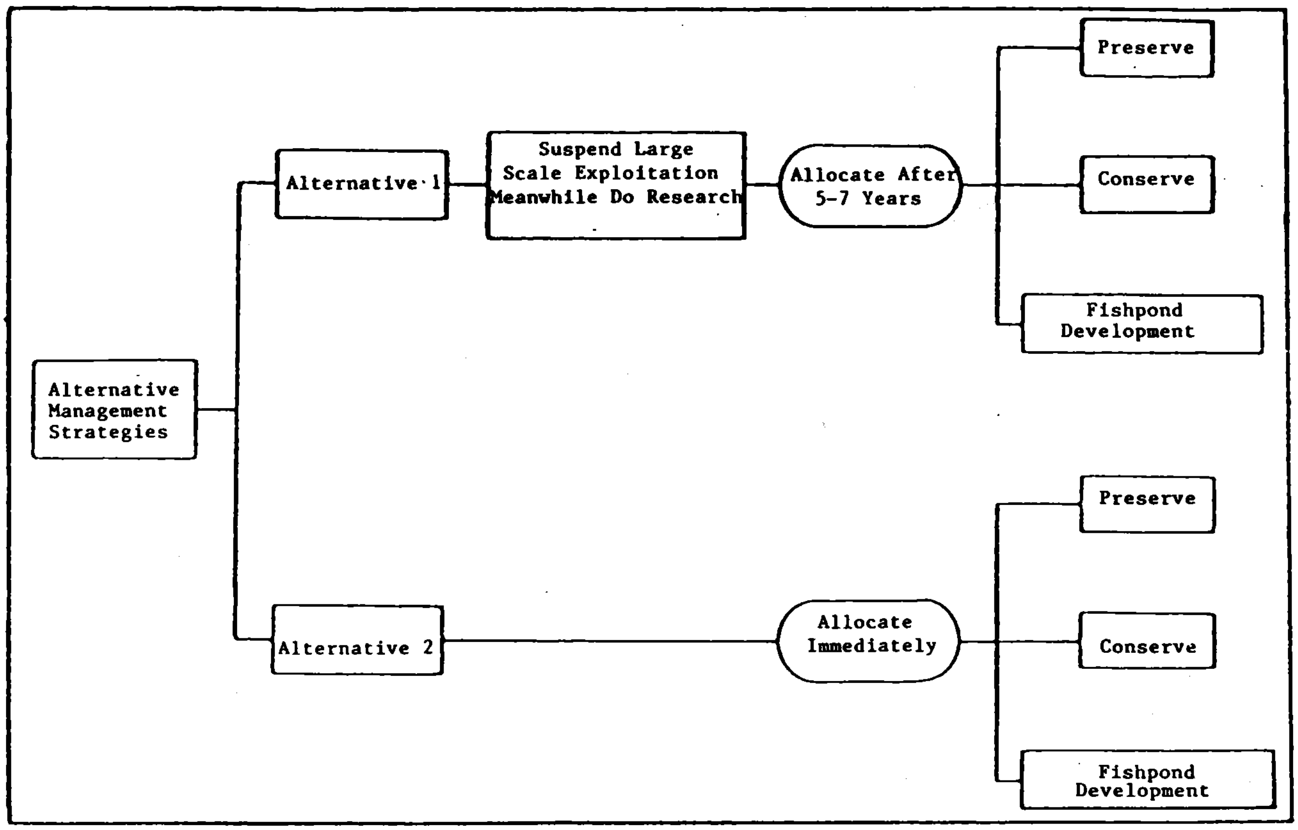

Figure 3(a). Alternative strategies for existing Philippines mangrove resources (Zamora, 1982)

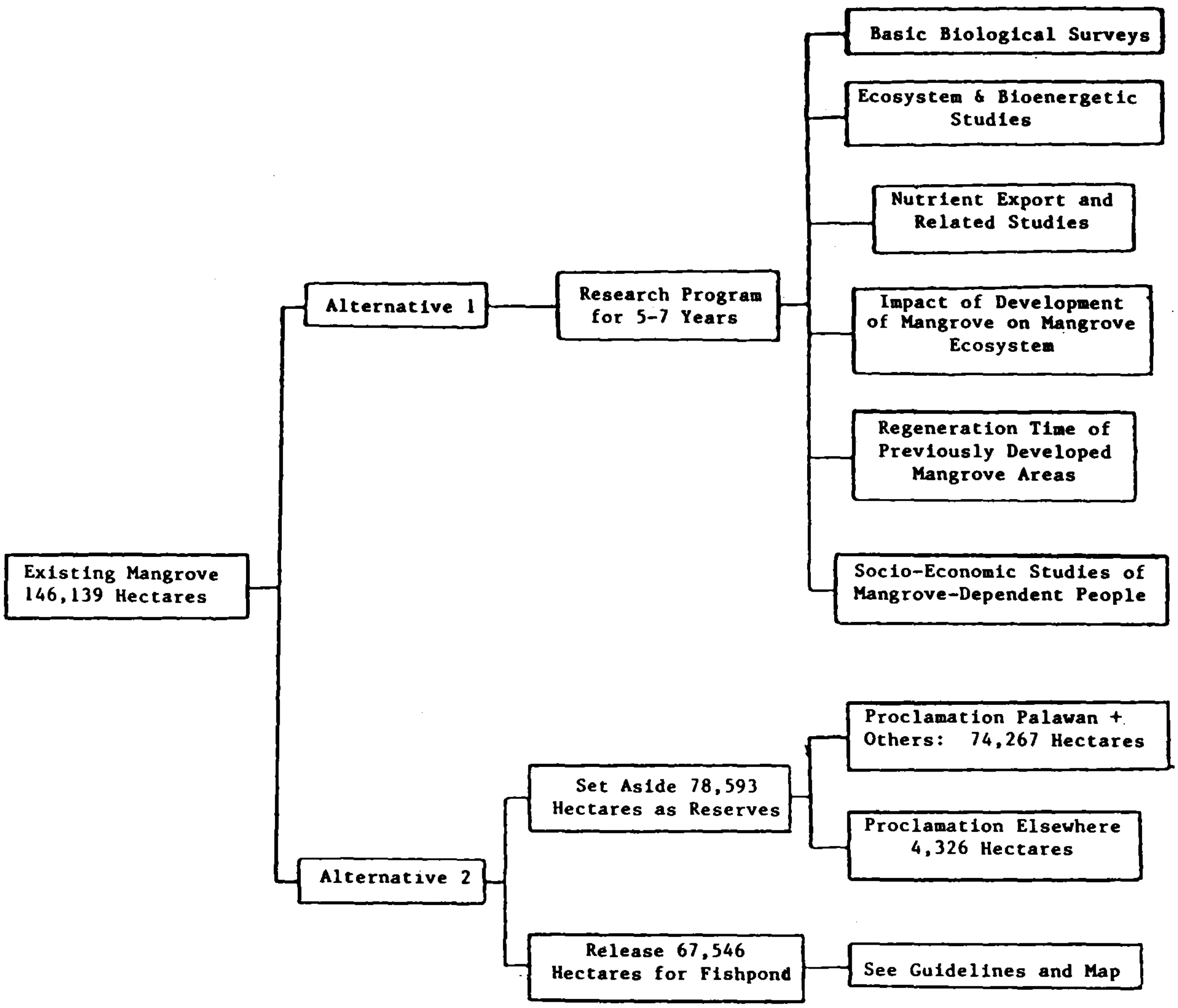

Figure 3(b). Proposed alternative action for the existing mangrove forest of the Philippines (Zamora, 1982)

Reforestation or afforestation of critically bare areas

According to Brown and Fischer (1918), planting of Nypa and Ryizophora first occurred within the first quarter of the present century in Luzon (in the swamplands of Pampanga Province in the upper reaches of Manila Bay extending from the towns of Malabon on the east to Balanga on the west side (Figure 6, arrow 11). The area planted extended 20 or more kilometers inland from the bay in certain places. Hundred of hectares of tidal flats were planted for fuelwood production to supply the Manila market. Since that time until 1980, no large-scale mangrove cultivation had taken place. The planted mangrove areas in Manila Bay have since been replaced by fishponds, saltbeds, human settlements, industrial sites, commercial sites, ports and harbours. When fishpond development boomed in the 1960's and 1970's, mangrove planting was limited to narrow fringing strips along fishpond dikes for buffer or protection against erosive action of sea current and tidal intrusion into the fishponds.

The first large-scale mangrove reforestation was initiated in 1981 by the government through the Bureau of Forest Development (BFD) in nine islands of Marungas, Sulu (Figure 6, arrow 0), covering an approximate area of 4,560 hectares of marshlands, sandy shores and tidal flats, of which 150 hectares were reforested (Yao, 1986). Encouraged by the initial success of the Sulu mangrove reforestation project, the BFD district office in Basilan Province apportioned part of its reforestation budget to reforest 1,500 hectares of logged-over mangrove areas in Basilan Strait (Figure 6, arrow 1). As of 1985, the BFD has rehabilitated about 50 hectares of critically degraded mangrove areas.

Several small community-based mangrove plantations also existed in the Central Visayas Region specifically in the province of Cebu (Figure 6, arrows 4 and 5), Bohol (Figure 6, arrows 6, 7 and 8) and Negros Oriental (Figure 6, arrows 2 and 3). Table 5 shows the location, area planted (in hectares) and the number of planters in these plantations. Among the small-scale mangrove rehabilitation projects, three have especially attracted the attention of policy makers and planners: (1) the community-based mangrove forestation in Banacon-Jaguliao Islands (Jetafe, Bohol), (2) the student-based, school-motivated mangrove forestation in Pangangan Island (Calape, Bohol) and (3) the backyard mangrove farming in Dewey Island (Bais City, Negros Oriental) (Yao, 1986).

In Banacon Island the settlers pioneered the establishment of mixed stand of Rhizophora stylosa and R. apiculata in sandy shoreline and mudflats in the region. This was originally intended as a protective belt for their community against strong monsoon winds. The success of this activity encouraged the community to plant the vast sandy mudflats adjacent to Banacon and Jaguliao Islands, reaching now to approximately 100 hectares of varying ages. The 22-year old pioneer stand is maintained as a model (Yao and Nanagas, 1984).

In Pangangan Island, the students started planting since 1968, using the 4.8 km causeway connecting the island to the Bohol mainland. Today, the 20-meter wide mangrove standing on both sides of the causeway has made the road stable. The mangrove cover serves as a windbreak to protect the road against damaging monsoon waves. Following the example set by the students, the inhabitants of Pangangan Island started planting the tidal flats and shorelines with Rhizophora apiculata, and R. mucronata and R. stylosa.

In Dewey Island, the nearshore dwellers have planted Rhizophora species on their respective backyards to protect their dwellings from strong winds and tidal waves.

In the foregoing activities, the initial intention was for environmental protection. Later, they were expanded for economic gain.

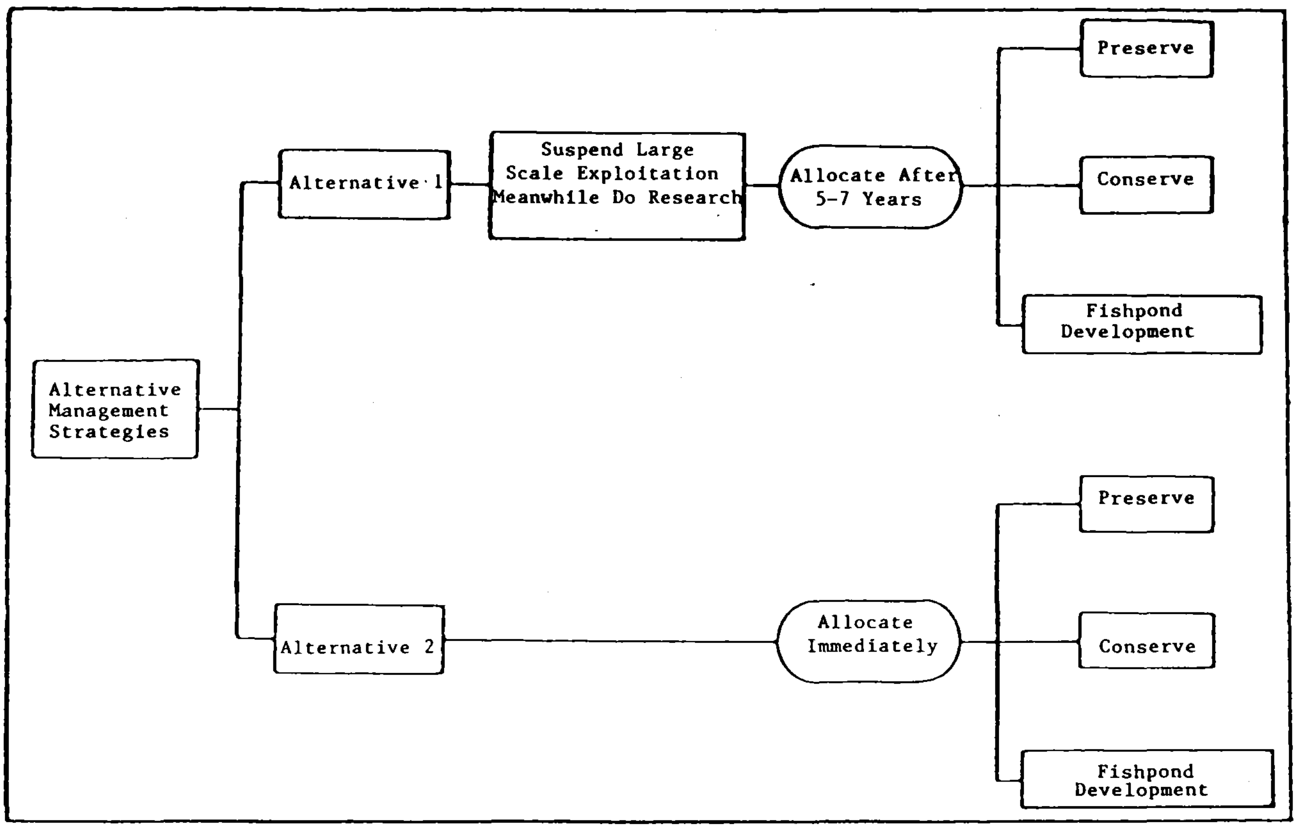

Figure 4. Guidelines for the selection of mangrove areas for preservation, conservation and fishpond development (Zamora, 1982)

	Location of mangrove	Proposed action	Main reason for proposed action
1.	Adjoining major river systems	Conserve; Not release for fishpond	Maintenance of ecological balance
2.	Adjacent to productive fry and fishing grounds	Conserve; Not release for fishpond	Insure breeding spawning and nursery grounds of fishes and shellfishes
3.	Adjacent to populated areas or urban centre	Conserve; Not release for fishpond	Insure continuous use for minor forest products
4.	Significant hazard if developed	Preserve	Protection against storm, erosion, flood, etc.
5.	Primary and dense growth regardless of location	Preserve or declare as forest preserve	Maintenance of ecological balance; protection against river bank erosion, wildlife sanctuaries, educational and research purposes
6.	Around small island	Preserve	Maintenance of ecological balance
7.	Others exclusive of 1 to 6	Release for development	Fish production, other land uses whichever is most compatible

Figure 5. Summary of Guidelines for the selection of mangrove areas for preservation, conservation, declaration as forest preserve and for release for fishpond Development.

Source: MNR Committee Report, October 1979.

Comments: (1) Proposed actions are compatible to the major economic uses or ecologic functions of mangrove forests in relation to their particular locations and stand status, i.e, whether primary, secondary or denuded;
(2) Guidelines 1, 2, 4, 5 and 6 insure continued economic usefulness to greater number of users, i.e., shell-gatherers, municipal fisheries, commercial fisheries;
(3) Guidelines 3 insures the renewable character of the mangrove forest for long-term economic benefits;
(4) Guidelines 7 assures the most compatible uses of denuded mangrove areas for economic benefits, i.e., fishpond. Some of these areas may be reforested or afforested or used for seaweed farming etc., if the ecologic situation demands said strategies.

Recently, the Central Visayas Regional Project (CVRP), a World Bank-assisted project, mobilized interested coastal dwellers and organized them to rehabilitate an initial 650 hectares of critically degraded mangrove areas in the region. The neashore component of the project provides planting materials as well as technical assistance and allocates use rights to the participants of the project in collaboration with the BFD.

To protect its coastal constituents against typhoon and storm surges, the local government of Mulanay, Quezon Province, in cooperation with the then National Environmental Protection council (NEPC) initiated a community-participated mangrove reforestation in the town's coastal areas. Similar undertaking was planned by the then Ministry of Human Settlements (MHS) to rehabilitate critically degraded mangrove areas in Pangasinan coastal towns.

Very recently, based on a combined consideration of guidelines evolved earlier (Zamora, 1986) and the results of field evaluation surveys, Howes (1987) presented site specific recommendations for the eight Philippine wetlands surveyed during April and May 1987, namely, (1) Lamon Bay, (2) Manila Bay, (3) Tayabas Bay, (4) Ragay Gulf in Luzon, (5) Cebu-Mactan, (6) Inabanga-NW Bohol, (7) SW Bohol in the Visayas and (8) Davao Gulf in Mindanao (Figure 7). Depending upon the status of the mangroves in each of the foregoing sites, Howes, is strongly recommending the implementation of the following strategies wherever applicable:

(1) prevention of further degradation of remaining mangrove areas for brackishwater aquaculture,

(2) rehabilitation (via small-scale community-based schemes) of degraded mangrove areas, eroded coastal fringes, bunds and abandoned aquaculture ponds,

(3) protection (preservation) of remaining mangrove areas of any dimension,

(4) designation of large areas of remaining mangroves as fish sanctuaries, and

(5) strict enforcement of existing laws, rules and regulations.

Cost of reforestation-afforestation

Tables 6 and 7 show direct cost estimates of mangrove plantation establishment in Banacon Island for 1-meter x 1-meter spacing and 0.5-menter x 0.5-meter spacing (Cabahug et al., 1986). These cost estimates include (1) site preparation cost, (2) planting and replanting costs, (3) cost of propagules and (4) maintenance or tending cost. The total establishment cost* ranges from P1,186 (US$59.30) to P1,251 (US$62.55) per hectare for 1-meter x 1-meter plantation and from P1,312 (US$65.60) to P1,562 (US$78.10) per hectare for 0.5-meter x 0.5-meter plantation. The 0.5-meter x 0.5-meter plantation has a higher establishment cost than that of a 1-meter x 1-meter plantation because it requires twice the amount of propagules and manpower needed for the planting and replanting.

A large part of the establishment cost is the maintenance or tending cost. This cost comprises 66.58% to 79.27% for a 0.5-meter x 0.5-meter plantation and from 83.13% to 87.69% for a 1-meter x 1-meter plantation. Ideally, this cost should be treated as separate from the establishment cost. However, in this case, maintenance cost for the first year is treated as part of the establishment cost. The exclusion of this cost will make the establishment cost very much lower.

Table 2. Number of mangrove wilderness areas in the Philippines covered in Presidential Proclamation 2151 of December 1981*

Provinces	Location	Number
Quezon	Ragay Gulf	1 a/
Camarines Sur	-	3 b/
Masbate	Asid Gulf	4 c/
Masbate	Sibuyan Sea	2 d/
Masbate	Samar Sea	1 e/
Cebu	Visayan Sea	1 f/
Bohol	Canigao Channel	5 g/
Bohol	Cebu Strait	13 h/
Bohol	Camotes Sea	5 i/
Surigao del Norte	Panay Bay	3 j/
Surigao del Norte	Hinatuan Passage	1 k/
Surigao del Norte	Dinagat Sound	7 l/
Surigao del Norte	Agusan Bay	5 m/
Davao del Sur	Davao Gulf	1 n/
Total		52 o/

* Declared for foreshore protection, maintenance of estuarine and marine life and exclusive habitats of rate and endagered flora and fauna.

a/ Alibijaban Island
b/ Basot Island, Quinalasag Island, Malabungot Island
c/ Guinauayan Island, Naro Island, Chico Island, Pobre Island
d/ Majaba Island, Napayauan Island
e/ Dampalit Island
f/ Bantayan Island
g/ Catiil Island, Calangaman Island, Lumislis Island, Tabangdio Island, Tintiman Islet
h/ Budlanan Island, Bugatusan Island, Panga Island, Silo Island, Cabgan Island, Cancostino Island, Tabaon Island, Maagpit Island, Basihan Islet, Bugatusan Islet, Hayaan Islet, Poom Point, East of Basihan Islet.
i/ Banaon Island, Basan Island, Saae Island, Tambu Island, Bambanon Island.
j/ Guimaras Island.
k/ Rosa Island
l/ Siargao Island, Poneas Island, Dahican Island, Tona Island, Laonan Island, Abanay Island, Bancuyo Island
m/ Awasan Island, Cabilan Island, Capaguian Island, Sugbuhan Island, Tagboaba Island
n/ Pandasan Island
o/ Total area: 4,326 hectares

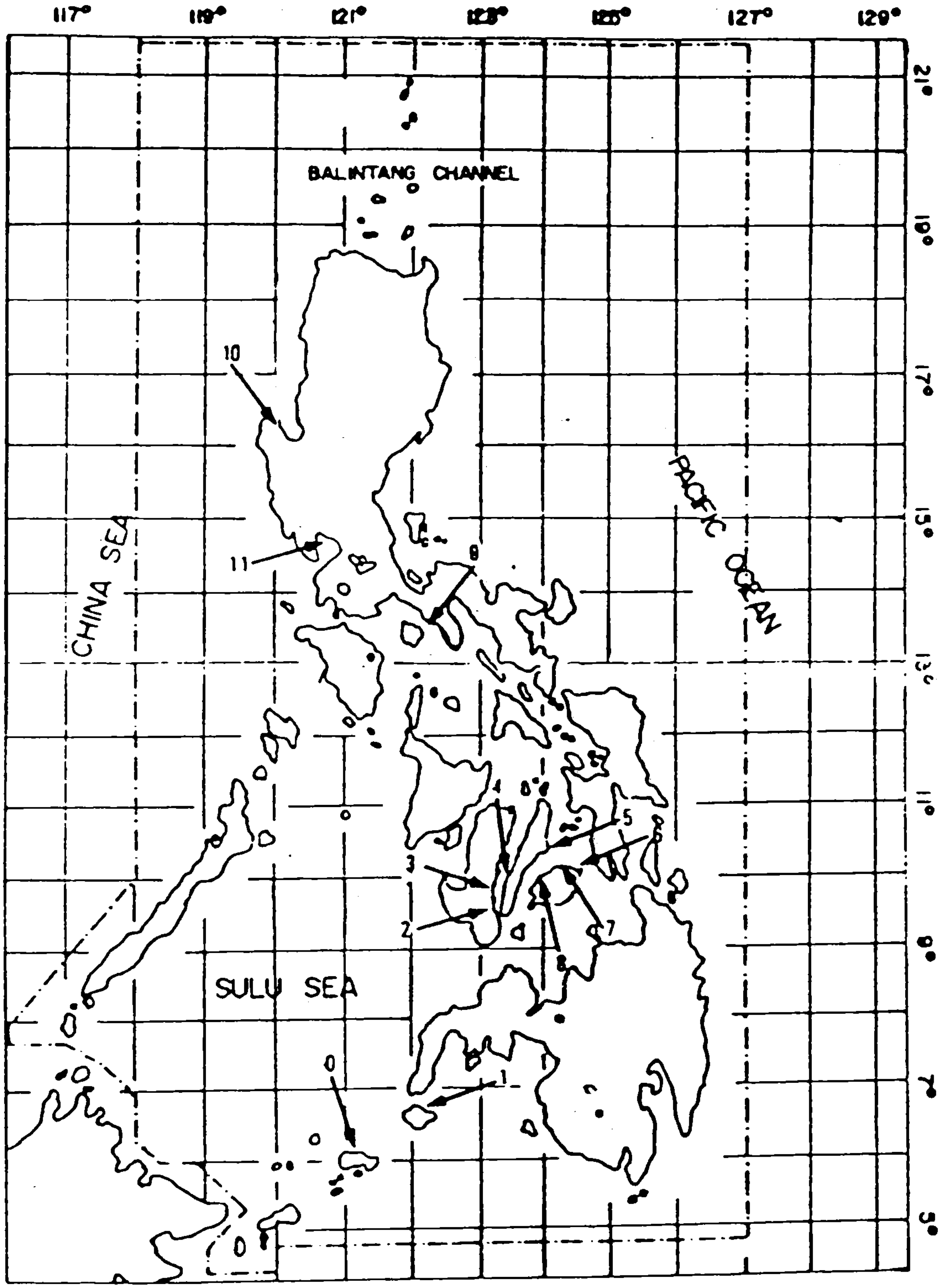

Figure 6. Afforestation-reforestation Map of the Philippines

0 Marungas Island (Sulu), 1 Basilan Strait (Basilan), 2 Bais City (Negros Oriental), 3 Jimalalud (Negros Oriental), 4 Badian (Cebu), 5 Olangu Island (Cebu), 6 Talibon (Bohol), 7 Jetafe (Bohol), 8 Calape (Bohol), 9 Mulanay (Quezon, Luzon), 10 Pangasinan (Proposed), 11 Manila Bay Area (1981).

Table 3. Islands containing parts declared as mangrove swamp forest reserves by virtue of Presidential Proclamation 2152 of December 1981[1/].

Luzon	Visayas
Camarines Norte	Cebu
Camarines Sur	Bohol
Albay	
Sorsogon	Mindanao
Marinduque	Misamis Occidental
	Davao
Mindoro	Surigao del Norte
	Surigao del Sur
Palawan (Entire Province)	Zamboanga del Sur

1/ Mangroves around islands, along banks of rivers, in coves with a total aggregate area of 74,267 hectares declared for conservation and protection purposes by reason of their ecological, scientific, educational and recreational values including terrestrial and marine flora and fauna found therein and other values.

Table 4. Mangrove resforestation-afforestation areas in the Philippines

Islands	Provinces	Area Available for Planting (Hectares)	Areas Planted (Hectares)	Initial Year of Planting
Luzon	Pangasinan[1/]	-	-	-
Luzon	Quezon[2/]	-	-	1983
C Visayas	Negros Oriental[3/]	-	13.60	-
C Visayas	Cebu[3/]	-	364.98	1984
C Visayas	Bohol[3/]	-	562.83	1968
Mindanao	Sulu[4/]	4.560	150.00	1981
Mindanao	Basilan[5/]	1,500	50.00	1985
Total			1,141.41	

1/ Proposal of the then MHS to rehabilitate critically degraded mangrove areas of some coastal towns (Cabahug et al., 1986)

2/ Community-based mangrove reforestation project to plant bare coastal areasalong the intertidal zone of the town of Mulanay in co-operation with NEPC.

3/ Small community-based mangrove plantations in the three provinces in the Central Visayas; see Table 5.

4/ BFD's first large-scale mangrove reforestation project. The areas include marshlands, sandy shores, tidal flats in 9 islands of Marungas (Yao, 1986).

5/ BFD's project to rehabilitate critically degraded logged-over mangrove areas.

Table 5. Community-based mangrove plantations in Central Visayas

Location (Province/Municipality)	Area Planted (Hectares)		Number of Planters	
Negros Oriental	13.60		57	
Bais City[1/]		13.60		57
Jinalalud	New Project (1986)			
Cebu	364.98		384	
Lapu-lapu City		70.00		58
San Remigio		200.00		114
Ronda		13.21		16
Badian		72.00		187
Carcan		9.77		9
Bohol	562.83		870	
Clarin		33.00		44
Tubigon		62.25		179
Loon		7.16		35
Calape[2/]		12.00		35
Corella		3.20		10
Catigbian		30.26		38
Jetafe[3/]		229.09		192
Candilay		23.00		37
Mabini		39.33		141
Talibon		123.54		159
Total	941.41		1,311	

Source: Integrated Forestry Report of BDF Region 7, 1986.

1/ Mangrove backyard farming in Dewey Island

2/ Self-reliant, school-motivated and student-based mangrove forestation in Pangangan Island.

3/ Community-participated mangrove forestation in Banacon-Jaguliao Islands.

Table 8 compares the costs of establishing plantation in some places. Yao (1986) estimated the mangrove reforestation cost in other parts of Central Visayas at P800 (US$40) and P1,600 (US$80) per hectare for plantation of 1-meter x 1-meter and 0.5-meter x 0.5-meter respectively.

This costing includes propagules and planting (labor) costs only. These estimates are very much higher than those in Banacon Island for the same cost components. This can be attributed to the lower cost of propagules and labor cost in Banacon Island.

The establishment cost of a government mangrove reforestation project in Marungas, Sulu is P2,500 per hectare. On the average, this cost is twice that in Central Visayas. This is due to the difference in the prices of inputs. In addition, this government reforestation project has a management cost which is absent in the Central Visayas plantation establishments because most of them are only family-size scale.

In the United States, the establishment cost per hectare is $1,140 and $2,470 for a 0.91-meter x 0.91-meter spacing and 0.61-meter x 0.61-meter spacing respectively (Cintron, 1978). This amount is very much higher than those in the Philippines. The disparity in mangrove plantation establishment between the United States and the Philippines is attributed to the difference in costs of inputs.

Thus, mangrove plantations establishment through the initiative of a community or an individual have lower costs compared to those established by the government. This can be attributed to the following factors: (1) use of simple technology; (2) minimal labor cost; (3) cheap labor and raw materials; and (4) minimal or no management cost.

Mangrove rehabilitation stressors (Table 9).

The worst marine organisms infesting mangrove plantation in Central Visays, particularly in Bohol, are the barnacles and oysters. The peak of infestation is during the rainy season (August-September) and mostly occurs near the mouth of rivers or estuaries where water salinity is generally low and substrate is muddy. These organisms excrete saliva (spat) that cements them on hypocotyls or stems. The added weight of these organisms results in the deformation of the seedlings.

Barnacle infestation is probably the biggest threat to mangrove plantation in Central Visayas. Several plantations have been wiped out by this problem (Yao, 1986). The newly established mangrove plantations in the river mouths of San Pedro, San Isidro, Tanghaligue, Estrella and Esperanza in Bohol are heavily infected by this mollusc.

Another marine organism which attacks mangrove plantations is the teredo. This wood-boring mollusc usually attacks the prop roots of plants in old plantations. It is not considered a major problem.

Crab attack is a problem in Mindanao. The mangrove plantation in Sulu is infected mostly by _Uca_ and _Sesarma_ species. The crabs usually girdle the root collar of the propagules. Infestation usually occurs in coralline muddy substrate of the plantation.

In Cebu, mangrove plantations suffer high mortality or retarded growth due to the green alga _Enteromorpha_. The alga chokes the seedlings to death by clinging on their hypocotyl. The Moalboal mangrove plantation in the northern part of Cebu is heavily affected by said alga (Yao, 1986). The alga is usually abundant during November to January.

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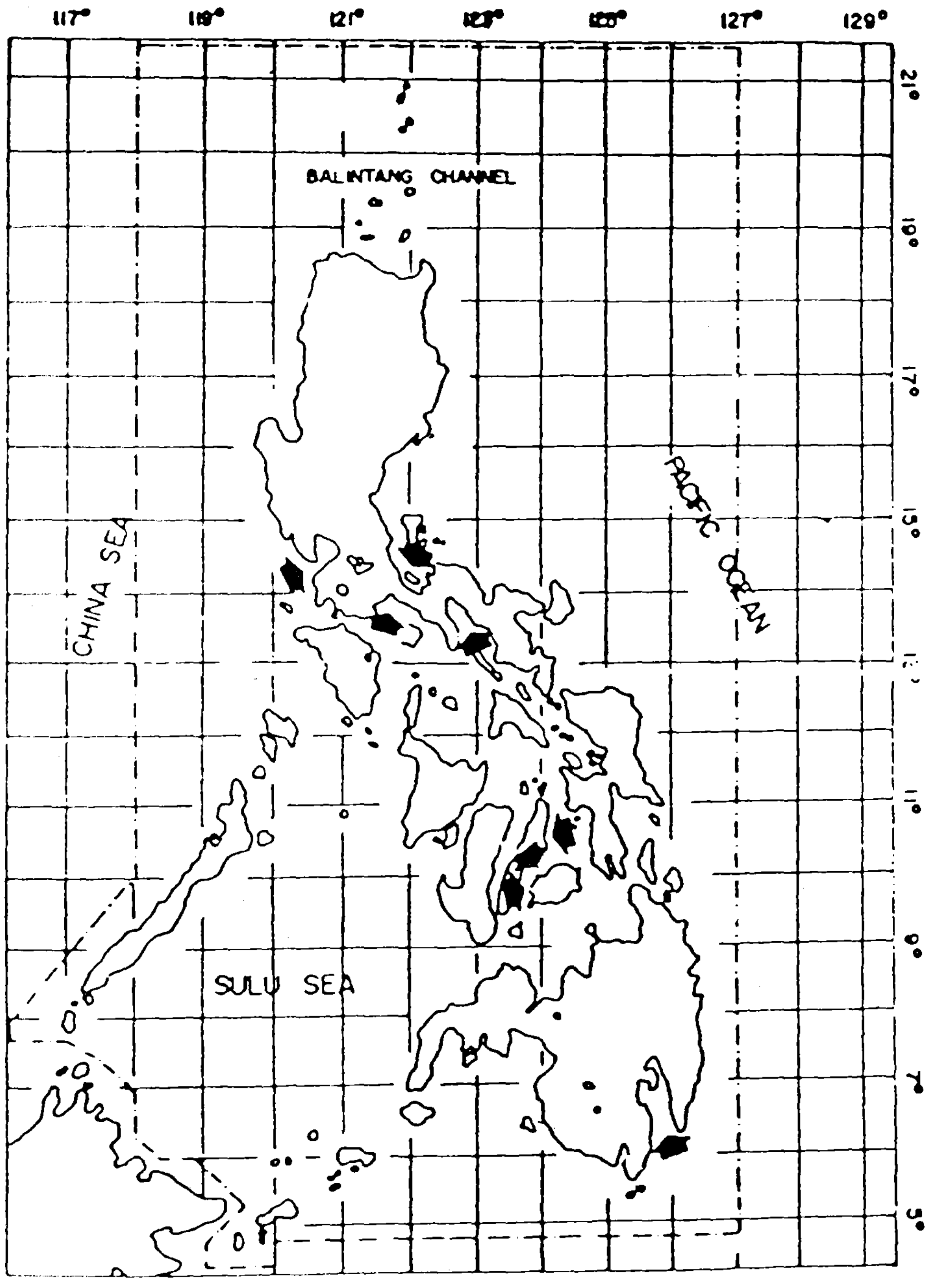
* Cost conversion ratio from Philippine currency to the US dollar is placed at P20 to US$1.



Luzon: Lamon Bay, Manila Bay, Tayabas Bay, Ragay Gulf. Visayas: Cebu-Mactan, Inabangan-NW Bohol, SW Bohol. Mindanao: Davao Gulf.

Figure 7. Areas John Howes recommended for mangrove protection, conservation and rehabilitation

Table 6. Direct cost estimates of mangrove forestation at a spacing of 1 m x 1 m in Babacon Island, Bohol

	Activity/Input	Quantity	Unit Cost	Cost/Ha.	% Total Cost
A.	Site preparation	0-5 md	P20.00/md	P -100.00	0-7.99
B.	Propagules	10,000 pcs	P 6.00-7.00/1,000 pcs.	P 60.00-70.00	5.06-5.60
C.	Planting	3-4 md	P20.00 md	P60.00-80.00	5.06-6.40
D.	Replanting (10-30% mortality)				
	1. propagules	1,000-3,000 pcs.	P6.00-7.00/1,000 pcs.	P 6.00-21.00	0.51-1.68
	2. labor	1-2 md	P20.00/md	P 20.00-40.00	1.69-3.20
E.	Maintenance (one year) (one day/week)	52 md	P20.00/md	P1,040.00	83.13-87.69
Total Cost				P1,186.00-P1,251.00	

Table 7. Director cost estimates of mangrove forestation at a spacing of 0.5 m x 0.5 m in Banacon Island, Bohol

	Activity/Input	Quantity	Unit Cost	Cost/Ha.	% Total Cost
A.	Site preparation	0-5	P20.00/md	P -100.00	0-6.40
B.	Propagules	20,000 pcs	P 6.00-7.00/1,000 pcs	8.96-9.15	
C.	Planting	6-8 md	P20.00/md	P120.00-160.00	8.96-10.24
D.	Replanting (10-30% mortality)				
	1. propagules	2,000-6,000 pcs.	P 6.00-7.00/1,000 pcs.	P 12.00-42.00	0.91-2.69
	2. labor	1-4 md	P20.00/md	P1,040.00	66.58-79.27
Total Cost				P1,312.00-P1,562.00	

Table 8. Cost (US$/ha of different reforestation/plantation establishment)

Spacing	Banacon Is. Bohol (base year-1986)	Jolo Ref. Proj. (base year-1983)	Central Visayas (base year-1986)	United States (base year-1977)
0.5 m x 0.5 m			$80.00	$2,470.00
	$65.60–78.10			
0.61 m x 0.61 m				
1.0 m x 1.0 m		$125.00	$40.00	$1,140.00
	$59.30–67.85			
0.91 m x 0.91 m				

Source: Cabahug et al (1986)

Table 9. Biological stressors in afforestation-reforestation sites in the Philippines

Stressor organism	Stage affected	Part affected	Degree of effect	Rehab. site
Barnacle	Seedling	Hypocotyl	(+)	Bohol
Oyster	Seedling	Hypocotyl	(+)	Bohol
Crabs[1/]	Seedling	Hypocotyl	(-)	Sulu
Green Alga[2/]	Seedling	Hypocotyl	(-)	Cebu
Teredo	Adult	Prop roots	(-)	Bohol
Beetle[3/]	Adult	Seeds	(-)	Negros Or

1/ Uca, Sesarma;

2/ Enteromorpha;

3/ Poecilips fallax.

(+) Serious. (-) not serious

Sources: Lapis and Valentine (1982); Yao (1986); Cabahug et al. (1986).

Table 10. Laws, Rules and Regulations promulgated relative to mangrove protection, conservation and management

L, R, R	Relevant Provisions
PD 389	Strip of land, mangrove and swampland not less than 50 meters wide from the shoreline facing the ocean, lakes and other bodies shall be retained as permanent forest for shoreline protection. Further, no cutting or removal of mangrove species therein shall be permitted, except when the same is done in connection with experiments or activities designed in accordance with the approved programme of research and development.
PD 704	Any person or association/corporation can lease 50 or 500 hectares, respectively, of suitable public land for fishpond purpose for a period of 25 years, renewable for another 25 years; that 50% of the said area shall be developed and made productive within 3 years and the remaining portion shall be developed and made productive within 5 years, both periods to be reckoned from the execution of the lease contract; that all portions not developed within said period of 5 years shall automatically revert to the public domain for disposition by the BFAR; and that no portion of the leased areas shall be subleased.
PD 705[1/]	Strips of the forests which protect shorelines, shoreline roads and coastal communities from destructive forces of the sea shall be maintained and not alienated. Specifically, a buffer zone of at least 40 meters wide along rivers, lakes and other inland water bodies, and a belt 100 meters wide in areas facing bays or the sea, must be retained and excluded from fishpond development to serve as protection of the shoreline from the destructive forces of the sea, strong winds and typhoons. Further, mangrove and other swamplands released to BFAR for fishpond purposes but not utilized, or which have been abandoned for 5 years from date to such lease, shall automatically revert to the category of forest land.
PD 953	Every holder of a licence, lease or permit from government involving occupation and utilization of forest or swampland with a river or creek therein shall be under obligation to plant trees extending at least 20 meters from edge of the banks of the said river or creek.
SO 3 (1976)	Creation of the Land Classification Team. Tasked to delineate mangrove areas based on socio-economic and ecological parameters and classify the same into permanent forests, timberlands, agricultural lands, areas suitable for fishpond development, and other purposes.
AO 74	Mangrove licensee is required to leave 20 or more seed trees per hectare with a diameter of 20 cm or more to ensure successful regeneration after logging; that no authorized person shall cut or gather any timber or other products of logging unless he plants thrice the number of trees of the same variety that were cut or destroyed by such operations; and that for open and heavily depleted areas, artificial regeneration or reforestation must be done by the licensee.
LOI 917	Mangrove forests essentially needed in foreshore protection and maintenance of estuarine and marine life including special forests which are exclusive habitats or rare and endangered Philippine flora and fauna, are declared wilderness areas, hence not subjected to exploitation of whatever nature.
CIR 13 (1986)	The processing of applications for land within mangrove and other forest reservations is prohibited.
RAD (1986)	The cutting of mangrove timber in all forest lands including those covered by the FLAs except those areas covered by existing permits is banned.

Legend: L, R, R: Laws, Rules, Regulations; PD: Presidential Decree; SO: Special Order; AO: Administrative Order: LOI: Letter of Instruction; CIR: Circular; RAD: Radiogram. BFAR: Bureau of Fisheries and Aquatic Resources; FLA: Fishpond Lease Agreement.

[1/] As amended by PD 1559.

In 1976, the seed-boring beetle Poecilips fallax infested large number of planted seedlings of Rhizophora mucronata and R. apiculata in the mangrove swamps of Dewey island (Bais City, Negros Oriental). Most of the infested seedlings died. The first three months of establishment are the most susceptible period of the seedlings to beetle attack. the larvae and adults of the beetle tunnel through and feed on the hypocotyl (Lapis and Valentine, 1982). Lapis and Valentine (1982) found that the eggs develop into adults in 39 to 53 days. The year-round breeding of the insect was attributed to the continuous abundance of food. Rhizophora mucronata and R. apiculata are the preferred hosts of P. fallax.

Implementation of other measures.

To complement the presidential proclamations and reforestation-afforestation programs, BFD (the appointed agency for forest resource management) has (through Presidential Decree 705: Revised Forestry Code of the Philippines) required the practice of the seed-tree method as silvicultural system in mangrove forest management which strictly enforces the regulation to holders of licenses, leases and permits during the entire duration of occupation. This method is based on a 50-year rotation period allowing 20 seed trees with diameter 10 cm or larger per hectare to be left to regenerate the cleared area. Likewise, BFD regulates the exploitation and utilization of the remaining mangrove resources by setting a standard rate of forest charges and the licensing system (see Table 10 for other measures).

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COASTAL HABITATS OF TROPICAL PACIFIC ISLANDS

by

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ABSTRACT

Three coastal habitats are addressed: Coral reefs, mangrove swamps, and seagrass beds. Typical patterns of zonation and community structure are discussed. Specific attention is given to the interactions of these three communities, including physical relationships as well as biotic interactions. Data are presented from coastal habitats of Papua New Guinea that indicate that juveniles and adults of tropical shorefishes tend to occur in the same habitats thus suggesting that seagrass beds and mangrove areas do not serve as nursery areas for the young of coral reef-dwelling fish species. The importance of community interactions to the proper management of tropical coastal habitats is stressed.

INTRODUCTION

The coastal zone is of great importance to the tropical Pacific region because there is proportionally so much of it. The tropical Pacific is a region of islands, ranging in size from New Guinea's 800,000 km^2 to small sand islands of only a few square meters. On the smaller Pacific islands, human activities are intimately connected with the coastal zone on a day-to-day basis. Even on the larger islands where there is substantial inland human activity (agriculture, forestry, mining), the coastal zone is the site of the major urban centers and developmental activities.

There is clearly a need for better understanding of coastal zone ecosystems in the tropical Pacific. How do they work? Why do they work the way they do? And how do coastal ecosystems interact?

DISTRIBUTION OF COASTAL HABITATS

The term "coastal zone" is somewhat of a catch-all phrase and is used differently depending upon whether one has a terrestrial or marine perspective. Generally speaking, it is that part of the marine shoreline and adjacent areas where there is a significant interaction between the land and the sea. On the ocean side, it excludes the pelagic and deep benthic habitats (although they may, in fact, be significantly influenced by adjacent land masses; Gilmartin and Revelante, 1974), and on the land side it excludes rainforests and strictly riparian habitats where marine influences do not directly make themselves felt. It thus includes the intertidal zone and the shallow marine habitats of the subtidal.

The specific nature of the coastal habitats at any particular spot depends to a great extent on the geography and geology of the area.

The islands of the Pacific can be divided into a number of geological types. The first division is between oceanic islands, formed by volcanoes arising from the deep ocean floor, and continental islands, those located on shallower continental shelves. The islands of Micronesia and Polynesia (except New Zealand) are examples of the ocean type, while the major islands of Melanesia and Indonesia are of the continental type.

Secondly, the islands can be divided into high islands, those in which the island mass extends to a significant height above sea level, and low islands such as atoll and barrier reef islands, which are little more than piles of sand and boulders heaped up on shallow reefs and extending only a few feet above sea level.

Coral reef development

Coral reefs develop in the tropics in clear, well lit waters. Although the coral polyps are filter feeders, their major source of nutrition, the one that most influences their pattern of growth, is photosynthetic production by symbiotic zooxanthellae.

Coral reefs are generally well developed around tropical oceanic islands and may take the form of fringing reefs, barrier reefs, or atolls. Reefs do not develop well in the vicinity of major river outflows where turbid, low salinity water reduces their growth and where siltation may smother the coral polyps. Around high islands with major rivers, channels form through the reefs offshore to these river mouths.

Low islands lack surface drainage and so adjacent coral growth is not inhibited.

Around continental islands, coral reefs can flourish in clear shallow shelf waters.

Mangrove swamp development

Along the shores of tropical islands, certain factors promote the development of mangrove swamps. Among these are low salinity water, soft substrate, and protection from wave energy. These conditions are best met along protected shores of high oceanic and continental islands adjacent to river estuaries. On large continental islands, protection from wave assault can be provided by the island itself, and mangrove dominated shorelines are characteristically found on the leeward coast of these islands. On oceanic high islands, protection is provided by barrier reefs, and mangroves shorelines are found on island coasts facing lagoons. Island coastlines with only fringing reef development lack mangrove communities. Occasionally, mangrove species occur on low barrier reef islands, but extensive mangrove swamps are not developed.

Seagrass bed development

Seagrass beds are best developed in shallow, protected, subtidal habitats and these are generally found adjacent to mangrove swamps. Seagrass beds can also be found on fringing reefs of high islands and in atoll lagoons and so do develop in some areas lacking adjoining mangrove habitats.

Typical pattern of zonation

On high oceanic islands, the occurrence of these three coastal habitats is typically zoned: mangrove swamps dominate the island shoreline; subtidally a band of seagrass predominates, which gives way at increasing distance from the island to coral-rich habitats culminating in the development of a barrier reef.

There are many variations in this typical pattern however. Where barrier reefs have not developed, mangrove habitats are generally replaced by sandy beaches and beach strand vegetation, and seagrass beds may be thinly developed or absent. Leeward shores of continental islands may have well developed mangrove and seagrass habitats, but coral barrier reefs may not occur.

ECOLOGY OF COASTAL HABITATS

The physical structure of each of the three coastal habitats discussed herein is provided by the bodies (and skeletons) of the dominant organisms. In the case of mangrove swamps, it is the mangrove trees (*Avicennia*, *Rhizophora*, *Sonneratia*, etc.) which provide this structure, aerially by the trunks and leafy canopy and intertidally by the proproots and pneumatophores. In seagrass beds, such structure as exists is provided by the blades or stipes of the various species of seagrass (*Thalassia*, *Halodule*, *Enhalus*, etc.). The calcareous skeleton of many species of living and dead hermatypic corals provide the principal framework for coral reef habitats.

It is within, around, and upon these biotic structural foundations that the ecological interactions and relationships that characterize these coastal communities take place.

Mangrove communities

Mangrove communities occur over a gradient of environmental conditions from the landward side to the seaward side (Johnstone and Frodin, 1982). These conditions include exposure to dessication and variations in salinity. As a result of these environmental variations, the dominant mangrove tree species are typically zoned, those species with pneumatophores (*Sonneratia* and *Avicennia*) occurring more to the seaward, and those species with prop roots (*Rhizophora*) occurring more to the landward. This zonation also appears to be related to successional processes in which the more seaward species tend to spread outward, colonizing new marine habitat (Johnstone and Frodin, 1982; Lugo and Snedaker, 1974). As they do so they are replaced from behind by landward species which favor the thicker soil and shallower water created by the consolidation of silt by the pioneer species.

In addition to the dominant mangrove trees, are a host of other vascular plants which characteristically occur in mangrove communities (Chapman, 1984). A number of these are rooted in the ground amongst the more common species, while many are epiphytic on the mangrove trees themselves. A great number of fungi, algae, and lichens also contribute to the flora of mangrove communities (Chapman, 1984).

A wide variety of animal life also inhabits the mangrove swamp. From the terrestrial side, birds, insects, and lizards predominate in the canopy. Intertidally, the most conspicuous animals are fishes, gastropod and bivalve molluscs, and crustaceans such as shrimp and prawns, mud lobsters, and mangrove and fiddler crabs. Less conspicuous, but numerically more important are the variety of substrate dwelling meiobenthic worms and crustaceans (Sasekumar, 1984).

The mangrove flora is extremely productive and some of this production is consumed directly by herbivorous insects and frugivorous birds. The majority of the plant productivity, however, falls to the substrate as litter and provides the basis, along with decaying roots and other organic input, for the detrital food webs which characterize mangrove communities (Por, 1984).

As this leaf litter and organic material is decomposed by microbial organisms it is consumed by a number of invertebrates while various meiobenthic species, notably nematode worms, feed on the microbial organisms. The decomposing litter, accompanying bacteria and fungi, and the invertebrates that feed on these are in turn consumed by the omnivorous crabs, shrimps, and fishes which make up the more conspicuous component of the mangrove fauna (Por, 1984).

Seagrass communities

Tropical seagrasses come in several varieties. The taller species (e.g. Enhalus) have stipes of a meter or more in length and usually occur in silty habitats. The shorter species (e.g. Thalassia and Halodule) rarely exceed 20 cm in length and, where well developed, occur in extensive meadows in clear water on sandy substrates. Prostrate species, such as Halophila, lie on the substrate and never form thick beds. The distribution of the various species of tropical seagrasses is correlated with water depth and tidal exposure (Johnstone, 1982).

The seagrass blades form a surface for the attachment of a variety of epibiontic algae and invertebrates, such as hydroides, tunicates, and sponges. The free living fauna is dominated by small gastropod and bivalve molluscs, crustaceans (notably hermit crabs utilizing the empty shells of the gastropods), echinoderms (sea cucumbers, starfish, and sea urchins), and fishes. A variety of interstitial meiofauna live in the substrate where the seagrass rhizoids also penetrate.

Some of the primary production of the seagrass and associated algae are directly consumed and enter herbivore food webs (although there is some questions as to whether seagrass blades that are eaten by herbivorous fishes are actually assimilated or whether only the attached epibionts are assimilated while the refractory seagrass are passed relatively intact through the gut; Birkeland and Grosenbaugh, 1985). The most important direct consumers of seagrasses are turtles and dugongs (Johnstone, 1982).

As in the case of mangroves, however, much of the production of seagrass biomass enters into detritus food webs. Because water circulation is generally better in seagrass beds than it is in mangrove swamps, much of the seagrass detritus is carried away from the seagrass bed itself either onto the shore (where it contributes to the detrital biomass of adjacent mangrove systems) or offshore where it may be lost to the island ecosystem. Some of this material does become buried in the substrate of the seagrass bed and, along with dead rhizoids, it is decomposed and consumed by meiobenthic and burrowing invertebrates. These then are consumed by various invertebrate-feeding organisms, notably fishes.

Coral reef communities

Coral reef communities are by far the most complex of the three coastal communities considered herein. Hundreds of coral species may be found in a given reef community and they may exhibit a wide variety of growth forms from encrusting to massive to branching and tabular.

Coral reefs also have a typical zonation pattern which is influenced by the geologic history of the island, water clarity and light availability, wave exposure, freshwater input, and sedimentation. Different species and growth forms of corals are associated with the various reef zones (Randall, 1983).

In addition to habitat structure, the corals provide the energetic basis for coral reef food chains through the symbiotic zooxanthellae which live within the coral tissues. A variety of other marine plants also occur in reef habitats, including all the major groups of marine algae. The distribution, abundance, and growth forms of algae species depends on substrate characteristics and, to a large extent, on grazing pressures by herbivorous fishes.

Intimately associated with the coral reef is a tremendous diversity of marine animals from many taxa. Most conspicuous are the reef fishes and the exchinoderms. Equally numerous, but less conspicuous because of their cryptic habits, are molluscs (mainly gastropods but with some notable bivalve such as the tridacnid clams), crabs, and polychaetes. Living within the skeletons of some corals are various burrowing and boring crustaceans and molluscs. Meiobenthic invertebrates inhabit the sandy substrates within coral reefs, as do a variety of planktonic organisms, which emerge at night into the water column.

As might be expected from the tremendous diversity of organisms inhabiting reefs, coral reef food webs are complex. One major pathway of energy leads from the primary production of photosynthetic zooxanthellae to the host coral to the various consumers of coral tissues (primarily fishes and echinoderms). Another major pathway leads from the photosynthetic production of benthic algae to various herbivores (fishes, molluscs, crustaceans, etc.). Yet another pathway is generated by reef phytoplankton which is consumed by herbivorous zooplankton and subsequently by planktivorous fishes and corals.

As in the other coastal communities considered, detritus food webs play an important role in the energy pathways of coral reef systems (Kinsey, 1985). Detritus is generated from benthic algal tissues torn free by wave and current action, coral mucus flocs, the fecal products of various reef species, and other sources. This material and its associated decomposition microorganisms are consumed by various midwater and benthic particle feeders, notably fishes, corals, and holothurians.

INTERACTIONS AMONG CORAL REEF, SEAGRASS, AND MANGROVE COMMUNITIES

Birkeland and Grosenhaugh (1985) recently reviewed the literature on ecological interactions among mangrove, seagrass, and coral reef communities. These interactions can be categorized broadly as physical interactions and biological interactions.

Physical interactions

Each of the three communities exerts stabilizing influences on the environment which may result in important effects on the other communities.

Barrier reefs protect coastlines and the intervening lagoons from currents and wave action. This allows sediment to accumulate and permits mangrove seedlings to take root and thus promotes the development of mangrove communities. Mangroves are virtually absent from oceanic islands lacking barrier reef protection. Likewise, the lagoon habitat created by the barrier reef is the location of most well developed seagrass beds. Seagrasses do best in relatively undisturbed sandy substrates.

Seagrass beds themselves are effective at trapping and stabilizing sediments. Currents passing through seagrass beds are slowed, and suspended sediments fall out. This trapping of sediments may benefit coral reefs downstream of seagrass beds by reducing abrasion and sediment load on the corals, but it also effectively excludes the colonization of new corals within seagrass beds because the substrate is insufficiently firm to allow coral settlement and development.

Mangrove communities provide a buffer between terrestrial runoff and adjacent marine communities. By slowing and diffusing freshwater runoff, mangroves shorelines prevent catastrophic salinity fluctuations that might accompany heavy rainfall during tropical storms. In addition, and perhaps more importantly, land-derived sediments are also trapped by mangrove communities thus sparing nearby seagrass and coral reefs periodic inundations of silt.

Biological interactions

Among the biological interactions discussed by Birkeland was the transfer of nutrients from seagrass beds to coral reefs by fishes which graze in seagrass beds at night, returning to their reef location by day where they, among other activities, defecate (Ogden and Zieman, 1977). There is some evidence that in the Caribbean, such behaviour on the part of fishes may enrich corals with nutrients derived from seagrass beds and increase the growth rates of the corals (Meyer et al., 1983).

Another biological interaction between corals and seagrasses is the development of seagrass-free "halos" around coral patches within seagrass beds. There is evidence that these halos are formed by herbivores (sea urchins and fishes) which occupy (or frequently visit) the corals and graze away the surrounding seagrass (Randall, 1965; Ogden et al., 1973; Gates, 1986).

A third interaction is the utilization of mangrove and seagrass communities as "nursery areas" by the young of coral reef species (Ogden and Zieman, 1977). While there is ample evidence that some important fishery species of shrimps and fishes utilize mangrove-dominated estuarine habitats during their young stages in continental shelf areas (Adams et al., 1973; Snedaker and Lugo, 1973), there is no clear evidence that coral reef species on oceanic islands do so. In fact the rich fish communities of atoll reefs, where mangrove habitats are lacking, suggest that such nursery areas are not essential.

To investigate this interaction further, Dr. Birkeland and the author carried out field work in the coastal habitats near Port Moresby, Papua New Guinea, in the spring of 1987. A total of 61 visual fish transects were made in a variety of coral reef, seagrass, and mangrove habitats. Although the data are not fully analyzed yet, some preliminary results of this work are reported here below.

Some 234 fish species were observed during the survey. Sixty-one of these species were observed as juveniles. Nine species of juveniles were seen in mangrove habitats, 14 in seagrass habitats, and 54 in coral reef habitats. Of the 54 species seen as juveniles in coral reef habitats, 51 were also seen as adults in the same habitats. Ten of the 14 species seen as juveniles in seagrass habitats were also seen as adults there, and 7 of the 9 species seen as juveniles in mangrove habitats also were seen there as adults. These results suggest that juvenile fishes tend to mature and live as adults in the same habitats they occupy as juveniles and that the supposed "nursery" function of mangroves and seagrasses may not be important to the reef fish fauna of oceanic islands.

A fourth interaction between mangrove, seagrass, and coral reef communities is through detrital food chains. All three communities produce organic detritus, but especially mangroves and seagrasses. Water circulation tends to carry this material throughout the coastal ecosystems and thus a considerable amount of organic material is redistributed among mangroves, seagrasses, and coral reefs. Furthermore, the tissues of seagrasses and mangroves (both terrestrially derived vascular plants) are rather resistant to marine bacterial decomposition. This slow decomposition stabilizes fluctuations in detritus availability and thus stabilizes fluctuations within detritus food webs.

CONCLUSIONS

There are two sides to our concern about coastal habitats. On the one hand we want to conserve them because they are valuable to us: they provide food (Johannes, 1977), building materials, firewood (Walsh, 1977), sites for recreation, and natural beauty. On the other hand, many essential, and perhaps inevitable, development needs depend upon our being able to use coastal areas for shipping facilities, waste discharge, aquaculture development (Macintosh, 1982), roads, and living areas. How can we valuate and balance these considerations? Or perhaps, more bluntly, how much development of coastal areas can we get away with?

It is not too difficult, in principle, to determine the commercial value of coastal resources within an area and compare that to the commercial value of a high rise hotel or a road in the same area. But until we have a better understanding of the interactive relationships among coastal zone habitats, we may seriously underestimate the impact of such a development on the whole system.

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SESSION III

ENVIRONMENTAL HEALTH ASPECTS OF COASTAL AREA ACTIVITIES

ENVIRONMENTAL HEALTH ASPECTS OF COASTAL AREA ACTIVITIES

by

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ABSTRACT

The paper deals with the public health aspects in relation to coastal area activities, particularly in connection with urbanization and industrialization. It describes possible hygienic and aesthetic effects of the resulting pollution on the marine ecosystem and living resources, and outlines several ways for the protection of the living resources and human health against waste discharge on the basis of established water quality criteria. The paper also gives the acceptable concentrations of both dissolved gases and inorganics (ions and free elements and compounds) in marine or estuarine waters. Finally, the paper briefly reviews the marine pollution by oil, pesticides and radionuclides and their health hazards.

INTRODUCTION

Urbanization and industrialization including tourist industry and fisheries are the main activities of coastal areas. These activities if left uncontrolled will lead to deterioration of the environment through the disposal of their wastes. For disposal purposes, we have treated land, sea and sky as though they are limitless. In fact they are not. We have pumped millions of tons of particulate matters and noxious gases into the atmosphere, polluted most of our water sources and sea, produced so much trash that we are running out of places for proper disposal, allowed pesticides to travel all through the food chain, accumulated mercury, lead, DDT, and other harmful elements in our bodies.

Also, urbanization and tourist activities are creating locally an immense sewage load for the coastal marine environment.

The ever increasing amounts of wastes from coastal activities are now interfering with marine life and environment. Industrial wastes often contain substances extremely toxic to marine life.

For this reason a safe way of marine disposal of liquid wastes must be adopted. The basic requirement for a satisfactory disposal of any liquid waste to the environment must be the adoption of the most economical system consistent with the protection of the community from health hazards, with minimum damage to amenity recreational and industrial use of the receiving waters. The system adopted should minimize the disruption of the natural environment and avoid undue adverse effects on the ecology of plant and animal life. In other words, when a liquid waste is discharged into the sea, the concern is directed to the possible hygienic and aesthetic and the impact on the fauna and flora in the marine environment.

PUBLIC HEALTH ASPECTS

Bathing water

The possible hazards arising from marine disposal of liquid wastes come from two sources: the amenity use of beaches for activities such as bathing, boating, water skiing, skin diving and the consumption of polluted fish, particularly shellfish. Although no association has been established between disease experience and bathing in polluted water, there seem to be universal agreement that bathing in polluted sea water increases the mathematical probability of contracting one or more of a variety of ailments, particularly those affecting the eye, nose and throat regions. It is important that coastal bathing waters be sufficiently free of pathogenic microbiological life so that water borne infections do not pose a significant health risk to those who utilize them for recreation. There are several potential routes of infection that microorganisms in water may follow in invading a human body. One of the more obvious routes is through ingestion of a sufficient quantity of water containing enteric disease producing organisms. Up to this date, there is little information concerning the amount of water a bather or swimmer ingests while swimming in coastal marine waters. It is assumed that the volume may be quite small, due to the saline characteristics of the coastal water.

Another route of infection is through the mucous membranes of the eyes, nose and throat. These portals of entry may result in localized infections or may cause general systemic disease. A third route may be the mechanical forcing of water into body cavities such as the nasal sinuses and ears. When this happens the infection tends to be localized in the body cavity into which the water was forced. A fourth route is through the skin.

Now there is some epidemiological evidence to suggest that there may be a positive correlation between the transmission of communicable diseases and the quality of bathing waters, i.e. the greater the degree of pollution of the bathing water the greater the health risk to the bather.

Effects on marine ecosystem and living resources

The protection of any living marine resources can most certainly be accomplished by protecting the integrity and balance of the greater or smaller ecosystem of which it is a part. Therefore, living resources depend upon the maintenance of primary and secondary production, as wastes which damage the plankton or secondary benthos may undoubtedly affect these resources. Both larvae of fish and shellfish are generally more sensitive to pollution damage than later stages in life. Fish and shrimps nursery areas, in particular, are often placed in shallow estuarine or coastal areas where pollution exterts its major effects. Although fish are frequently able to swim away from polluted areas, their very young stages are planktonic and drift only with tides and currents. Fish spawning and nursery areas are more or less fixed in position, and if seriously affected by pollution the stock may be severely damaged. Crustacea have a limited capacity for moving out of polluted areas, but mulluscs and other exploited invertebrates, and especially edible sea weeds are static and may require conditions for their cultivation which, if altered by pollution cannot be easily provided on alternative sites.

Oxygen depletion due to high organic pollution, the supply of excess nutrients and the discharge of toxic materials produce serious effects on marine ecosystem. A more specific risk to health can arise from the consumption of filter feeding shellfish taken from sewage contaminated waters, particularly where such shellfish may be eaten raw or partially cooked.

There is extensive evidence of the spread of diseases to man following the consumption of polluted shellfish. When shellfish are taken from polluted areas or handled under unsatisfactory hygienic conditions, they present a high risk to the consumer, which increases in frequency as greater quantities of shellfish are consumed.

In production areas, the handling, processing and transport to the consumer of shellfish should be under the control of the public health authorities. The implementation of an effective system of control may be costly to both the public health authorities and industry. However, epidemics of shellfish borne-disease may be more costly to the community in several ways. In addition to the direct and indirect costs of the diseases involved, there are further costs to the shellfish industry, as a result of stopping production, and to the tourist industry, as a result of stopping adverse publicity often given to epidemics associated with shellfish.

Generally, for the protection of living resources and human health from waste discharge, the following should be avoided:

- Concentrations likely to be directly toxic to any stage in the long life cycle.
- Long term exposure to lower levels of pollution likely to cause physiological damage.
- Bio-accumulation leading eventually to direct toxicity or loss of quality as sea food.
- Tainting
- Reduction of growth either directly or by impoverishment of food supply, e.g. by excessive turbidity.
- Eutrophication
- Alteration of environment, e.g. by deposition of sediments or ecosystem inbalance.
- Accumulation of surface films.

These requirements can be related directly to the characteristics of the waste, the control measures taken and to the choice of means and site of disposal. In general, for the protection of aquatic life the disposal of waste into the marine environment should not result in degrading the quality of water, and should comply with the following concentrations of the different parameters.

Dissolved Gases

Dissolved Oxygen:

Concentrations below 4.0 mg/l in marine or estuarine waters are unacceptable, and it is better to maintain the dissolved oxygen level above 6.0 mg/l, except when temporary natural phenomena cause this value to decrease.

Ammonia:

Concentrations of unionized ammonia in marine or estuarine waters should not exceed 0.4 mg/l. However, the maximum acceptable concentration of ammonia in these waters is 0.1 of the 96-hour LC_{50} value determined, using the receiving water in question and the most sensitive species in the locality as the test organism.

Hydrogen Sulfide:

Concentrations of hydrogen sulfide should not exceed 0.01 mg/l in marine or estuarine waters. The maximum acceptable hydrogen sulfide concentration in these waters is 0.1 of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Chlorine:

Concentrations of free residual chlorine in marine or estuarine waters in excess of 0.01 mg/l are unacceptable. The maximum acceptable concentrations of free residual chlorine is 0.1 of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Inorganics (Ions and free elements/compounds):

Antimony:

Concentrations of antimony in excess of 0.2 mg/l in marine or estuarine waters are unacceptable. The maximum acceptable concentration of antimony in these waters is 0.2 of the 96-hour LC_{50} value determined using the receiving water in question and the most important sensitive species in the locality as the test organism.

Arsenic:

Because of the tendency of arsenic to be concentrated by aquatic organisms, it is recommended that an application factor of 0.01 be applied to the 96-hours LC_{50} value for the appropriate organisms most sensitive to arsenic. It is suggested that concentration of arsenic should not exceed 0.05 mg/l in marine or estuarine waters.

Barium:

The maximum acceptable concentration of barium in marine or estuarine is 1/20 (0.05) of the 96-hour LC_{50} value for the receiving water in question with the most important sensitive species in the locality as the test organism. Concentration of barium in excess of 1.0 mg/l in marine or estuarine waters is unacceptable.

Beryllium:

The maximum acceptable concentration of beryllium in marine or estuarine waters must not exceed 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism. Concentration of beryllium in marine or estuarine waters in excess of 1.5 mg/l is unacceptable.

Bismuth:

No level of acceptability for the concentration of bismuth in marine or estuarine waters is prescribed.

Boron:

The maximum acceptable concentration of boron in marine and estuarine waters is 1/10 (0.1) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Bromine:

The maximum acceptable concentration of free (molecular) bromine in marine and estuarine waters is 0.1 mg/l; further the maximum acceptable concentration of ionic bromine in the form of bromate in these waters is 100 mg/l.

Cadmium:

The maximum acceptable concentration of cadmium in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism. In waters known to have concentrations of copper and/or zinc in excess of 1 mg/l, the maximum application factor for cadmium is 1/1000 (0.001) of the 96-hour value. Concentrations of cadmium in marine or estuarine waters in excess of 0.01 mg/l are unacceptable.

Chromium:

The maximum acceptable chromium concentrations in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism. Concentration of chromium in marine or estuarine waters in excess of 0.1 mg/l is unacceptable.

Copper:

The maximum acceptable concentration of copper (expressed as Cu) in marine and estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined by using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of copper in marine or estuarine waters in excess of 0.05 mg/l are unacceptable.

Fluorides:

The maximum acceptable concentration of fluorides in marine and estuarine waters is 1/10 (0.1) of the 96-hour LC_{50} value determined, using receiving water in question and the most important sensitive species in the locality as the test organism. Concentrations of fluoride in excess of 1.5 mg/l in marine or estuarine waters are unacceptable.

Iron:

The maximum acceptable concentration of iron in marine and estuarine waters is 0.3 mg/l.

Lead:

The maximum acceptable concentration of lead in marine or estuarine waters is 1/50 (0.02) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism. Further, the maximum acceptable 24-hour average concentration is 1/100 (0.01) of the 96-hour LC_{50}. Concentrations of lead in marine or estuarine waters in excess of 0.05 mg/l are unacceptable.

Manganese:

The maximum acceptable concentration of manganese in marine or estuarine waters is 1/50 (0.05) of the 96-hour LC_{50} value determined using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of manganese in excess of 0.1 mg/l in marine or estuarine waters are unacceptable.

Mercury:

The maximum acceptable concentration of mercury in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of mercury in excess of 1.0 mg/l in marine or estuarine waters are unacceptable. Further, intentionally adding mercury in marine or estuarine waters is unacceptable.

Molybdenum:

The maximum acceptable concentration of molybdenum in marine or estuarine waters is 1/20 (0.05) of the 96-hour lc_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Nickel:

The maximum acceptable nickel concentration in marine or estuarine waters is 1/50 (0.02) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of nickel in excess of 0.1 mg/l in marine or estuarine waters are unacceptable.

Phosphorus:

The maximum acceptable elemental phosphorus concentration in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of the elemental phosphorus in excess of 0.1 mg/l in marine or estuarine waters are unacceptable.

Selenium:

The maximum acceptable selenium concentration in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentration of selenium in excess of 0.01 mg/l in marine or estuarine waters are unacceptable.

Silver:

The maximum acceptable silver concentration in marine or estuarine waters is 1/20 (0.05) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of silver in excess of 0.5 ug/l in marine or estuarine waters are unacceptable.

Thallium:

The maximum acceptable thallium concentration in marine or estuarine waters is 1/20 (0.05) of the 20-day LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of thallium in excess of 0.1 mg/l in marine or estuarine waters are unacceptable.

Uranium:

The maximum acceptable uranium concentration in marine or estuarine waters is 1/100 (0.01) of the 96-hours LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentration of uranium in excess of 0.5 mg/l in marine or estuarine waters are unacceptable.

Vanadium:

The maximum acceptable vanadium concentration in marine or estuarine waters in 1/20 (0.05) of the 96-hour LC_{50} value, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Zinc:

The maximum acceptable zinc concentration in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the locality as the test organism.

Concentrations of zinc in excess of 0.1 mg/l in marine or estuarine waters are unacceptable.

Oil pollution

Oil pollution is popularly regarded as an important contaminant of the sea, very largely because it is visible and is a great despoiler of coastal amenities. It also kills sea birds, particularly the diving birds.

In general, oil is lighter than water and tends to spread fairly rapidly, forming a thin layer which moves over the sea surface under the influence of winds and tides.

In temperate and tropical zones oils are biodegradable and also polymerized, under the action of light and oxygen, density increases and the particles may become dense enough to sink. In very cold waters, such as the arctic, the rate of biodegradation appears to be very slow. Fresh crude oil can lose up to 30% by evaporation in 30 hours. A much smaller amount can dissolve in the water which increases the density to the sinking point.

Oils with high wax content or which are very viscious do not degrade so rapidly and are frequently found on beaches as lumps or tar balls. When highly dispersed, oil may be moderately toxic to marine life but under normal field conditions, toxicity is low.

In inland estuarine waters or enclosed bays or similar situations, the effect of the more toxic aromatic fractions together with the reduction in dissolved oxygen resulting from biodegradation may produce more marked mortality in many species.

Some oils contain carcinogenes, and their reported occurrence in the food chain as the result of pollution could lead to some risk to man as the ultimate consumer. Fish and shellfish become tainted in polluted areas and become unsaleable.

It is recommended that no oil or petroleum products should be discharged into estuarine or marine coastal waters, that:

- can be detected as a visible film of petroleum oil, sheen or discoloration of the surface, or by odour;

- can cause tainting of fish or edible invertebrates or damage to the biota;

- can form an oil deposit on the shores or bottom of the receiving body of water;

Pesticides:

The maximum acceptable concentration of pesticides in marine or estuarine waters is 1/100 (0.01) of the 96-hour LC_{50} value determined, using the receiving water in question and the most important sensitive species in the area as the test organism.

Radioactivity:

The acceptable levels of radionunclides in sea water are concentrations which are sufficiently small, that the concentration in any marine organism harvested for human consumption will not cause the total radionuclide ingestion by the most exposed group using the food to exceed that prescribed in Federal Drinking Water Standards. If the consumption of these foodstuffs is so widespread that the aggregate dose to the exposed population is likely to exceed 3000 man-rems per year. Limitations on the distribution and sale should be considered by the relevant public health authorities.

Aesthetic effects:

All coastal waters should be aesthetically pleasing. The use of beaches, shorelines and offshore waters for amenity and recreation make it necessary to avoid sewage discharge offensive to the nose and eyes. The assessment of what is aesthetically acceptable or objectionable is a matter of subjective opinion, and although efforts have been made to suggest quantitative standards, no authoritative standards have yet obtained general approval. Therefore, criteria concerning these aesthetic characteristics must be general and descriptive rather than specific and numerical.

The basic intent of these criteria is to maintain natural conditions of beauty and to restore degraded conditions of their former state of amenity. The presence of gross solids represents the main aesthetic objection to sea outfalls. When stranded on shore and combined with floating solids, they may constitute a health hazard. If the solids are wholly or even partially removed, aesthetic objections may be satisfied and the health hazard reduced. The breakdown of solids into finer particles causes greater exposure of sewage microorganisms to the inimical agencies of sea water and sunrays and thereby accelerates their death in the sea. The presence in sewage of grease, oils, wax and fats results in the formation of a visible film on the surface of the sea in the vicinity of the discharge point. These materials, which have surface active properties, tend to smooth out ripples and small waves, thus giving a ready indication of sewage discharge. Standards relating to solids, grease and oils would be particularly relevant if an outfall were to be located off the shore, which is continually susceptible to onshore winds. If solids, grease and oils come in contact with fish caught by trawling, there is a risk of the catch becoming a health hazard and hence financially devalued.

Colour and odour:

The incidence of detectable odours from marine discharges of sewage has recently been the subject of a preliminary study in which an attempt was made to relate the presence of smell to the dilution of sewage in a marine environment.

Indications were that fresh sewage was only detectable when undiluted, and that anaerobic sewage might only be detectable in a 5% concentration. Colour is another aesthetic problem, but with enough dilution, colour can disappear.

An initial dilution of 50:1 ensures dispersion of colouring material and other toxic materials discharged with the waste. A dilution of 500:1 at amenity shorelines is advisable to prevent colour and odour. Clarity of waters used for bathing and swimming is highly desirable from the standpoint of visual appeal (aesthetics), recreational enjoyment, and safety. Variations in natural conditions make it impracticable to establish definitive criteria.

In swimming areas, the water should be clear enough so that a secchi disc is visible to depths of at least 1.25 metres.

pH value:

Ideally, the pH of swimming water should be approximately the same as that of the lacrimal fluid of the eye, i.e. 7.4. However, since the lacrimal fluid has a high buffering capacity, a range of values from 6.5 to 8.5 can be tolerated under average conditions.

Generally, for aesthetic consideration, the disposal of waste should not result in degradation of the aesthetic quality of the aquatic environment of the seaside.

Waste disposal

The addition of the waste should not:

- Drop the pH of the coastal waters below 6.5 or raise it above 8.5
- Cause sewage odour at beaches; a dilution of 100:1 or even 500:1 is preferable to dissipate odour-producing materials.
- Result in reducing the clarity of water in designated bathing and swimming areas to allow detection of subsurface hazards or submerged bodies. A secchi disc should be visible to depths of at least 1.25 meters.
- Result in changing the physical and chemical characteristics of bathing water that render it toxic and irritating to the skin and mucous membranes of the human body.
- Contain chemicals in such concentrations as to be toxic to man if small quantities are ingested.
- Contain materials which may settle to form objectionable or undesirable deposits.
- Contain floating debris, oil, scum, and other similar materials.
- Contain substances which may produce objectionable or undesirable colour, tastes and/or turbidity.

Effects on other legitimate uses of the sea:

Some of the more important uses of the sea are: shipping, fishing operations, undersea mining, power station operation, industrial activities dependent on sea water, desalination, etc. Certain of these such as a power station operation, desalination and also most forms of mariculture, require particular standards of water quality and pollution control which must be kept firmly in mind when making a choice of treatment and disposal methods. Settleable matters in the waste may interfere in the long run with the shipping routes through the forming of sludge banks, and also through the blockage of cooling systems and the fouling of propellers. Certain pollutants may interfere with the cooling system in power plants which take their cooling water from polluted areas in the sea. Ocean mining on the bottom of the sea and extraction of chemicals from sea water may be affected by impurities or physical obstructions introduced by marine outfalls.

Certain scientific purposes, e.g. nature reserves, wildlife conservation (especially of sea mammals and sea birds) and marine parks, may be critically dependent upon freedom from pollution damage, and their presence may influence waste disposal policy beyond their immediate vicinity.

It must also be noted that cultured organisms are essentially captive and cannot escape a toxic water mass. Development of criteria for aquaculture should include consideration of: environmental stability, prevention of deleterious chemicals, physical and biological conditions and prevention of those environmental conditions favourable to the development of disease.

Outdoor recreation increases continually, and sea shore recreation ranks as one of the most important, economically and socially. Floating matters and grease constituents of the wastes interfere with these activities and should be removed before discharge.

Finally, we should bear in mind that man is the major pollutant of the environment. The problem is that the way man handled his environment was mere exploitation with a spirit of egoism and selfishness, which may have been unconscious, and if ignored, the future of the resources and of man himself will be endangered.

DOMESTIC WASTE RELEASE INTO THE ROPME SEA AREA

by

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ABSTRACT

The pollution load resulting from the discharge of sewage into the ROPME Sea Area from the different States is reviewed. The future trends based on available information is described. The potential impacts of the deposited sewage on the marine ecosystem and public health are also discussed. The alternatives for disposal and the re-use of the treated effluents for agricultural or other purposes and the economic, and social or other consequences and the methods for enhancing the safe re-use are outlined.

INTRODUCTION

The ROPME Sea Area is vital for the mere existence of the member states. It is used for transportation, fishing and as a source of drinking water via desalination. The importance of the sea for recreation cannot be overemphasised.

Discharge of sewage into the sea is considered one of the major pollution problems. It will cause the release into the marine environment of organic and mineral substances. Some are biodegradable and converted into simple elements, while others may accumulate in the water or in the sediment. The first may be well tolerated, the latter may be harmful. Their concentration may rise in the sediments or may pass through the food chain (Taylor, 1986).

Generally, three concerns, namely, the determination of the aesthetic values, the ecological impacts and public health protection are discussed by Price (1980). The appearance of an ugly floatsum from untreated domestic waste water discharged into the coastal area is particularly objectionable to the public (Myers and Ainger, 1980). The ecological impacts result mainly from the organic load that cause depletion of dissolved oxygen in satisfying the Biological Oxygen demand (BOD). Enrichment of the sea water by N and P can disturb the nutrient balance at the site of the discharge (Taylor, 1986). It can enhance the growth of certain marine organisms. The effect of such changes on fishes could be beneficial, however increased overall marine productivity might be detrimental. The nutrient load in the ROPME Sea Area resulting from the sewage discharge should however be compared to the nutrients carried by river. In extreme cases abundant weed growth may be caused, specially in low energy areas. Decay of these weeds can cause oxygen depletion and nuisance.

Public health may be threatened from the undue risk to the bathers who use the coastal area for recreation. Other health impacts would result from consumption of sea food contaminated by pathogenic organisms. Shellfish grown in polluted areas are particularly vulnerable to infection since they filter large volumes of water in feeding and may be consumed by the people raw or with insufficient cooking to kill the microorganisms (WHO, 1979).

The bacteriological standards for bathing water vary between countries. The European Economic Community's (EEC) directives require that 95% of the samples collected fortnightly at any particular point on the shore line shall show a total coliform count of less than 10,000/100 ml and a fecal coliform less than 2000/100 ml (EEC, 1976). Other levels are set for introviruses, streptococci and salmonella (Price, 1980). The WHO recommends that the level of fecal coliform should not exceed 100/100 ml for excellent beaches but <10,000 is acceptable (WHO, 1974). In U.S.A. the standards was set at 200/100 ml, not to exceed 400/100 in 10% of the samples taken within a month (EPA, 1976). Standards followed for Italy (100/100 ml), Belgium (200/100 ml in 50% of the samples) and Sweden (100/100 ml) are probably more strict than in other countries. USSR and Denmark set the standards at 1000/100 ml and Yugoslavia 2000/ml using the method of the most probable number (MPN). The proposed standard for Egypt is 100/100 ml in less than 50% of the samples and less than 1000/100 ml in 80% of the samples (ASRT, 1985).

The difference between countries is generally based on the prevalence of potentially water borne diseases (cases and carriers). More strict standards may be enforced in certain seasons when infectious disease may be more common (ASRT, 1985).

Care should be taken to provide a balanced outlook on water quality standards. First by studying existing qualities of sea water and their effects on the human environment. Legislation should be matched to prevent spreading disease. Assuming the law is designed not to be abused, too strict a legislation may prove unattainable, unrealistic because of financial constraints, and unnecessary because higher permissible limits of a particular contaminant would obtain the same end effect (Price, 1980). No standards have formally been adopted for the ROPME member states; proposals are however being discussed.

The infective dose of certain microorganisms as typhoid, cholera or virus is disputed. Certain authorities believe that 1% of those taking a single organism may develop the disease. Others report that it needs 2-4 microorganisms to show the symptoms.

Many investigations show that entrococci are more resistant and can out-survive the B coli (Vasconcelos and Anthony, 1985). Moreover many viruses may live for days or weeks in sea water depending on a multitude of physical, chemical and bacteriological factors. Sedimentation, solar energy, biotoxins, availability of nutrients, dilution process and pH should be considered.

The discharge generally takes place from outfall situated directly on the coastline. Fig 1 shows a schematic diagram of an outfall frequently seen in Kuwait. The figure is taken from a report prepared for EPC in Kuwait for study of the water front (El Sarawy et al, 1986). The behaviour of the water at both the low and high tide together with the role of dilution of the pollutants and the changes in the bacteria and algae according to the distance from the outfall is shown. The figure is just illustrative and is not to scale.

The level of B coli in the coastal area of Kuwait is being regularly monitored by the Environment Protection Departments and is published in the annual report. Weekly samples are taken from 10 sites. The total coliform and fecal coliform is being determined. Determination of the fecal streptococco was added in 1986. The annual mean total number of the total and fecal coliform at the different sites in the coastal water in 1985/86 expressed as the NO/100 ml is summarised in Table (1). For 1985 (EPD, 1986) the highest mean total coliform was observed at Al Salam (1228/100 ml) and Fintas beaches (1105/100 ml). The level was also high with Abuhalifa (989/100 ml) and Fahaheel (927/100 ml). The level was relatively lower with Al-Belajat (634/100ml) and Messila beaches (719/100 ml).

Table 1. Annual mean of total and fecal coliforms in coastal water, Kuwait in 1985 and 1986.

Location (Beach)		1985 No.	1985 Total Col/ Mean	1985 Fec. Col/ Mean	1986 No.	1986 Total Col./ Mean	1986 Fec. Col./ Mean
Al Salam	Z1	44	1228	538	44	9170	2320
Br. Emb.	Z2	42	823	427	44	5590	2240
Hilton	Z3	44	709	229	44	1890	780
Al-Shaa'b	Z4	44	894	274	44	1730	280
Ras-Al-Ard	Z5	44	857	233	44	1260	400
Al-Balajat	Z6	44	634	73	44	4040	360
Messila	Z7	41	720	334	44	940	280
Abu Al-Hass	Z8	41	883	364	46	1360	280
Abu Halifa	Z9	41	989	188	45	1780	660
Fintas	Z10	41	1106	386	47	2490	1230
Fuhaheel	Z11	41	927	293	46	3000	2490
Al-Beda's	Z12	41	191	84	46	650	280
Total			508		538		

The mean number of fecal coliform was persistently lower than the total. The general pattern was however preserved. The mean for Al Salam Beach (537/100 ml) was quite high. This was followed by the beach opposite the British Embassy (426/100 ml) and at Fintas (386/100 ml). The minimum was also observed at Al-Belajat (73/100 ml) and at the reference point (83/100 ml).

For 1986 (EPD, 1987) the level of pollution by the total or the fecal coliform was much higher than that observed for 1985. For the total coliform the levels were quite high for Al Salam Beach (9170/100 ml), the beach opposite to the British Embassy (5590/100 ml) and at (Z6) Al Belajat beach (4040/100 ml). The minimum was observed at the reference point (650). The mean number of the fecal coliform also seem to follow the fluctuation in the total coliforms. The maximum was observed at Al Salam (Z1) (2330/100 ml). The minimum was found at Al Shaab (Z4) and Al Beda beach (Z12), Messila (Z7) and at Hasaina beach with a mean of (280/100ml) each.

The monthly distribution of both types of microorganisms for the two years is summarized in Table (2). For 1985, the highest monthly mean total coliform was observed in March (1413/100 ml). The mean was also high in September (1197/100 ml) and October (1127/100 ml). January had the lowest mean (340/100 ml). The mean for Nov. (588/100 ml) and February (687/100 ml) came next. The mean fecal coliform is also shown in the Table. Much higher levels were observed also in March (438/100 ml), April (373/100 ml), September (488/100 ml), and October (424/100 ml). The minimum was seen in January (104/100ml) and November (179/100 ml) compared to the other months.

Table 2. The monthly mean number of the total and fecal coliforms in the coastal sea water samples, Kuwait (EPD) in 1985 & 1986

Month	1985		1986	
	Total	Fecal	Total	Fecal
January	340	104	3900	1176
February	687	192	2810	1183
March	1413	438	2607	566
April	901	373	6484	1524
May	910	245	7159	466
June	87	3	706	77
July	643	208	1692	288
August	827	309	806	125
September	1197	488	853	167
October	1127	424	1387	465
November	588	180	1874	669
December	930	433	954	245

For 1986, as was observed with the geographical distribution, the levels were relatively much higher than those observed for 1985. The maximum mean total coliform was reported in May (7159/ml). The mean was also high in April (6484/100 ml). It was appreciably lower for the other months. The minimum was observed in August (806/100 ml) and September (853/100 ml). The monthly distribution for fecal coliform for 1986 was seen to follow the distribution of the total. The minimum was quite high for May (2466/100 ml) and April (1524/100ml). This was followed by the mean for January (1177/100 ml) and February (1183/100 ml). The minimum is observed in June (77/100 ml). It was also low for August (125/100 ml) and September (167/100 ml).

It could be concluded that the sewage discharged into the coastal areas of Kuwait is causing pollution by fecal coliform and that there was much fluctuation between the different sites. The levels were appreciably higher in 1986 but marked monthly fluctuations were encountered. Moreover, there is some information which indicates that the situation was the same for a number of years.

Many high quality investigations were done by the Kuwait Institute for Scientific Research (KISR) (Al Mossawi et al, 1979) and by Kuwait University (Salem and Salama, 1981). Antibiotic resistant strains was investigated in the area opposite the hospitals (Al Mossawi et al., 1982). An investigation for the Kuwait Water Front sponsored by the EPC examined the prevalence of the major types of entrobacteria that were found in each month during a complete year (Al Sarawi et al., 1986). Al Mossawi et al., (1983) used clams as indicators of pollution.

No epidemiological surveys were done to investigate the impacts of the pollution of the beaches in Kuwait on the health of the bathers. Moreover, no data are available for the ROPME Sea regions; however the risk may be significant. The case of Alexandria, Egypt, may be of special significance since it was done in an area of similar geographical characteristics (ASRT, 1986). The socio-economic characteristics of the population and the prevalence of communicable diseases in Alexandria, Egypt, is not very different from what is found in Kuwait or in the ROPME Sea Area. The investigation was a longitudinal one that took 3 years and included examining the health status of those using 3 different beaches for bathing with significantly different levels of pollution by raw sewage.

At the time of investigation, 81 minor shore outlets were used to discharge raw sewage. Moreover the major sewage outfall extending for 735 m at a depth of 16m at the seaward side, was broken 300m from the shoreline.

The investigated subjects were divided into two categories: those living permanently in Alexandria and those coming for summer vacation. The two groups were further divided into bathers and non-bathers. The survey was directed to find out the difference in the incidence of gastroenteritis and certain other diseases that are transmitted by water as infection of the external ear, and eye or skin lesion between bathers and non bathers. 300-400 families were taken from the attendants of each of the 3 beaches. The results are summarised in Table 3.

Significant differences in the incidence of complaints were found out between the bathers and non bathers attending the 3 beaches. The difference was much higher among the summer visitors compared to the local group and this was found for 2 of the 3 beaches. However, the total score for the difference in case of the summer visitors attending sporting (14.76) and Ibrahimiya (10.68) were appreciably higher than the corresponding scores for the local group (8.62 and 6.40) respectively. The difference was not that marked with Montazah attendants, where the scores were 3.79 and 3.91 for the visitor and local groups respectively. The difference could be explained by the proximity of each of the beaches to the points of sewage discharge and hence the level of pollution by human excreta. The geometric mean for coliform using the MPN and % confirmed fecal streptococci at the 3 beaches is summarized in Table 4. It could be seen clearly that the level at the beach in which the higher prevalence of symptoms were reported (sporting) had also the highest pollution by the two types of microorganisms. The least polluted beach was the Mantazah, where the symptoms were significantly much lower (ASRT, 1986).

The other type of health impact is through the consumption of toxic materials. Discharge of waste water arising from industry may contain toxic substances. Certain heavy metals and non biodegradable chemical (BCP and pesticides) are likely to persist in the marine environment and will probably build up in the food chain (Taylor, 1986). Oil pollution may result from the refinering, transportation or drilling for petroleum. Moreover, oil discharged through the sewarage system is frequently reported.

Table 3. The difference in the prevalence of water-borne infectious diseases among the bathers and non-bathers attending the 3 beaches of Alexandria, Egypt. (Summer visitors and Local Group)

	Summer visitors			Local group		
Infec. Dis.	Sporting	Ibrahimiya	Montazah	Sporting	Ibrahimiya	Montazah
Fev.	2.1 +	1.0 +	0.4 +	1.0 +	0.3 +	0.3 +
Diar. & vom.	5.0 +	2.0 +	0.1 +	2.4 +	1.4 +	0.4 +
URT	2.6 +	2.3 +	1.4 +	1.0 +	0.9 +	0.6 +
Otitis ext.	0.6 +	0.9 +	0.6 +	0.9 +	0.8 +	0.2 +
Eye inf.	0.7 +	1.1 +	0.3 -	0.6 +	1.3 +	0.9 +
Skin inf.	2.6 +	3.4 +	1.7 +	2.7 +	1.8 +	0.5 +
Total	14.8 +	10.7 +	3.8 +	8.6 +	6.4 +	3.9 +

Quoted from ASRTE (1985).

Table 4. The number of the total and percentage of fecal coliform, together with fecal streptococci and percentage confirmed in the 3 beaches of Alexandria, Egypt included in the investigation.

		Total Coliform			Fecal Streptococci		
		Sporting	Ibrahimiya	Montazah	Sport	Ibrahimiya	Montazah
Number	Summer	11481	1862	316	32387	1622	933
% fecal/conf.	Summer	79	74	36	89	87	79
Number	Winter	25119	1995	64	117490	3239	407
% fecal/conf.	Winter	89	65	8	85	83	59

Quoted from ASRTE (1985).

SEWAGE DISCHARGED INTO THE ROPME SEA AREA

Two investigations were done to estimate the volume and the quality of the sewage being discharged into the ROPME Sea Area. The first was done by a UNEP expert group in 1980 in the context of investigating domestic pollution in the ROPME states (Hamza, 1980). The second was done for ROPME in 1986 by a group of consultants (Taylor, 1986). The second study is rather comprehensive and covered the urban centres in the coastal area, development of the sewage system, the existing sewerage, the annual pollution load from the domestic waste water and the future discharge to the ROPME Sea Area from each state from which the information was made available. The report, distributed as a ROPME document, was based on the information provided by the Member States in response to a questionnaire which was mailed to them. The Islamic Republic of Iran and Iraq did not respond and very little information was available from the 2 states. Only the highlights of the report is being presented in this paper. More details are available the document.

The volume of the sewage discharged into the Sea Area from the coastal areas of the different sites is summarized in Table 5. From Bahrain, a total of 115,000 m^3 of both treated (TSE) (74.0%) and non treated water (UTSE) (26.0%) is being discharged daily into the Sea Area. Most of the untreated sewage is disposed of into the land. The design specification, the length or depth at the sea side of the outfall is not reported. Presently none of the TSE is used for irrigation. The effluent contains 3200-4000 mg.litre TDS. All the sludge is being disposed of into the land.

From the Islamic Republic of Iran the available information denotes that a total of about 60165 m^3 of waste water is being discharged into the Sea Area with almost 79.3% treated. Most of the treatment works are package plants serving specific development. The level of treatment provided at each is not known. Moreover, the location of the sea outfalls is not reported. Major sources of discharge include Abadan and Khoramshaher. Sewage from these centres (50% untreated) is discharged in Krun river (Niyati and Keyrani). Untreated sewage from Mashur and Bandur Khomeyni is discharged into Khowr El Mosa estuary. However, self purification of the rivers will probably remove 50% of the organic load by the time the effluent reaches the ROPME Sea Area.

From the Republic of Iraq most of the sewage comes from the town of Basra (1 million) 100 km inland. A sewage system was commissioned for the city. The first two phases of the system are completed. The quality of water being discharged into any river in the Republic is set and a ministerial order was passed to regulate that. The design of the sewerage is based on an estimate of 125 litres/head/day. For the industrial effluent, amounting to 25% of the design volume, only primary treatment is provided. The quality of the water of Shatt El Arab is being monitored regularly.

The volume of water discharged from Kuwait amounts to 83,000 m^3/day, mostly treated (85.0%). Most of the effluent is treated to the tertiary level and is being used for irrigation. Partially treated effluent amounting to 11,800 meter is discharged daily from the Ardiya plant to the sea owing to overloading of the system. Also raw sewage is occassionally discharged from several pumping stations in the event of failure. The effluent quality is monitored to determine its usability for agriculture. In general, 14.6% of the water reaching the sewage treatment plants come from industrial sources, usually light industry. The effluent has notably low salinity.

Table 5. The volume of sewage effluent discharged into ROPME Sea Area from the different states according to the type of treatment

	Treated		Non Treated		Total	
	Vol.	%	Vol.	%	Vol.	%
Bahrain	85,100	74.0	29,900	26.0	115,000	100
Iran	12,475	20.7	47,690	79.3	60,165	100
Iraq						
Kuwait	71,400	85.8	11,800	14.2	83,200	100
Oman	5,000	100	0	0	5,000	100
Qatar	0	0	0	0	0	100
S. Arabia	160,000	95.2	8,000	4.8	168,000	100
Emirates	53,000	96.0	2,050	3.7	55,000	100

Very little effluent is probably discharged into the Sea from the Sultanate of Oman. The estimated volume is about 5000 m^3/day. The majority is chlorinated and is discharged from a 700 m sea outfall. Very little effluent is presently used for irrigation. The content of the septic tanks is discharged to land tipping sites.

From Qatar no sewage is regularly discharged into the Sea. The treated effluent has always been discharged into the desert or utilized for irrigation. Only surface water ranging from 5,000-16,000 m^3/day with high salinity is dumped into the sea. The salinity of the TSE is quite high and measures are taken to improve the quality to make it more suitable for irrigation.

The Saudi Arabian coast line is the most extensive. Sewage systems have been operational in many coastal urban centres for several years. At the time being, about 16,000 m^3 of treated and 8,000 m^3 untreated effluent is being discharged from sea outfalls into the ROPME Sea Area from seven urban centres in addition to discharges from Armaco package treatment plants. Full utilization of 3,400 m^3/day representing 83.0% of the TSE for agriculture is planned.

From the United Arab Emirates, 55,000 m^3/day is discharged into the Sea. Mostly treated (96.0%). In Abu Dhabi, the majority of the TSE (73%) is utilised for irrigation. It is planned to use all waste water by 1995. In Dubai, the sewage is serving 60% of the population. About 400 m^3 of untreated sewage is discharged daily from an emergency outfall. Another 100 m^3/day is discharged through unauthorised connections. From Sharjah tertiary treated effluent is available and is mostly used for irrigation though it had a high salinity (10,000 EC). Most of the effluent received by the sewage treatment plants in U.A.E. have about 5% of industrial effluent.

The estimated pollution load reaching the ROPME Sea Area with the discharge of sewage from Bahrain, Kuwait, Saudi Arabia and U.A.E. is shown in Table 6. No effluent reaches the sea from Qatar and the information is not available for either Iran or Iraq. The total BOD load is 7,650 ton/year. Similar loads come from Bahrain (2,647 tons), Kuwait (2,342 tons) and Saudi Arabia (2,191 tons). The load reaching the sea from the Emirates was significantly lower (469 ton/year). The suspended solids (SS) amounted to 8,019 tons. Bahrain contributed a higher load (3,097 tons) compared to either Kuwait (1,735 tons) or Saudi Arabia (2,580 tons).

Table 6. The pollution load discharged into the ROPME Sea Area from the different states. No wastewater is discharged from Qatar, details from Iraq and Iran are not available and insufficient information was provided by Oman.

POLLUTANT	LOAD CURRENTLY DISCHARGED FROM MEMBER STATE (Ton/yr.)				
	BAHRAIN	KUWAIT	SAUDI ARABIA	U.A.E.	(Ton/yr.)
BOD (5)	2,647	2,342.8	2,191	469.8	7,650.6
SS	3,097	1,735.3	2,580	606.6	8,018.9
SULPHIDE	-	87.4	-	28.2	115.6
AMMON.NITR.	461	935.3	-	251.4	1,647.7
NITRITE NITR.	-	25	-	19.8	44.8
NITRATE NITR.	-	1,284.5	365.3	154.8	1,804.6
CALCIUM	-	-	-	1013.2	1,013.2
MAGNESIUM	-	-	-	1391.4	1,391.4
SODIUM	-	-	-	6131.9	6,131.9
POTASSIUM	-	-	-	617.4	617.4
CHLORIDE	12,902	8,935.2	43,768	20,337.7	85,942.9
SULPHATE	6,144	9,195.8	-	4,552.2	19,892.0
ALKALINITY	-	9,121.3	-	4,785.6	13,906.9
PHOSPHATE	768	968	512.7	308.2	25,569.0
MERCURY	-	FREE	-	-	-
BORON	-	12.6	-	-	12.6
CADMIUM	-	2.4	-	263.7	266.1
ZINC	-	0.4	-	0.75	1.2
COPPER	-	0.3	-	1.72	2.0
NICKEL	-	0.7	-	1.3	2.0
ANIONIC DET.	-	-	-	2.0	2.0
RESIDUAL CHL.	-	10.4	-	50.5	60.9
C.O.D.	-	4,712.6	-	-	4,712.6

- Data not provided.

Analysis for sulphides was only available for Kuwait and U.A.E. This was also seen for boron, cadmium, zinc, copper, nickel and residual Cl_2. The load for chlorides 85,942 tons was mostly contributed by the UAE (20,337 tons) and Saudi Arabia 43,768 tons. Analysis of calcium and magnesium, were done only for UAE.

The characteristics of the sea area to which the effluent is being discharged is rather critical. These have been reviewed by several authors, for example, Taylor, (1986). The relevant characteristics of the sea area include clarity, high incident sunlight, temperature and dissolved Oxygen (Myers and Ainger, 1980). In ROPME Sea Area away from the wave action of the shore zone the water is generally clear and it is not unusual to be able to see to the depth of 20 metres or more. This is due to the low phytoplankton levels and the general low level of biological productivity in the water column resulting from low concentrations of nutrients. The climate of the area, with long periods of clear skies, combined with the clarity of the water ensure that the waters are subjected to the action of sunlight over long periods and to a great depth. Areas subjected locally to discharges of nutrients from wastes may experience intensive growth of phytoplankton. Where nutrients are maintained below the level which stimulates algal growth, the sunlight has a considerable bactericidal effect on coliform organisms. Based on the experience from the Mediterranean, the time taken to reduce coliform bacteria by 90 percent (T90), is probably less than 3 hours (Gameson and Gould 1974). The time of viruses to reach similar levels of dilution is probably longer (WHO Scientific Group, 1979).

In ROPME Sea Area current velocities are generally low. Normal velocities of 15 cm/sec are found and average values in the main body of the sea are frequently of the order of 5 cm/sec. As a consequence, effluents discharged at a distance from the coast line will move onshore only slowly and the suspended matter will settle out rapidly.

During the winter months, due to mixing processes, the difference in temperature between the lower and upper levels of the sea is relatively small. However, during the spring and early summer the surface layers are rapidly warmed, forming a low density strata from the surface to a depth sometimes reaching 15 to 20 metres. Effluents mixed with cold, denser seawater by a seabed diffuser system rises only as far as these layers and is then trapped beneath them. Thus, during the important summer months, effluents trapped in this manner will never reach coastlines except in the areas which experience the unusual phenomenon of upwelling.

The waters of the ROPME Sea Area is often saturated with dissolved oxygen, though the level may be low compared with other seas due to the high temperatures. Except where pollution has resulted in algal growth, it is not unusual for the waters to be supersaturated with dissolved oxygen. However, even given these low values, the oxygen demand of effluents discharged to the sea may be satisfied many times over, given appropriate design of the diffuse system.

Comparison between the conventional inland sewage treatment practices with marine treatment by long outfall is being discussed frequently for the coastal areas (Price, 1980). The choice of the treatment system is dependent on a number of factors, including the area of land available, proposed sludge disposal arrangements, capital cost, ease of operation and maintenance. It should be emphasised that the eventual degree of purification will also depend on many factors, including the strength of the untreated sewage, design of plant and competence of operation (Price, 1980).

Sites selected for inland treatment works should satisfy certain requirements (Price, 1980). Where possible, the site will be, below all properties to be served, to enable flows to gravitate to the works without unduly flat sewer gradients. It is better located about

1 km from any residential development and leeward of the prevailing winds to minimize any nuisance resulting from operational difficulties. Stable sub-soil at the site is required to avoid expensive foundation works. Land for construction and future expansion should be available. Reasonable access for heavy lorries to ease construction and to operate and maintain the works, particularly for sludge removal is important. The majority of development in the coastal region is placed along the shoreline thus making sewage treatment works difficult to locate. The lowest point or an urban complex is usually by the shore at the town centre. Sewage would have to be pumped some considerable distance to treatment site upland (Price, 1980).

In the conventional treatment works, the bulk of mineral and organic matter is separated from the water. The resultant water together with about 10 percent of the organic impurities is passed out of the works as effluent, while the remaining matter must be disposed of as concentrated liquid sludge. Treatment/disposal of sludge is generally the most difficult and expensive part of any sewage works operation and one which is likely to cause odour and other nuisances. A population of 200,000 would produce daily some 350 tonnes of wet sludge at 97% moisture content. Treatment generally involves digestion/dewatering before disposal or utilisation. There are a variety of disposal processes practised, all of which are extremely costly disposal methods (Price, 1980).

Any sludge disposal scheme should provide at least emergency storage of about one month's production. Most sludges have a high moisture content, incineration can only be considered seriously, if communes were to use the same process for the disposal of their domestic solid wastes, and even then there are problems (Price, 1980). Controlled tipping of sludge may present a potential hazard to polluting the groundwaters. Increasing scientific interest is being applied to sludge utilisation as an agricultural or horticultural fertiliser. If this were to be adopted, it is essential that treatment includes heated digestion because some viruses and bacteria, including Escherichia coli, salmonella and other pathogens can be retained in raw sludge. Raw sludge also contains large concentrations of heavy grease which, when decomposed within the soil, can lower the pH to produce acid conditions (Price, 1980). Raw sludge can contain weed seeds and may hold eelworm, tapeworm and helminthic cysts affecting cattle as well as humans.

Sludge digestion does not remove trace metals such as zinc, nickel and chromium. The uptake of these metals by plants is dependent on several factors related to the soil, but excessive dosing by sludge could increase the trace elements beyond tolerable limits. Spreading treated sewage sludge onto land as a soil conditioner/fertilizer is probably the most economic disposal process. However, application entail transporting sludge to agricultural areas at some distance from a treatment works, thus eroding any positive cost-benefit. Where industrial effluents are combined with domestic sewage for treatment, the sludge may contain toxic industrial effluents and thus may not be suitable for land disposal.

SEWAGE DISCHARGE INTO THE MARINE ENVIRONMENT

The marine environment is a good alternative in coastal areas for disposal of domestic sewage. After domestic sewage has been diluted one hundred times with clean sea water, i. is indistinguishable from a secondary treated effluent bacteriologically and is superior in quality from the point of view of biochemical oxygen demand and suspended solids. The natural purification processes of oxidation and disinfection treat the raw sewage so that eventually no change in the character and composition of the sea can be detected (Price, 1980).

The principal conditions to be achieved in the selection of any outfall should be that the combined effects of wind, tide and current ensure that no sewage can reach any part of the shore or target area without sufficient time has elapsed for adequate dilution and purification of organic pollutants and mortality of bacteria to have taken place. The discharge point and type of discharge nozzle should be such that the dilution is great enough, to avoid the formation of a slick. Where a slick is inevitable, discharge should be far enough offshore to render it inoffensive to people utilising recreational areas.

The siting and type of diffuser should take local fishing interests into consideration. The sea bed topography and geology should make the construction of the submarine pipeline practical and economic. It is fundamental to any sea outfall that the flows arriving at the discharge point should be comminuted and screened to produce finely divided particles free from gross solids. This process will provide the maximum interface between sewage and oxygen dissolved in the sea to accelerate the natural purification process. It is very important that machinery chosen for this operation should be designed to divide the particles into a size not greater than 12 mm in diameter. Disinfection together with drum screens can reduce bacterial concentration by three orders of magnitude or more. However, other sewage parameters are little changed. Such a process can reduce the length of the outfall but can only be used where the shorter outfall is compatible with water quality standards set for other sewage constituents. At present, chlorination is the only viable choice for disinfection of raw sewage. The coastal location of marine outfalls is attractive for on-site electrolysis of sea water for chlorine production. To avoid the hazards required for transport and storage of Cl_2.

The dilution of sewage discharged into the sea by a submarine pipeline at sea bed level some distance from the shore falls into three main categories. Initial dilution, which occurs between the point of discharge and surface, secondary dilution which is dependent upon the natural mixing forces of the sea caused by its turbulence, currents and eddies induced by wind and tide and dilution made possible by the die-off rate of bacteria (Price, 1980). The initial dilution of sewage discharged from a submerged pipe depends on the velocity of the jet leaving the pipe, the diameter of the outlet, the depth of water over the outfall and the ambient velocity at the point of discharge.

It has been suggested (White and Agg, 1975), that an outfall positioned close to a shoreline should be designed to give a higher initial dilution than one further out to sea. At distant points offshore, initial dilution would become relatively less important.

Newton (1975) observed that a slick will occur when initial dilution is less than 100 but is most unlikely to occur when initial dilution is in excess of 400. Between these two dilution levels, slick formation will depend upon the grease content of the sewage.

The point of discharge usually consists of a number of diffusers spread along the length of the last 100 or 200 metres of the outfall pipe, each of which discharges a horizontal jet of sewage into the sea just above sea-bed level. Once the sewage is released from the diffuser, the ensuing turbulence achieves an initial mixing and dilution with the sea; because the sewage, which is mainly composed of fresh water, is lighter than sea water, the mixed waters then rise to the surface of the sea in a "plume" with further mixing and dilution taking place (Price, 1980).

After reaching the surface the mixed waters move with the rest of the sea, there is a rapid rate of die-off for coliform bacteria. The "T90" figure can vary considerably, but in the summer months it was between 1.2 and 2 hours in the marine environment (WHO, 1979). After two hours, the natural dilution of the sewage may be as great as 1000 before any account is taken of purification or disinfection aspects. Well before this time, the dilution and natural purification will have made it impossible to detect the presence of sewage by physical and chemical indicators.

This comparison shows that properly designed marine treatment produces a satisfactory degree of treatment and should be more than acceptable. During the past decade, there has been a remarkable advance in the technology of laying submarine pipelines. It is now possible to construct sea outfalls which terminate in much deeper waters than was previously possible.

The older shorter outfalls earned "sea outfalls" a poor reputation. There is no doubt that many such old outfalls are most unsatisfactory. Chemically, the health risks associated with untreated sewage discharges from a correctly designed long sea outfall are minimal, as indicated by epidemiological studies of illness associated with swimming in sea water receiving sewage discharge (Cabelli, 1978). The situation does not appear to warrant spending large sums of money on research to fill the gaps between the bacteriological evidence showing the presence of known pathogens and the epidemiological evidence suggesting an absence of any effective health risk (Jaeger Report, 1970). During 1975, sea water samples were taken from above the new long sea outfall at Hercegnovil for bacteriological examination. In every case, the coliform count was found to be less than 500 per 100 ml which more than adequately complies with many public health standards.

Inland treatment works are liable to have occasional smell and operational problems and should be sited as far as reasonably possible from residential development. A sewage works sited in otherwise undeveloped land is a visual intrusion, and reduces the public's potential enjoyment of the area. Road haulage tankers that transport the sludge cause further disturbance. The preliminary treatment works of a long sea outfall consists of very smaller structures than those of an inland treatment works and can usually be located below ground level and designed to reduce odour problems.

A comprehensive study of the effect of that sewage discharges to the sea have on marine life was undertaken recently by the British Government. on the inshore waters of Liverpool Bay in England in connection with the 5 km North Wirral long sea outfall (HMSO, 1976). A marked improvement has been achieved in the quality of the inshore waters as a result of the abandonment of the old short falls. Apart from the small area immediately surrounding the discharge point of the new outfall, the new sewage discharge had no measureable effect on the general condition of the off-shore waters. It was also apparent that the dilutions achieved were considerably better than had been predicted and the presence of sewage from the outfall could not be detected by chemical or bacteriological indicators beyond 200 m and 400 m respectively from the new discharge point (HMSO, 1976).

Certain species of fish are attracted to points where the sewage is discharged and there maybe some localized changes in fish colonies. Except for certain bi-valves and shellfish, there is no health risk in eating fish caught in such waters. The operation of an inland treatment works can be affected by interruption of power supply, shortage of essential materials like chemicals, or spare parts and difficulties in recruiting skilled workers for the plant. Inhibition of the purification and/or the sludge digestion processes by toxic or other unusual industrial wastes in the sewage is likely to result in serious problems. Any pumping station conveying sewage to the works is also vulnerable to the same problems.

Interruption in the normal operation of an outfall are likely to be less frequent and the consequences will probably be minor because of the fewer processes involved, smaller amounts of machinery and equipment to operate, and reduced labour requirements. Because there is no sludge disposal problem, a long sea outfall is significantly easier to operate, as well as being more reliable in its operation to achieve the design treatment standards. Disposing of sludge into the marine environment does not in any way create undesirable conditions. The sea has enormous capacity to absorb and treat very large quantities of domestic sewage sludge (Doe, 1972).

Water re-use

Unintentional re-use of waste water has been practised since ages. Rivers have almost always served as public water sources and as receiving bodies for waste water. Drainage has often percolated into underground water and has been later used. The water cycle itself is a form of re-use on the global scale.

Some of the more important intentional uses are, industrial, agricultural, recreational and non-potable municipal uses. Industry has differing requirements for the quality of water used in its processes. It is generally only worthwhile to consider treatment of municipal sewages to an intermediate quality where reuse is contemplated, each industry further improving the quality to its own requirements. The distribution of this effluent to industry would necessitate a network completely separate from the potable supply. It is however unlikely that textile or food processing industries would consider the use of such effluent. Industries requiring large quantities of water for cooling have generally been located at the coast and use sea water. The treatment of effluent to a quality suitable for industrial re-use could not be justified, given the existence of an adequate source of fresh water and industries existing practice of ground water abstraction. (Myers and Ainger, 1980).

The use of treated wastewaters for filling lakes to be used for boating, fishing, and sometimes swimming is not new. Lakes fed by treated wastewater at California, U.S.A. have been in existence for 10 years (Merrell et al., 1967). At this location the municipal wastewater is treated by the activated-sludge process, fed into a lagoon, chlorinated and spread onto a natural bed of sand and gravel, where it passes through several hundred feet of horizontal filtering. The water then flows into man-made lakes, which are used for boating and fishing. The water has been found to be bacteriologically safe and free of enteric viruses. No deleterious effects on the health of the users have been detected. Similar lakes are being established (Dryden and Stern, 1968).

Municipalities can use well treated effluents for many non-potable purposes. Examples are, street-flushing and flushing of toilets, watering landscapes, roadside verges, public parks, and the grounds of the treatment plant itself. Underground injection to repel salt water intrusion, and fish farming may be advised. In 1956-57, reclaimed water was used for public water supply in Chanute, Kans., U.S.A as an emergency measure for a limited period (Metzler et al., 1958). Despite an accumulation of dissolved minerals to objectionable levels due to continuous recycling, no adverse health effects were detected.

The re-use for agriculture is an old and common practice in many countries, especially in warm arid regions. In India, the first sewage farm was established in 1985. Today, there are 130 farms covering 12,000 Ha, using over 500 million m^3/year. In Germany, the first sewage farm was established even earlier (1880). Today, 120 to 300 million m^3 of sewage is used in this manner per year. In the U.S.A., over 1,300 industries and 950 municipalities practice land disposal. Not only is the water reused, but nutrients are effectively removed from it. The major disadvantage is the seasonal nature of irrigation demand requiring alternative methods of disposal or of holding the wastewater till such time as it can be used again for irrigation. Indiscriminate use can damage soil conditions, pollute ground waters and affect the health of those who work on the farm or consume its products. None of these problems should exist in a well-designed and properly managed farm (Arceiva La, 1976).

Water application rates depending on climate, crop and soil. Nutrient requirements of crops, nutrients available in wastewater and organic load on the soil should be considered. Pathogen transmission, toxic substances transmission in food chain, build-up of salts in the soil and the long-term effects on soil and plants, should be alleviated.

Generally, fodder grasses are preferred to be grown on sewage farms since they have a high nutrient demand, a greater tolerance to wastewater quality and a relatively longer growing season. Stoppage of wastewater irrigation about two weeks prior to harvesting is often recommended.

Many variables affect survival rate of different organisms. Farm workers have to follow hygienic methods of work to avoid worm and other infections. Certain persistent substances contained in the irrigational waters may first accumulate in the soil and then be taken up by the crops, thus entering the food chain. More serious consideration is being given at the present time to the fate of cadmium, copper and zinc in the food chain. However, agronomists studying the application of Chicago sludge on land concluded that the land in question had the ability to accept accumulations of heavy metals for at least 100 years without any adverse effects on crop productivity or usefulness.

Plant uptake depends on plant species and soil chemistry. Generally, in alkaline soils, heavy metals are precipitated and are practically not available. Metals are absorbed on hydrous oxides of Fe and Mn. Organic matter in soil also tends to chelate and fix heavy metals. Chemical tie-up of metals is promoted in clayey soils with higher cation exchange capacity.

The methods of application of the water is critical. Three alternatives are in use. These are overland flow, spray irrigation, or injection at the subsoil level. The last method is most favourable and has the extra advantage of economising on the water by limiting the evaporative losses in arid regions. The least acceptable of the methods is the use of spray. However, a number of investigators do not think that the method is as bad as it looks (Popp, 1967). Popp (1967) by testing specimens of the soil in several depths and within different periods of time after sprinkling found that the bacteria of the sewage water were distributed vertically and rather evenly in the soil up to the depth into which the water penetrated. Penetration of the water at the same time depends on the sprinkled amount of water and the field capacity of the soil; at sprinkling of 50 to 70 millimetres, the depth of penetration normally does not substantially exceed 50 to 60 centimetres. The bacteria and worm-eggs in the sewage water do not remain on the surface like in a filter, but disappear during sprinkling into the soil and therefore, do not encounter personal contacts. It is remarkable that even on an intensively cultivated soil with a good top soil, the bacteria of the sewage water do not seem to penetrate into the lower depths and possibly into the subsoil water. In a field test where the subsoil water was close to the surface, it did not cause pollution of the subsoil water by bacteria. Testing the bacteria within different periods of time after the irrigation, and at different depths, showed that the contents of bacteria (E.coli) declined within the first ten to twelve days by several ten orders of magnitude. Of a total of 920 samples from an area on which sewage water had been utilized, the presence of salmonella bacilli was indicated in about 5% of the samples, and were found mainly right after the sprinkling or within the first week after sprinkling. Obligatory pathogenic salmonella bacilli typhosa and enteroviruses (Polio, Coxsacke, Echo) do not seem to be existent in this consistency in the soil, for out of 73 samples, one case of Enterovirus was isolated, and that was taken immediately after the irrigation with sewage water. Sprinkled sewage water in about 65-70% of all tested contained enterovirus. The conditions in the soil are quite different from that when sewage is drained into waters. The capacity of the soil for control of microorganisms seem to be much better from the hygienic point of view, and that is not only because pathogenic agents can be killed more reliably and quickly in the soil than in water, but because the pathogenic agents are fixed in the soil, whereas in the water they are spread out and distributed over wide distances (Popp, 1967).

The behaviour of pathogenic microorganisms in the sewage sprinkled over vegetation is interesting. Practically all hygienically important germs can only remain viable on the plant for a limited time. In outdoor experiments on grass plants, within a week after the sprinkling, there is a drastic reduction in the number of B.coli, and 14 days after the sprinkling, the number of B.coli on the plant's surface was reduced by an order of magnitude; corresponding roughly to that on an unsprinkled plant. These are reproduceable phenomena. It is quite obvious that pathogenic microorganisms from sewage can only remain viable for a very limited time on sprinkled plants growing in outdoor conditions.

As far as the spreading of eggs of taenia saginata through the sprinkling of pasture-land with sewage is concerned, extensive inquiries have so far produced no indications that there has ever been a case of cattle being infected with tape worm (Popp, 1967). Investigations about the spread of bacteria when employing various types and sizes of spray and working under various wind conditions have shown that effective protection of residential property or roadways can only be guaranteed if as a general principle sprinkling is not carried out in the vicinity of these vulnerable localities when the wind is blowing towards them (Katzenelson et al., 1977). In the vicinity of these protection zones, moreover, only sprinklers with small nozzle openings (5-7 mm) and a small setting angle (15^{o}) may be used. Serious danger to persons who come within range of the sewage sprinkling or spraying is small by the fact that local residents and passers-by try to avoid coming within range of the spray. An epidemiological inquiry revealed that in the villages immediately bordering on the area used for sewage utilisation by the Wolfsburg Sewage Company, not a single case of typhoid, paratyphoid or other salmonella infections occurred between the years 1950 and 1965 (Popp 1967).

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SESSION IV

ASSESSMENT OF DEVELOPMENT ACTIVITIES AND THEIR IMPACT ON COASTAL AREAS

ENVIRONMENTAL IMPACT ASSESSMENT - A PRACTICAL APPROACH

by

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ABSTRACT

The suggested practical approach to EIA differs from the conventional one in the following ways: (a) it recognizes and utilizes the fact that very few projects are unique in nature or size. Therefore, knowledge about observed environmental effects in analogous cases can be used as a tool in environmental impact assessment; (b) with a monitoring activity as an integrated part of EIA, errors in prediction can be observed and corrected, more knowledge about environmental consequences can be gathered on an on-going basis, and more accurate predictions can be made; and (c) as a consequence of better use of knowledge from analogous cases and monitoring programmes, less time-consuming and costly collection of site-specific data will be required. As a result, in the preparation of EIA one can concentrate on effects known to be of practical relevance and put less emphasis on the theoretical consequences.

The advantages of this practical approach to EIA are that in most cases: (a) it can be based on existing or deducible information; (b) it should be possible to produce within a few months; (c) after initial training, national civil servants, administrators or scientists should be able to prepare it, so that foreign consultants should no longer be needed; and (d) that cost to produce an EIA should be lower.

BACKGROUND

History of environmental impact assessment development

The need for environmental assessment was clearly recognized at the Stockholm Conference on the Human Environment in 1972. Thus UNEP was given that task and has been engaged in developing methodologies for sound environmental management.

The formal process that we know today as Environmental Impact Assessment, or EIA, resulted from the raising of environmental awareness during the 1950's and 1960's; during those two decades it became increasingly evident that many industrial and development projects were producing undersirable environmental consequences. In response to these problems, the United States government decided that a mechanism was needed to ensure that all major government development proposals were subjected to some sort of examination of the total environmental consequences. Therefore, on January 1, 1970 the United States Congress enacted the National Environmental Policy Act (NEPA) which was both the first comprehensive piece of environmental legislation and the first use of the concept of environmental impact assessments. Section 102 of NEPA set forth the requirements for environmental impact assessments in the U.S. Essentially, they were to be systematic and interdisciplinary evaluations of the potential environmental effects of all major federal actions. Since the enactment of NEPA, EIA legislation has increased worldwide and even certain countries lacking environmental legislation produce environmental impact assessments selectively.

Worldwide, EIAs are provided for to varying degrees in various international agreements (UNECE, 1984). In the Law of the Seas Convention, Article 206 requires any state which expects an activity to cause "substantial pollution or significant and harmful changes to the marine environment" to assess and report these outcomes. Similarly, the Convention for Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region requires that when planning projects, the concerned parties should attempt, when possible, to assess the potential environmental effects within their territories.

In the Genoa Declaration of September 1985, the Contracting Parties to the Convention for the Protection of the Mediterranean Sea against Pollution adopted a decision to "apply Environmental Impact assessment as an important tool to ensure proper development activities". (UNEP, 1985).

An ambitious attempt to develop EIA further and to define environmental capacity on scientific grounds was made by GESAMP. (GESAMP, 1986). Unfortunately the attempt fell short both on scientific grounds, because the ability to theoretically forecast ecological effects is not available, and on practical grounds, because the exercise became too theoretical for management purposes. However, the report contains many thought provoking concepts and ideas and provides interesting reading on the subject.

Basic concepts and applications

The first step in understanding EIAs is to define what the process actually entails. While many definitions are given in the literature (Ahmad and Sammy, 1985; Munn, 1975; Canter, 1979; Jain *et al*., 1977), the actual working definition varies between countries. In general, an EIA is the process of identifying, predicting, interpreting , and communicating the potential impacts that a proposed major project or plan will have on the environment. However, in the United States, an EIA is used to determine if a project will have significant or controversial environmental impacts and only if the conclusion is positive will a more detailed Environmental Impact Statement (EIS) be required.

An EIA process is often described as an assessment of how — negatively or positively -- a project affects various impact indicators. An impact indicator is an element or parameter that provides some sort of measure of the magnitude of an environmental impact. (Munn, 1975). Examples of different indicators are: level of employment, loss of forest and vegetation, or changes in water quality parameters such as pH and turbidity. The measurement may be either qualitative or quantitative, depending on the parameter and the means of evaluating future change. For instance, some indicators may be evaluated according to preexisting standards or laws, for example, air and water quality, and noise. Other indicators, such as morbidity and mortality, may have numerical scales for judging the future impact. In some cases, it may be necessary to use a more qualitative and possibly a more value-based scale of change, such as acceptable and unacceptable. However, even when using such a scale, the basis for evaluation may be somewhat quantitative, such as the number of trees to be harvested or the number of residents to be dislocated. The assessment of the potential effects on a cross-section of these impact indicators is the backbone of EIA.

The responsibility of carrying out EIAs depends on the legislative requirements of each country. Each country has established different requirements for the preparation and review of EIAs as best fits its governmental system. Essentially, three basic options exist for assigning responsibility for such projects. (OECD, 1979). In the first option, the agency or group proposing the project is responsible for preparation of the EIA. Alternatively, the government agency controlling or authorizing the project may be responsible. Thirdly, an independent party could be established for preparation of EIAs. To eliminate possible bias which could arise when a project proponent prepares the EIA, guidelines for form and content can be prepared by a responsible government agency, supervision can be provided by a reviewing or controlling body with no interest in the project, and/or publication and public review of the final EIA can be required (OECD, 1979).

Past experience of EIA and justification for a practical approach

EIAs have been extensively produced and used over the last 15 years. Their wide application clearly indicates a need to ensure that environmental considerations are included in the decision making process. However, particularly in developing countries, the established procedure for EIA has met such criticism. Specifically, the following shortcomings have been highlighted:

- Collection of data for EIAs has taken considerable time, often delaying urgently needed projects;

- The infrastructure in developing countries with regard to available information, institutions and personnel has made it impossible to prepare EIAs without assistance from foreign experts. Hence, the knowledge and experience of the procedure has remained with foreign consultant firms;

- Frequently, a large proportion of the background material included in the EIAs has been excerpted from the foreign consultant's word processor memory, and ends up being identical, whether the project is proposed for the wetlands of Bangladesh or the arid area of Chile;

- Past EIAs have been too voluminous (frequently more than 1,000 pages), and have often attempted to cover every theoretical possibility, with the result that they have been of little value as management tools;

- The cost of preparing EIAs is frequently high.

The practical approach to EIA suggested herein differs from the conventional one in the following ways:

- It recognizes and utilizes the fact that very few projects are unique in nature or size. Therefore, knowledge about observed environmental effects in analogous cases can be used as a tool in environmental impact assessment;

- With a monitoring activity as an integrated part of EIA, errors in prediction can be observed and corrected, more knowledge about environmental consequences can be gathered on an on-going basis, and more accurate predictions can be made;

- As a consequence of better use of knowledge from analogous cases and monitoring programmes, less time-consuming and costly collection of site-specific data will be required. As a result, in the preparation of EIA one can concentrate on effects known to be of practical relevance and put less emphasis on the theoretical consequences.

The advantages of this practical approach to EIA are that in most cases:

- It can be based on existing or deducible information;
- It should be possible to produce within a few months;
- After initial training, national civil servants, administrators or scientists should be able to prepare it, so that foreign consultants should no longer be needed;
- The cost to produce an EIA should be lower.

Contents of EIAs

The EIA usually includes the following:

- Description of the proposal and activities it is likely to generate;
- Description and evaluation of the site and its surrounding elements without the proposed project;
- Reasons for selecting the proposed site and the proposed technology;
- Identification and assessment of anticipated or forecasted negative as well as positive impacts on environmental quality and environmental health as a consequence of implementing the project; and
- Description of measures proposed for eliminating, minimizing or mitigating the adverse impacts.

Role in the decision-making process

A satisfactory decision can no longer be made on any project without consideration of the environmental consequences. Obviously, in many cases socio-economic and/or political considerations are of decisive importance. However, the role and function of EIA is to focus on the environmental issues to ensure that the potential impacts are considered in a thorough and systematic manner; when such impacts cannot be avoided, they may at least, with foresight, be minimized or mitigated.

EIA as a continuous process

Any assessment of environmental consequences involves uncertainties. It may be argued that the practical approach suggested here, with an EIA prepared largely based on existing knowledge and analogies from previous experience of similar projects, is even more uncertain than the more elaborate, time consuming and costly approaches usually used.

In order to make sure that unexpected adverse effects do not occur, a monitoring programme is advocated. The monitoring programmes would gradually add to the knowledge about environmental consequences and thus improve the quality of future analogous assessments. In a specific site the monitoring programme may lead to results that necessitate reassessment of the project or of the mitigating measures. Thus EIA is a continuous process. Programmes would gradually add to the knowledge about environmental consequences and thus improve the quality of future analogous assessments.

GENERAL PRINCIPLES OF ENVIRONMENTAL IMPACT ASSESSMENT

Based on proposals made by the Working Group of Experts on Environmental Law during its session on environmental impact assessment held in Geneva 12-16 January 1987 (UNEP/WG. 152/2), the following principles were approved by the Governing Council of UNEP at its Fourteenth Session (UNEP.GC/14.17).

Principle 1

States (including their competent authorities) should not undertake or authorize activities without prior consideration, at an early stage, of their environmental effects. Where the extent, nature or location of a proposed activity is such that it is likely to significantly affect the environment, a comprehensive environmental impact assessment (EIA) should be undertaken in accordance with the following principles.

Principle 2

The criteria and procedures for determining whether an activity is likely to significantly affect the environment and is therefore subject to an EIA, should be defined clearly by legislation, regulation, or other means, so that subject activities can be quickly and surely identified, and EIA can be applied as the activity is being planned.

For instance, this principle may be implemented through a variety of mechanisms, including:

(a) List of categories of activities that by their nature are, or are not likely to have significant effects;

(b) Lists of areas that are of special importance or sensitivity (such as national parks or wetland areas), so that any activity affecting such areas is likely to have significant effects;

(c) Lists of categories of resources (such as water, tropical rain forests, etc.), or environmental problems (such as increased soil erosion, desertification, deforestation) which are of special concern, so that any diminution of such resources or exacerbation of such problems is likely to be "significant";

(d) An "initial environmental evaluation", a quick and informal assessment of the proposed activity to determine whether its effects are likely to be significant;

(e) Criteria to guide determinations as to whether its effects are likely to be significant. If a listing system is used, it is recommended that states reserve the discretion to require the preparation of an EIA on an *ad hoc* basis, to ensure that they have the flexibility needed to respond to unanticipated cases.

(f) An identification and description of measures available to mitigate adverse environmental impacts of the proposed activity and alternatives, and an assessment of those measures;

(g) An indication of gaps in knowledge and uncertainties which may be encountered in compiling the required information;

(h) An indication of whether the environment of any other state or areas beyond national jurisdiction is likely to be affected by the proposed activity or alternatives;

(i) A brief, non-technical summary of the information provided under the above headings.

Principle 3

In the EIA process the relevant significant environmental issues should be identified and studied. Where appropriate, all efforts should be made to identify these issues at an early stage in the process.

Principle 4

An EIA should include, at a minimum:

(a) a description of the proposed activity;

(b) a description of the potentially affected environment, including specific information necessary for identifying and assessing the environmental effects of the proposed activity.

(c) A description of practical alternatives, as appropriate;

(d) an assessment of the likely or potential environmental impacts of the proposed activity and alternatives, including the direct, indirect, cumulative, short-term and long-term effects;

(e) An identification and description of measures available to mitigate adverse environmental impacts of the proposed activity and alternatives, and an assessment of those measures;

(f) An indication of gaps in knowledge and uncertainties which may be encountered in compiling the required information;

(g) An indication of whether the environment of any other State or areas beyond national jurisdiction is likely to be affected by the proposed activity or alternatives;

(h) A brief, non-technical, summary of the information provided under the above headings.

Principle 5

The environmental effects in an EIA should be assessed with a degree of detail commensurate with their likely environmental significance.

Principle 6

The information provided as part of EIA should be examined impartially prior to the decision.

Principle 7

Before a decision is made on an activity, government agencies, members of the public, experts in relevant disciplines and interested groups should be allowed appropriate opportunity to comment on the EIA.

Principle 8

A decision as to whether a proposed activity should be authorized or undertaken should not be taken until an appropriate period has elapsed to consider comments pursuant to principles 7 and 12.

Principle 9

The decision on any proposed activity subject to an EIA should be in writing, state the reasons therefore, and include the provisions, if any, to prevent, reduce or mitigate damage to the environment. This decision should be made available to interested persons or groups.

Principle 10

Where it is justified, following a decision on an activity which has been subject to an EIA, the activity and its effects on the environment or the provision (pursuant to principle 9) of the decision on this activity should be subject to appropriate supervision.

Principle 11

States should endeavour to conclude bilateral, regional or multilateral arrangements, as appropriate, so as to provide, on the basis of reciprocity, notification, exchange of information, and agreed-upon consultation on the potential environmental effects of activities under their control or jurisdiction which are likely to significantly affect other States or areas beyond national jurisdiction.

Principle 12

When information provided as part of an EIA indicates that the environment within another State is likely to be significantly affected by a proposed activity, the State in which the activity is being planned should, to the extent possible:

(a) Notify the potentially affected State of the proposed activity;

(b) Transmit to the potentially affected State any relevant information from the EIA, the transmission of which is not prohibited by national laws or regulations; and

(c) When it is agreed between the States concerned, enter into timely consultations.

Principle 13

Appropriate measures should be established to ensure implementation of EIA procedures.

Evaluation of Principles

These principles are general in nature and can be applied anywhere in the world. However, it is felt that they are not of immediate value to countries unless they are supplemented by more specific procedure and guidelines. It was therefore decided to suggest a model procedure that would be adopted and implemented by countries when they start to apply an EIA in their decision making process.

SUGGESTED PROCEDURE

INTRODUCTION

An EIA consists not only of the writing of a report through which information is provided to the decision maker, but also of procedural provisions to make sure that the decision maker takes the information adequately and fully into consideration. Broadly speaking, this means that an EIA procedure should contain at least those process elements that guarantee that the decision maker is provided with the proper information, and that this information is taken adequately and fully into account in the decision making. A successful EIA is therefore one which "ensures that all relevant impacts associated with proposed projects are adequately and fully taken into account in the decision making process." (ENV.GE/1/R.35).

An EIA should be viewed as an integral part of the project planning process, beginning as early as possible with identifying the potentially significant environmental impacts, continuing throughout the planning cycle, and including as far as possible, public participation.

Definition of terms

Applicant: A person, company or organization applying for permission to carry out a project which may have an environmental impact.

Authorization: Permission to carry out a project which may have an environmental impact.

Authorizing Authority (A.A.): The national authority legally authorized for issuing authorization.

Environmental Authority (E.A.): The national authority in charge of environmental management and protection. Could also be a branch of the Authorizing Authority.

Environmental Impact: Effects on the environment caused by man.

Environmental Impact Assessment (EIA): The assessment of the character and strength of the effects on the environment caused by a proposed action. In principle an EIA should also compare various alternatives by which a desired objective may be realized, and seek to identify the one which represents the best combination of economic and environmental costs and benefits.

Environmental Protection Measures: Any action taken in order to mitigate or eliminate the damage or risk of damage.

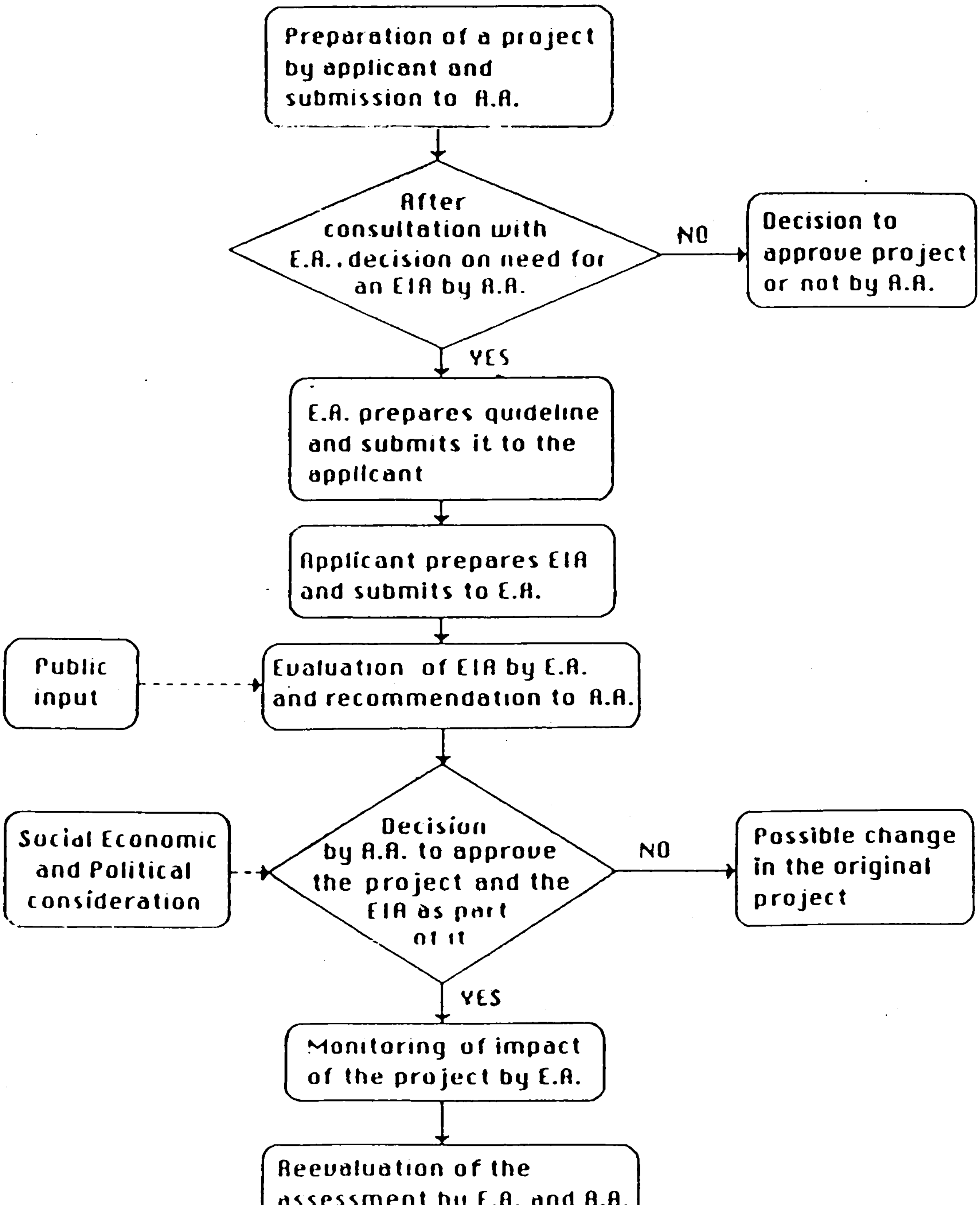
Guidelines: Set of subjects to be dealt with by the applicant in the preparation of the EIA; they are prescribed by the E.A.

Specific Guidelines: Questions that the applicant should deal with in the preparation of the EIA based on the Guidelines, and prepared specifically for a certain project.

Contamination: Introduction by man into the environment of elements or energy that will lead to changes in ambient levels or concentrations.

Pollution: Adverse environmental effects resulting from the introduction by man into the environment of elements or energy.

A FLOW CHART FOR THE EIA PROCEDURE



Environmental impact assessment procedure

(See Flow Chart, previous page)

Preparation of a project by applicant and submission to A.A.

In applying for an authorization of a project proposal, the applicant should provide the Authorizing Authority (A.A.) with a detailed description of the planned project including all relevant information such as maps and drawings.

After consultation with E.A., decision on need for an EIA by A.A.

The A.A. then consults with the E.A. as to whether or not an EIA is needed for the decision making process. The E.A. should determine whether an activity is likely to significantly affect the environment and is therefore subject to an EIA (see principle 2, above). If there is no need for an EIA, the A.A. will proceed in the decision making process and will determine whether or not to approve the project.

E.A. prepares guideline and submits it to the applicant

If the A.A. decides that an EIA is needed, the E.A. will prepare guidelines for the preparation of the EIA. This is done in order to ensure that the EIA will include all the necessary information, but will not be too long or contain irrelevant data.

Applicant prepares EIA and submits to E.A.

It is suggested that in order to insure that the environmental implications are fully taken into account in the project's planning preparation, and as early as possible in the decision making process, the applicant of the project should be responsible for the preparation of the EIA. It should be kept in mind that the applicant is also responsible for the preparation of all other documents submitted to the A.A. and therefore should be prepared to submit the EIA and cover all the expenses involved.

Evaluation of EIA by E.A. and recommendation to A.A.

After the EIA is prepared it should be submitted to the E.A. for evaluation. The E.A. and the applicant should be in close contact during the process, to assist the applicant and to ensure that the EIA will meet with the approval of the E.A. After evaluating the EIA, the E.A. should make its recommendations to the A.A. These recommendations could be:

(a) To approve the EIA and the project as it was submitted;

(b) To reject the project on the basis of the information contained in the EIA;

(c) To ask for modifications of either the EIA or the proposed project;

The evaluation may involve input from the general public.

Decision by A.A. to approve the project and the EIA as part of it

The A.A. will then make the decision whether to accept the recommendation of the E.A. The A.A. can ask for changes in the original plans in order to minimize the environmental impact or to reduce it to an acceptable level. It should be emphasized that the EIA should be considered as part of the proposed project and not as a separate entity. Once the EIA has been approved, it should be binding in the same way as all the other project documents.

Monitoring of impact of the project by E.A.

In many cases an EIA will be based on predictions, and the validity of these predictions needs to be verified during the operation of the project. Therefore, a follow-up monitoring programme and reevaluation of the assessment is frequently necessary. The components of such a monitoring programme will be specified by the E.A. The programme may involve lists of parameters which should be checked at specified intervals and at specified locations. The data from such programme should be submitted and evaluated by the E.A. and the A.A. The monitoring could be required from the applicant as a condition of the issued authorization.

Reevaluation of the assessment by E.A. and A.A.

The A.A. may want to specify a time frame for the reevaluation of the authorization based on data from the follow-up monitoring programme. This reevaluation should be done in consultation with the E.A., should be documented very carefully and used both by the E.A. and the A.A. in future decision regarding similar projects.

<u>General comments</u>

Early planning is the key to development without the occurrence of unacceptable changes in the natural environment. If environmental concerns are considered concurrently with initial technical and economical planning of a major project, and precautions are applied from the outset of the planning process and through the phases of development, it may very well be possible to simultaneously develop a project and at the same time protect the natural resources of an area. An EIA will help the decision maker with his task by providing, at an early stage of the decision process, a statement where the consequences to the environment of a proposed programme of action are identified, described and evaluated. Furthermore, the EIA will support efforts aimed at preventing or reducing environmental damage in the short and long term. Thus EIAs provide insight into the nature of the options and trade-offs open to the decision maker. At the very least, EIAs are useful reminders of the environmental consequences of taking various actions; at best, EIAs provide quantitative estimates of the magnitudes of these consequences and of the costs of subsequent remedial actions.

An EIA should be carried out by an organization specializing in that type of work. In cases where the data available for the preparation of an EIA is lacking, it is even more important that the organization which prepares the EIA should be a competent one. It is better to prepare an EIA based on partial or incomplete information than not to prepare one at all. The organization which prepares the EIA should use, as much as possible, existing information or analogous information from similar cases. One should always remember that an EIA is only one method of tool among many to be used in the decision making process, and should not be used exclusively.

If the planned project is extensive, and particularly if it involves considerable risk to the environment, it is usually necessary to carry out some type of field study in order to assess the background situation. This may also be needed if the local environment, for some reason, is particularly vulnerable or sensitive. Such a field study may have to be rather extensive. However, in most cases a synoptic analysis, based on existing information supported with a limited amount of new data, will usually be sufficient. Data generated with the EIA are compiled and compared with similar cases.

An EIA should assess possible impacts (type and degree), and the use of technical solutions, such as production technology, anti-pollution measures etc. Based on this assessment, the proposed action may have to be revised and changed to an alternative which will cause less impact on the environment.

GUIDELINES FOR EIA FOR SELECTED DEVELOPMENT PROJECTS

Introduction

An environmental Impact Assessment (EIA) is a process that defines and specifies possible positive and negative effects of development projects on the environment. With the help of EIA, we should get a better understanding of the consequences of a development project.

The specific purpose of an EIA is to allow decision makers to introduce environmental aspects into the decision making process leading to a better understanding of the possible impact of the proposed project on the environment.

To help the proponent or applicant in the preparation of the EIA, and to reduce the volume of information to the basic minimum required, it is proposed that "Specific Guidelines" be prescribed by the E.A. for the applicant for each specific project. To help the E.A. in preparing those specific guidelines, this paper includes guidelines for five development projects that could be used by the E.A.

1. GUIDELINES FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT ANALYSIS OF A MARINA

A. Description of the proposed project

The proposed plan of the marina should be described including the following:

- General description of the entire project including location and structure of main and lee breakwaters, depth of water at the entrance to the marina, the number and type of boats for which the marina is planned, water and power supply, roads, dry docks, boat maintenance and repair facilities, slipways, housing units, hotel accommodation, restaurants, commercial areas, parking, etc.;

- Access for vehicles, boats and parking;

- Breakwaters, jetties, bridges, causeways, reclaimed land, and dredged channels;

- Sources of construction material for breakwaters;

- All areas to be reclaimed. Source of reclamation material;

- Drainage and sewage systems, solid waste disposal system and fuel supply to boats;

- Expected quantity of sanitary waste and the means for its disposal both on land and on sea;

- Description of the proposed stages of construction with timetable:

- Description of the expected normal operation of the marina such as its maintenance and aeration of the water;

- Description of built structures in relation to natural landscape.

- Expected movement of population during construction and operating periods.

B. Description of the Environment

A description of the environment of the site without the proposed marina in the form of maps and cross sections should include the following:

a. **Physical site characteristic**

- An onshore topographic and offshore bathymetric map of the site and its surroundings at a scale of 1:5000* covering at least 2 kilometers in each direction along the coast of the proposed site, and to an offshore water depth twice the depth of the proposed project;

- In the case of a cliff shore, details of the base, face and head of the cliff and at least 50 meters inland from the cliff head;

- Details of any existing or proposed offshore structures within 5 kilometers of the proposed project;

- Cross sections every 250 meters along the shore, showing offshore water depth and topography;

- Physiographic features such as cliffs, terraces, beach rock, sand dunes, and a description of their level of stability and erosion.

b. **Hydrographic and hydrologic information**

- The tidal conditions and the probability of extreme conditions;

- The wave climate and currents at the proposed site, including the probability of extreme conditions;

- Hydrologic conditions of natural or artificial water channels and outlets to the sea;

- Dissolved oxygen and nutrients concentration, microbial pollution.

c. **Sedimentological information**

- Longshore sand movement at the area proposed for development;

- Present on and onshore sand accumulation and sand loss, seasonal and over a period of time;

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*The scale of the maps given here is an indication, and is not mandatory.
Standard maps which are available in each country could be used.

- Detailed information on the stability and erosion of coastal cliffs within 2 kilometers of the proposed site, based on aerial photographs over a period of time, and analyzed by cross section every 250 meters along the cliff shore.

d. Biological conditions

- Identification on maps of onshore and offshore habitats;

- Identification of species which could be used as indicators of the condition of the ecosystem;

- Location of main components of the habitats, e.g. areas for feeding, refuge and reproduction, and areas important for migrating species;

- Protected or rare species;

- Fishing areas and species important to commercial fishing.

e. Present land uses on site and in surroundings

- Location and size of nearby settlements;

- Location and description of cultural properties;

- Roads and patterns of vehicular access;

- Existence of aquaculture: fish or shell fish farms, fisheries;

- Existence of beaches used by swimmers in the immediate surroundings; and

f. Esthetic values

C. Identification of possible impacts

An assessment of anticipated or forecasted impacts, using accepted standards wherever possible, should be given, including the following:

- Topographic and bathymetric changes, and the occurrence of the changes during and after construction until stable conditions are resumed;

- Sand movements and where increased sand accumulation and coastal erosion is likely to occur;

- Measures proposed to reduce sand depletion and coastal erosion with assessment of their impacts on the surrounding environment;

- Oceanographic changes likely to occur over a period of some 10 years, including the location and risk of wave reflection on adjacent shores and the concentration of wave energy and currents which could endanger swimming or disturb fisheries;

- Risk of sea pollution by uncontrolled sewage, polluted surface runoff, oil and gasoline, paints and anti-fouling materials resulting in change of dissolved oxygen and nutrients concentration and/or microbial pollution due to pollution and/or change in circulation patterns;

- Impacts on flora and fauna in the area likely to be affected by the proposed project, the risk of loss of a habitat, changes likely to occur in existing habitats and the possible creation of a new habitat, and the impact of barriers to movement on migrating species;

- Impacts on nearby present or proposed land uses;

- Visual impacts of construction on landscape;

- Impacts on fish and seafood production and safety; and

- Impacts on the quality of bathing water and on the cleanliness of beach sand, if any.

D. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed marina.

This section should describe all measures whether technical, legal, social, economic or other to prevent, reduce or mitigate the negative effects of the proposed marina. In addition, it should describe measures to be used to monitor the effects on a long term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

2. GUIDELINES FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT ANALYSIS FOR A TOURIST ACCOMMODATION COMPLEX

A. Description of the proposed project

The proposed complex should be described, accompanied by plans on a scale of 1:2500*, including the following:

- Types of overnight accommodation, number of beds, hotels, campsites, etc.;

- Entertainment facilities, e.g theatres, cinemas, nightclubs, discotheques, restaurants, bars;

- Intensive recreation activities; e.g water sports, swimming pools, beaches, sports facilities;

- Extensive recreation activities, e.g areas for walking/hiking, golf, mountain climbing;

- Associated development, e.g commercial (shops), tourist agencies, cafes, restaurants;

*The scale of the maps given here is an indication, and is not mandatory.
Standard maps which are available in each country could be used.

- Circulation patterns and facilities for vehicles, pedestrians, heavy traffic and light traffic (e.g cycles), including parking areas (number of vehicles);

- Infrastructure, including facilities for sewage and solid waste disposal, water and electricity supplies;

- Changes to surface topography, including locations and levels of cuttings, terraces, fills and embankments;

- Location, height and volume of buildings, and types of building materials;

- Location and height of other built structures, e.g retaining walls, lookout towers, sport facilities, marine structures;

- Location and surface of areas to be covered by asphalt or other artificial surfaces;

- Sources of construction materials;

- Areas to be protected in their natural state - types of landscape and methods of protection;

- Areas to be landscaped for recreational activities;

- Areas to be landscaped after building construction;

- Present and anticipated demand for proposed facilities;

- Stages of construction of building facilities and infrastructure;

- Expected movement of population during construction and operating periods;

- Additional bodies of fresh water to result from the project, if any.

B. Description of the environment

A description of the environment of the site without the proposed project should include the following:

a. **Physical site characteristics**

- Site location on ordinance survey (or equivalent) map at a scale of 1:10,000, including access roads, settlements, topography (contour) within 5 km radius;

- Slope and relative relief of site and its surroundings, viewpoints and sightlines;

- Physiographic features of the site and its surroundings, e.g cliffs, dunes, water bodies, shore types, caves, waterfalls, springs;

- Geomorphological processes in area, e.g cliff erosion, beach recession, landslides;

- Seismic processes in area, e.g earthquake risk.

b. **Vegetation and habitats**

- Vegetation and soil types, including height and density of vegetation cover;

- Location and type of areas and sites of attractive landscape;
- Location and type of areas and sites of sensitive and natural scientific importance;
- Location of rare species, flora and fauna; and
- Marine habitats, fishing grounds, aquaculture sites.

c. **Climatological and meteorological conditions**

- Time and length of visitors' season for different types of activities;
- Sources and impacts of air pollution which could affect the site's potential.

d. **Hydrological and oceanographic conditions**

- Location and type of surface water bodies on site and in surroundings and their potential for attracting visitor activity;
- Surface and subsurface water sources sensitive to pollution and present levels of water quality;
- Dissolved oxygen and nutrients concentration, microbial quality of coastal water and beaches; and
- Suitability of sea conditions for recreation activities, including swimming and water sports.

e. **Present land uses on site and in surroundings**

- Location and size of nearby settlements;
- Roads and patterns of vehicular access;
- Present tourist and recreation land uses;
- Present protected areas, e.g nature reserves;
- Land in agricultural production; and
- Quarries, industries, power stations and engineering structures.

f. **Present environmental quality of site and surroundings**

- Air quality;
- Water quality; and
- Noise levels.

g. **Present infrastructure**

- Water and electricity supply;
- Sewage and solid waste disposal.

h. **Present health conditions**

- Endemic diseases, if any, and zoonosis;
- Availability of medical care services; and
- Presence of insect vectors of diseases.

C. Identification of possible impacts

An assessment of anticipated or forecasted impacts, using accepted standards whenever possible, should be given, including the following:

- Loss of natural features, habitats and species by construction and building;
- Intrusion into sensitive visual landscape;
- Visitor access to sensitive habitats;
- Landscape impacts of quarrying, cutting and embarkments;
- Creation of new habitats;
- Risks of erosion, e.g cliffs, shores;
- Loss of agricultural land;
- Impacts on size and character of nearby settlements;
- Creation of potential for further development, e.g along new road or electricity line;
- Loss or creation of public open space;
- Changes to present drainage patterns;
- Pressure on present or proposed sewage treatment facilities during peak visitor periods;
- Capacity of water and electricity services and waste disposal;
- Air pollution, including dust from construction and pollution from vehicles;
- Noise during construction and from different types of activities proposed on nearby residential areas and on sensitive habitats;
- Water and sea pollution; and
- Loss of fishing grounds and impact on aquaculture sites.

D. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed tourist accommodation complex

This section should describe all measures - whether technical, legal, social, economic or other - to prevent, reduce or mitigate the negative effects of the proposed tourist accommodation complex. In addition, it should describe measures to be used to monitor the effects on a long term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

3. GUIDELINES FOR PREPARATION OF AN ENVIRONMENTAL IMPACT ANALYSIS FOR A SEWAGE TREATMENT PLANT FOR A CITY WITH MORE THAN 100,000 INHABITANTS

A. Description of the proposed project

The proposed treatment plant should be described, accompanied by plans on a scale of 1:2500*, including the following:

- Types of sewage to be treated (industrial, domestic, agricultural);
- Number of inhabitants to be served by the plant;
- Types of clients to be served, e.g industrial, residential, commercial, hospitals;
- Quantity of sewage (cubic meters per day, per year);
- Quality of sewage to be treated, including suspended solids (mg/liter), settleable solids (mg/liter), pH, turbidity, conductivity, BOD (mg/liter), COD (mg/liter), nitrogen, ammonia, phosphate, oil, surfactants, and heavy metals such as arsenic, cadmium, copper, lead, nickel and mercury;
- Method to be used in treatment of sewage;
- Layout of the plant (including treatment facilities and service area);
- Use of effluents (agriculture, recharging aquifer, disposal to sea or to nearest river);
- Description of the plant's recipient body of water, if any;
- Sludge quantity and quality;
- Method of sludge treatment and disposal; and
- Chemical, physical and bacteriological characteristics of effluents such as suspended solids, settleable solids, pH, turbidity, conductivity, BOD, COD, nitrogen, ammonia, phosphate, oil, surfactants, and heavy metals such as arsenic, cadmium, copper, lead, nickel and mercury, total coliforms, faecal coliforms and faecal streptococci.

B. Description of the environment

A description of the environment of the site without the proposed sewage treatment plant should concentrate on the immediate surroundings of the proposed project. The size of the area described will be determined by the predicted effects of the proposed plant.

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*The scale of the maps given here is an indication, and is not mandatory. Standard maps which are available in each country could be used.

a. **Physical site characteristics**

- Site location on a map at a scale of 1:10,000 or 1:50,000 including residential areas, industrial areas and access roads.

b. **Climatological and meteorological conditions**

- Basic meteorological data such as wind direction and wind velocity;

- Special climatic conditions such as storms, inversions, trapping and fumigation, proximity to seashore, average yearly rainfall and number of rainy days per year;

- Existing sources of air pollution, especially of particulates and odours.

c. **Geological and hydrological conditions**

- Geological structure of proposed area, including hydrology and aquifers;

- Existing uses of water bodies around the proposed site and the quality of the water.

d. **Present land use of the site and its surroundings**

e. **Characteristics of sea area which will be recipient of discharged treated sewage.**

- Water circulation;

- Existence and characteristics of the thermocline and its structure;

- Dissolved oxygen and nutrients concentration;

- Microbial pollution;

- Fishing grounds;

- Aquaculture sites; and

- Marine habitats.

f. Existence of endemic water borne diseases

C. <u>Identification of possible impacts</u>

An assessment of anticipated or forecasted impacts, using accepted standards whenever possible, of short term impacts associated with activities related to the construction of the plant and long term impacts related to the functioning of the treatment plant should be given, including the following:

- Odours and air pollution from the plant and from the disposal of effluents and sludge;

- Infiltration of sewage into topsoil, aquifer or water supply and impact on drinking water quality;

- Mosquito breeding and diseases transmitted by mosquitoes;

- Pollution of water bodies such as rivers, lakes or sea by effluents and impact on bathing water quality;

- Flora and fauna;

- Fruit and vegetable safety, if land disposal of effluent or sludge;

- Noise levels around plant and its sources;

- Solid waste disposal of sludge and other wastes;

- Devaluation of property values;

- Tourist and recreation areas such as nature reserves, forests, parks, monuments, sport centers, beaches, and other open areas which would be impacted; and

- Possible emergencies and plant failure, the frequency at which they may occur, and possible consequences of such emergencies.

D. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed plant

This section should describe all measures-whether technical, legal, social, economic or other-to prevent, reduce or mitigate the negative effects of the proposed sewage treatment plant. In addition, it should describe measures to be used to monitor the effects on a long term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

4. GUIDELINES FOR PREPARATION OF AN ENVIRONMENTAL IMPACT ANALYSIS FOR A SEWAGE TREATMENT PLANT FOR A CITY WITH BETWEEN 10,000 AND 100,000 INHABITANTS

A. Description of the proposed project

The proposed treatment plant should be described, accompanied by plans on a scale of 1:2500*, including the following:

- Types of sewage to be treated (industrial, domestic, agricultural);

- Number of inhabitants to be served by the plant;

- Types of clients to be served, e.g industrial, residential, commercial, hospitals;

- Quantity of sewage (cubic meters per day, per year);

- Quality of sewage to be treated, including suspended solids (mg/liter), settleable solids (mg/liter), pH, turbidity, conductivity, BOD (mg/liter), COD (mg/liter), nitrogen and oil;

*The scale of the maps given here is an indication, and is not mandatory. Standard maps which are available in each country could be used.

- Method to be used in treatment of sewage;
- Layout of the plant (including treatment facilities and service area);
- Use of effluents (agriculture, recharging aquifer, disposal to sea or to nearest river);
- Description of the plant's recipient body of water, if any;
- Sludge quantity and quality;
- Method of sludge treatment and disposal; and
- Chemical, physical and bacteriological characteristics of effluents such as suspended solids, settleable solids, pH, turbidity, BOD, COD, nitrogen and oil.

B. Description of the environment

A description of the environment of the site without the proposed sewage treatment plant should concentrate on the immediate surroundings of the proposed project. The size of the area described will be determined by the predicted effects of the proposed plant.

a. **Physical site characteristics**

- Site location on a map at a scale of 1:10,000 including residential areas, industrial areas and access roads.

b. **Climatological and meteorological conditions**

- Basic meteorological data such as wind direction and wind velocity;
- Special climatic conditions such as storms, inversions, trapping and fumigation, proximity to seashore, average yearly rainfall and number of rainy days per year;
- Existing sources of air pollution, especially of particulates and odours.

c. **Geological and hydrological conditions**

- Geological structure of proposed area, including hydrology and aquifers;
- Existing uses of water bodies around the proposed site and the quality of the water;

d. **Present land use of the site and its surroundings**

e. **Characteristics of sea area which will be recipient of discharged treated sewage**

- Water circulation;
- Existence and characteristics of the thermocline, and its structure;
- Dissolved oxygen and nutrients concentration;
- Microbial pollution;

- Fishing grounds;

- Aquaculture sites; and

- Marine habitats.

f. **Existence of endemic water borne diseases**

C. Identification of possible impacts

An assessment of anticipated or forecasted impacts, using accepted standards whenever possible, of long term impacts related to the functioning of the treatment plant should be given, including the following:

- Odours and air pollution from the plant and from the disposal of effluents and sludge;

- Infiltration of sewage into topsoil, aquifer or water supply and impact on drinking water quality;

- Mosquito breeding and diseases transmitted by mosquitoes;

- Pollution of water bodies such as rivers, lakes or sea by effluents and impact on bathing water quality;

- Flora and fauna;

- Fruit and vegetable safety, if land disposal of effluent or sludge;

- Solid waste disposal of sludge and other wastes;

- Tourist and recreation areas such as nature reserves, forests, parks, monuments, sport centers, beaches and other open areas which would be impacted; and

- Possible emergencies and plant failure, the frequency at which they may occur, and possible consequences of such emergencies.

D. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed plant

This section should describe all measures - whether technical, legal, social, economic or other - to prevent, reduce or mitigate the negative effects of the proposed sewage treatment plant. In addition, it should describe measures to be used to monitor the effects on a long term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

5. GUIDELINES FOR THE PREPARATION OF AN ENVIRONMENTAL IMPACT ANALYSIS OF A SUBMARINE SEWER OUTFALL FOR A CITY OF UP TO 100,000 INHABITANTS

Introduction

The main object of a sea outfall is to discharge effluent from a sewerage system at an adequate distance, the outlet being located at a point at which hydrodynamic effects will assist dispersal of the effluent. The first requirement, therefore, is to determine these effects and, basically, the water circulation in the discharge area.

Until fairly recently, the sea was taken for granted as a convenient natural dumping ground for sewage without a thought being given to how much polluted effluent it could reasonably accept. With growing interest in environmental problems came the realization that there is in fact a limit to the sea's capacity to accommodate such pollutants.

However, a sea outfall is sometimes the only feasible solution. In such cases, the importance of reducing unavoidable pollution to a minimum is generally recognized and, accordingly, official regulations have been issued on the subject and optimized outfall design methods developed.

Once it has been decided to implement a sea outfall project, it is up to the project authority's technical staff to site the outfall in a manner ensuring that the water in areas to be protected from contamination will meet the required quality standards. The effects of sea outfall effluent should be determined considering the most critical pollution conditions for the areas requiring protection. A discharge point can be considered acceptable if the pollutant outflow concentrations are consistent with the water quality standards applicable in the areas requiring protection, e.g holiday beaches, shellfish breeding areas.

A. Description of the proposed project

The proposed outfall should be described, including the following:

a. **The outfall**

- Length of pipe of outfall, diameter, depth, pipe material;
- Pipe laying method: on seabed, buried in seabed;
- Method of control corrosion;
- Method to protect from trawls and anchoring;
- Diffuser length, orifices, configuration and diameter;
- Discharge velocity; and
- Primary dilution, final dilution.

b. **The effluents**

- Effluent characteristics, e.g quantity, degree of treatment, physical, chemical and bacteriological composition, seasonal variations; and
- T90: die out time for 90% of bacteria.

B. Description of the environment

A description of the environment of the site of the proposed outfall should include the following:

a. **Physical site characteristics**

- An onshore topographic and offshore bathymetric map of the site and its surroundings at a scale of 1:5000* covering at least 2 kilometers of the coast, 1 kilometer from the waterline offshore and 200 meters from the waterline inland;

- Geological and geomorphological conditions at outfall site including rock outcrops on and offshore, sedimentological conditions and cliff stability.

b. **Hydrographic and meteorological information**

- Surface and shallow depth currents under various tidal and weather conditions;

- Current at the depth of effluent disposal;

- Turbulent diffusion coefficients;

- Existence and characteristics of thermocline;

- Seawater temperature and salinity and their variation with depth; and

- Wind velocities and direction.

c. **Biological conditions**

- Status of benthic fauna and flora and of various sediment categories, e.g gravel, mud, sand; and

- Available knowledge on pathogens survival capacity in the marine environment.

d. **Present and future uses of sea and beach**

- Tourism, recreation, fishing;

- Shellfish breeding; and

- Quality standards of seawater for different uses.

C. Identification of possible impacts

An assessment of anticipated or forecasted impacts, using accepted standards whenever possible, should be given, including the following:

a. **Impacts of construction**

- Earthworks;

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*The scale of the maps given here is an indication, and is not mandatory. Standard maps which are available in each country could be used.

- Road access;
- Noise of equipment.

b. **Impacts of operation**

- Flora and fauna;
- Seawater temperature;
- Bacteria concentration;
- Oxygen and nutrients concentration;
- Water turbidity and colour.

c. **Impacts on other present and potential land uses on and offshore**

- Recreation activities, including bathing waters and sand beaches;
- Fishing grounds, especially relation to shellfish.

d. **Expected impacts on the reduction of enteric diseases**

D. Proposed measures to prevent, reduce or mitigate the negative effects of the proposed submarine sewer outfall

This section should describe all measures - whether technical, legal, social, economic or other - to prevent, reduce or mitigate the negative effects of the proposed submarine sewer outfall. In addition, it should describe measures to be used to monitor the effects on a long term basis, including the collection of data, the analysis of data, and the enforcement procedures which are available to ensure implementation of the measures.

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THE ENVIRONMENTAL IMPACT OF DEVELOPMENT IN THE CARIBBEAN ISLANDS FROM 1660 TO THE PRESENT

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ABSTRACT

During the four centuries since Europeans first set foot on Caribbean soil, the environment has been changed significantly. By and large the Caribbean islands had little in the way of mineral resources, their value lay in an equable (tropical) climate suitable for the cultivation of coffee, cocoa, sugarcane and tobacco. Agriculture became pre-eminent and the natural forests were cleared for that purpose. From the 1950s to the present, most Caribbean islands have adopted industrialization policies. Economic development in the Caribbean can be generally considered coastal. In this paper an examination is made of the historical industrial development of the Caribbean islands and the consequent environmental impact, with particular reference to economic conflicts related to tourism, fisheries and agriculture.

INTRODUCTION

The history of the Caribbean and its development is as varied as its ethnic, linguistic and ideological composition. Fought over for three centuries by the British, French, Spanish and Dutch; and the indigenous populations virtually anihilated, the Caribbean of the twentieth century is still struggling to determine its identity. Very few of the islands comprising the archipelago have mineral or energy resources on which to base their industrial development. Economically, basically they stand on two legs - agriculture and tourism. Notable exceptions are Trinidad and Tobago which has oil and natural gas, Jamaica (bauxite), the Dominican Republic (gold and silver) and Cuba (nickel).

During the nearly five centuries since Europeans first set foot on Caribbean soil, the environment has been changed significantly. For example, the island of Barbados was once covered by forest; today there are few native trees.

As mentioned above the Caribbean islands had little in the way of mineral resources; their value lay in an equable (tropical) climate suitable for the cultivation of coffee, cocoa, sugar cane and tobacco. They also provided heavens and safe refuge to the many pirates (particularly British) who waylaid the Spanish galleons transporting gold, silver and precious stones from Central and South America to Spain.

Agriculture became pre-eminent and the natural forests were cleared for that purpose. At one time some seventy percent of Barbados was under sugar cane. From the 1950s to the present most Caribbean islands have adopted industrialization policies. However, due essentially to a lack of indigenous raw materials, manufacturing industries are based on imported materials mainly in a semi-finished state.

With the exception of the larger islands of Cuba, Jamaica, Hispaniola and Trinidad, any economic development in the Caribbean can be considered to be coastal since no point is more than a few kilometres from the sea. Even in the aforementioned islands most of the economic activity is coastal in nature.

THE COLONIAL ERA

As mentioned in the previous section, the colonies were seen mainly in terms of their value as suppliers of raw materials, primarily agricultural products. By far, the biggest crop being sugar cane; although cocoa, coffee, cotton and bananas were also cultivated on a fairly large scale on some of the islands. Latterly minerals such as bauxite, nickel and gold and more importantly, oil and natural gas have determined the countries' value. The smaller territories of the Caribbean are also prized for their golden or white beaches and amiable climate. Nevertheless, regardless of the period of history chosen, the wealth of the countries has always been measured in terms of and determined by their value to the metropolitan powers rather than the local inhabitants.

As a consequence of the above, production of commodities by individual territories were (and still are) out of all proportion to their populations, leading to environmental degradation more rapidly and far greater than would be the case if production had been primarily to meet local needs.

The sugar industry

Thus to take the production of sugar as an example, over 55% of the total surface area of Barbados is permanently under sugar cane, while the figures for Trinidad and Tobago and Jamaica are approximately 10% (representing about 30% of the land presently under cultivation) and 7.5% respectively. In terms of the production of sugar, the per capita figures for the three countries are 0.53, 0.24 and 0.22 tons per year respectively, while the consumption for each territory is about 0.04 tons per capita per year. One would expect a single operation on such a scale to have a significant direct effect on the environment of those countries. The magnitude of the impact is related to the following main aspects of the industry:

(a) Monocultural agricultural practice.

(b) Large-scale crop-spraying.

(c) Large-scale use of inorganic fertilizers.

(d) The generation of solid wastes viz. filter press mud cakes and bagasse.

(e) The generation of large volumes of liquid effluents with a very high bio-chemical oxygen demand (BOD). This problem is compounded by the fact that the effluent is generated during the dry season when river flows are at their lowest.

(f) The generation of air-borne pollutants resulting from the burning of the cane before reaping and from the use of bagasse as a fuel for the factory boilers.

Since production is presently between five (Jamaica) and thirteen (Barbados) times the local requirement for this commodity, the impact on the environment must be at least that much greater than would be the case if the industry were geared primarily towards local needs.

The irony of the situation is that, with the exception of Cuba, even without sugar cane the available land would be insufficient to grow enough food to feed the islands populations, yet the cultivation of basic essential foodcrops would be far less environmentally harmful.

The Immediate pre-independence situation

The effect of colonialist policies therefore was the degradation of the natural environment occasioned by the development of export oriented "one-crop" economies. At the same time, the result was that very few types of pollutants were introduced into the natural ecosystem. Thus, prior to the middle of this century, the only significant industrial pollutants in the region were: those resulting from the sugar industry and (for some countries) the banana industry; those caused by the bauxite industry in Guyana and Jamaica and other quarrying operations carried on to obtain materials primarily for local construction; and those introduced by the petroleum industry in Trinidad.

The most serious forms of pollution which affected the population at large resulted from the lack of adequate sanitation facilities. Even today, gastro-enteritis and other water-borne diseases, occasioned by inadequate sewage disposal systems, remain the greatest cause of infant mortality through Caribbean.

Another legacy of the colonial era is the effect of uncontrolled deforestation in the mountains which took place in many of the islands. Some of the forests were cut down for timber and some by peasant farmers who, being unable to obtain land on the plains or in the valleys, had very little choice. The effect has been the partial destruction of the watersheds, erosion of the thin topsoil and the silting up of the rivers. This in turn has led to very uneven river flows during the rainy and dry seasons, together with increasing incidences of flash flooding.

Bauxite production in Guyana and Jamaica as in most producer countries is an export-oriented operation. Thus Guyana, with a small population of 400,000 in 1948, produced 2.6×10^6 metric tons (i.e. 32% of total world production). By 1973 (population 760,000) production had increased to 3.5×10^6 metric tons (5% of world production). However, Guyana has a large land area (2.15×10^5 km^2) and it may be argued that the effect of the operations on the total environment is not too serious. Even if one were to agree with this argument, it certainly cannot be applied to Jamaica, which has a population of 1.8×10^6 and a land area of only 11424 km^2. That country first produced bauxite in 1952 (4.2×10^5 tons) and by 1973, output from the mines had increased to 13.49×10^6 tons (i.e. 20% of world production). A growth rate of 7 percent per annum from 1960 and 6 percent per annum from 1969 to 1973 was recorded. In the 1980s however there has been a dramatic decline due mainly to lack of demand.

Although the environmental impact of the bauxite industry in Jamaica has been serious, particularly that associated with alumina production, it is interesting to note that the leases signed by the Jamaican Government with the foreign companies, required the latter to rehabilitate the mined out areas. No such provision was made in the case of Guyana, where operations began at the beginning of this century, at a time when it was never thought that the colonies would ever be granted independence.

THE MODERN ERA (1950 TO PRESENT)

When after the Second World War, the local populations began to gain increasing political control of their countries, and finding their economics so underdeveloped, the "Lewis doctrine", for development, emerged. The cornerstone of that philosophy was that since they lacked the necessary capital and technology, the only way to accelerate the process was to entice foreign companies to establish subsidiaries. By doing this, it was anticipated that advanced technology would be assimilated rapidly in the country leading to its diffusion throughout the economy, and that as a result of the generation and distribution of substantial income, the local population would, automatically, be able to continue the process themselves. This was the so-called "industrialization by invitation" process which was universally adopted throughout the region. To facilitate the process, the Governments of the region devised generous fiscal incentives, including duty-free imports of machinery and raw materials, which were to be granted to the foreign investors.

The strategy of industrialization by invitation, subsequently, had one of import-substitution superimposed on it, and the policy instruments, used to hasten this phase of development, remained essentially the same.

Throughout this entire period, very little attention was given to the protection of the physical environment. Indeed it was generally felt, throughout the Developing World, that to insist on pollution control and protection of the environment would be counter-productive with regard to the attraction of capital.

As might be expected it was the islands which had the better infrastructure and large and better trained manpower which became the more developed, i.e. Trinidad and Tobago, Jamaica, Cuba, Dominican Republic and to a lesser extent Barbados and more recently St. Lucia. The smaller islands including Barbados and St. Lucia concentrated more on tourism development (Puerto Rico has been omitted intentionally as it is a very special case).

Thus, in the context of the historical development of the Caribbean, as very briefly summarized above, it should be expected that the environmental problems of the region would be quite different to those of the metropolitan countries.

During this period of time, many industries were established in virtually every field of activity such as: food processing, lead smelting, battery manufacture, metal plating and finishing, cement, fertilizers, cosmetics, pharmaceuticals, and weaving and dying. This has led to the introduction into the environment of increasing quantities of BOD, phosphates, inorganic and organic chemicals, and the highly toxic heavy metals such as lead, chromium, zinc and copper. The majority of the new establishments commenced operation during the last forty years, and one might expect that in the absence of environmental legislation and controls, the situation in the countries which have industrialized the most, should be close to catastrophic. However, taking Trinidad and Tobago as an example, the situation is nowhere nearly as bad as may be expected.

The dearth of quantified data makes it impossible to paint the total picture. However, a qualitative analysis may be made of the situation by considering the nature of each enterprise together with its location. Additionally, the daily water consumption of the enterprise can be used as a guideline for the type of operation carried on.

Trinidad and Tobago as an example

Table 1 shows a breakdown by number of enterprises of ten main manufacturing categories established in Trinidad and Tobago between 1961 and 1975 (two categories namely, garments and furniture, have been omitted from the analysis as they were assumed to be basically non-polluting).

Table 1: Number of Manufacturing Establishments in Each of Ten Categories, Established in Trinidad and Tobago between 1961 and 1975

CATEGORY	NUMBER	% OF TOTAL
Food and Drink Processing	58	15.0
Textiles	10	2.6
Building Materials	67	17.3
Plastics Processing	19	4.0
Printing and Packaging	28	7.2
Paper Products	31	8.0
Cosmetics	14	3.6
Chemical Processing	19	4.9
Assembly Type and Related Industries	57	14.8
Miscellaneous Manufacturing	84	21.7
TOTAL	387	100.0

This table shows that of the three hundred and eighty seven (387) establishments tabulated, just four categories accounted for two hundred and sixty five (265) (i.e. 68.8 percent of the total).

These are the categories of miscellaneous manufacturing (21.7%), building materials (17.3%), food and drink processing (15%) and assembly-type and related industries (14.8%). Of these it was found that only two (food and drink processing and building materials) were responsible for the bulk of the water pollution in the country.

Of the three broad categories: water pollution, air pollution and land pollution, the study showed that water pollution was the most serious and widespread. 28.3 percent of the establishments discharged pollutant of one sort or another. However, the range of pollutants was found to be quite small, the majority being BOD from the food processing industry (28% of the total) and suspended solids from the building material industry (26%).

The other pollutants of significance which could be identified were: titanium, lead and zinc from the paint industry; chromium, zinc and acids from electroplating; acids and lead from the metal treatment and battery industries, and polychlorinated biphenyls (PCBs) from the plastics and adhesives industries. The quantities of these tend to be fairly small individually. However, some of them particularly lead, chromium, titanium, zinc and PCBs are toxic in very small quantities and can be concentrated by the biological food web. In the absence of quantitative analyses it is not possible to determine the nature of the problem. Nevertheless, it should be noted that since most of the establishments are concentrated along the East-West Corridor, the substantial majority of these effluents are discharged either directly to the Caroni River or indirectly via the small tributaries such as the St. Joseph or San Juan River. Ultimately of course, it ends up in the Caroni swamp and Gulf of Paria.

Air pollution is not a general industrial problem, but does create severe localized problems. This is not surprising since air pollution is more a phenomenon of primary industries, domestic heating, motor vehicular traffic and electrical power generation from fossil other than natural gas.

There are a few large primary industries in the country which give rise to localized problems which can have serious effects on the population. The main gaseous air-pollutants in this country are oxides of sulphur and hydrocarbons from the petroleum refineries, and oxides of sulphur from the sulphuric acid plants. Particulate air-pollution results from the cement company's operation at Claxton Bay. These pollutants only make themselves obvious during the infrequent wind reversals. However, that is not to say the local population is not at risk nor have suffered respiratory damage. What is required in order either to condemn or exonerate the industries is a detailed analysis of the nation's health statistics to determine whether or not the incidence of respiratory illnesses is higher in certain areas than in others and thereby to see if there is any correlation with the location of particular industries.

A more general widespread source of pollution is that emanating from vehicular traffic which generates carbon monoxide, particulates, oxides of sulphur, hydrocarbons, oxides of nitrogen and compounds of lead. However, this aspect cannot be dealt with in this paper.

In fact a complete and more detailed investigation of the present situation in Trinidad and Tobago and indeed of the entire Commonwealth Caribbean area showed that the most serious environmental effects are associated with domestic sewage, large export oriented extractive industries, agriculture, food and drink processing, emissions from motor vehicles and the building materials industry, in that order.

This pattern is completely different from that which is obtained in a highly industrialized country such as the United States of America. Of the major polluting industries in the U.S.A. only three of the eight listed (petroleum, chemical plants and food, drink and meat processing), contribute significant quantities of pollutants to the environment in any of the Commonwealth Caribbean countries.

Nevertheless, given the absence of environmental legislation and minimal controls, and given the list of products manufactured in Trinidad, the following toxic chemicals should appear in the environment in significant quantities: arsenic, cadmium, chromium, copper, fluoride, lead, mercury, titanium, thallium, zinc and PCBs; and their concentrations should be such that their presence would result in sickness and disease among the population. However, this is not the case. Indeed even highly polluting industries such as paper products and plastics processing which exist in Trinidad and which have fairly large outputs, discharge only relatively small amounts of pollutants to the environment.

The main reason for the absence of significant quantities of the toxic pollutants is that the majority of the industries are "screw-driver", finishing-touch or packaging establishments. The closer an industry is to primary production, in general, the greater and more toxic the effluent becomes. Thus if backward linkages had been created in the economy, the country would have been faced with very serious problems in the absence of environmental controls. Even in the food and drink processing industry, the lack of backward linkages with local agriculture has lessened the effect of the BOD loading.

Hence ironically, the absence of substantial quantities of toxic pollutants, is an indictment of the type of industrial development which has taken place so far.

In the second half of the 1970s and early 1980s Trinidad embarked on a major energy-intensive industrial development programme based on its large natural gas resources. Three of the world's largest ammonia plants have been built there as well as plants to manufacture urea, ammonium sulphate, iron and steel (by direct reduction) and methanol. Earlier plans to construct an aluminium smelter and an LNG plant were subsequently dropped for economic reasons. All of the plants together with two oil refineries are on the west coast, facing the Gulf of Paria, a virtually enclosed body of the sea between Trinidad and Venezuela. The Gulf of Paria is smaller and shallower than Lake Eerie (the smallest of the North American Great Lakes) and is the source of much of Trinidad's fish supply.

To date Trinidad and Tobago has no meaningful environmental laws, but most of the plants were built with modern pollution control equipment. However, no systematic monitoring of effluents is carried out and there is no regulatory body.

Tourism

As mentioned earlier the smaller islands concentrated more on tourism as the engine of their economic development, the main ones being Barbados, the Bahamas, U.S. Virgin Islands, St. Lucia, Grenada and Antigua. However, as with industrial development, little attention was paid to the environment - which is even more critical for sustainable tourism development.

The majority of tourism activities occur in the immediate coastal zone, whose resources constitutes major attractions such as beaches and coral reefs or are highly functional for anchorage and marinas.

Several of the major beaches of the islands are experiencing or have experienced deterioration which threatens the quality of beach tourism. Important marine habitats face increased stress.

Island habitats tend to be vulnerable environments and, where management is inadequate, island environments are particularly vulnerable.

Small island states cannot afford mistakes as the entire country can be affected. The land area of Barbados is only one quarter that of London; even the comparatively large island of Trinidad is less than three times the size of London. As a consequence, virtually the entire country of every island state is accessible to each and every tourist within a one day period.

The result is that carrying capacity thresholds are often reached quickly, with consequent economic, social, visual and ecological effects not easily quantified.

Apart from the physical environment the tourists' per capita demands on other natural resources such as water, infrastructure - airports, seaports, roads and sewage systems and treament of facilities and garbage disposal as well as energy, exceed (often by many times) those of the local population. Where such resources are scarce or non existent and necessitate imports, the real economic value of mass tourism development can be questionable.

Given the very brief and somewhat simplistic explanation of problems related to tourism development in the smaller Caribbean Islands one may turn to some of the conflicts related to general economic development and tourism.

Conflicts between tourism and general economic development

In a large country, planners may set aside certain areas for exclusive tourism purposes. This is very difficult in a small island state. A country such as St. Lucia has very (small) rivers all of which empty to the sea through the more attractive bays containing some of the best beaches. Barbados has no permanent rivers. Hence any industry which uses a river to dispose of its liquid effluents has a direct and immediate effect on a tourist (or potential tourist) resort area. One may consider essentially two conflicts: the effect of inland development on tourism or the effect of tourism on inland development, or the effect of tourism on inland or coastal development, depending on the development priorities of the government. Briefly, one may highlight the following conflicts of interests.

(a) **Mangrove swamps**

Areas in which mangrove swamps occur have often been determined to be the best areas for the development of marinas or other aquatic oriented tourist facilities. Hence they have been drained or removed and dredged. These areas however, are often among the most biologically productive as spawning grounds for fish, shrimps and shell fish. The destruction of mangrove areas can lead to serious detrimental effects to the local artisanal fishing industry.

(b) **Coral Reefs**

Coral grows very slowly. Good management practices are needed to prevent "amateur" scuba divers from trampling and destroying the small reefs offshore of the small islands. Coral reefs are very delicately balanced ecosystems, serve as nurseries for much sea-life and act as barriers to the erosive power of the sea. Some beach erosion in the Caribbean has been attributed to the destruction of coral reefs. Apart from trampling and removal of coral to sell to tourists, destruction of reefs has also been blamed on the sea disposal of untreated or inadequately treated sewage. Inland or coastal activities leading to high levels of sediment loading of rivers or coastal waters can smother reefs and also hasten their demise. Once a reef has been destroyed, rapid coastal erosion normally ensues. Dickenson Bay, Antigua, Grand Anse and Levera, Grenada are reportedly experiencing erosion rates of 3.6 m per year.

(c) **Beach mining**

In most of the Caribbean Islands, the only source of sand for construction purposes is the beach. Beach sand is mined legally and illegally for that purpose. In general extraction rates far exceed natural replacement rates, leading to increased erosion. The Governments are then faced with very expensive sea defense public (civil) works programmes to prevent erosion. However, the beach is virtually lost and not much time is required before the tourists stop going to the resort.

(d) **Agriculture**

Intensive monocultural agriculture requires the use of high fertilizer, pesticide and herbicide dosages much of which find their way via the small coastal bays, presenting potential health threats. More insidious however, is that the allocation of the best agricultural land to export-oriented monoculture has denied the landless local population access to good agricultural land. This practice has driven them into the hills and mountains where they engage in illegal "slash-and-burn" subsistence farming. Such practices lead to the destruction of the watersheds as well as water retention and aquifer recharge, siltation of rivers and increased flash-flooding and possible smothering of coral reefs. All of these effects have direct or indirect effects on tourism.

(e) **Resource allocation**

As mentioned in the previous section, most of the small islands have very limited natural resources and no indigenous energy resources. In some cases, tourism has become so important that the tourists' needs have priority. When the tourists' needs have to be satisfied to the exclusion of the local population, it is difficult to see how the rest of the economy can develop properly.

CONCLUDING REMARKS

The issues related to coastal development, particularly as related to small island states are extremely complex.

The analysis given above is very brief and, therefore, rather simplistic. A paper of this nature cannot go into complex explanations of the relationships between humans and their environment and their economic development needs. It has been written more to stimulate discussion than to provide answers or diagnoses.

In 1981 the Wider Caribbean adopted the Action Plan for the Caribbean Environment Programme. The Plan was enthusiastically adopted by the island states of the region who recognized the environmental fragility of their countries.

THE IMPACT OF COASTAL DEVELOPMENT PROJECTS: A CASE STUDY OF COMPETING INTERESTS

by

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ABSTRACT

The coastal area of Kuwait could be divided into those bordering the Bay of Kuwait and the coast line along the open sea. This portion is mostly mud flats (31.7%) owing to the low energy in the area. The rest of the coast is mostly sand or rock (13.3%). A large portion of the coast line is filled up (18.4%). The coast is almost totally taken up. The area that is not developed is that to the north and west of the Bay of Kuwait owing to its inaccessibility. Ports, desalination plants, Shuaiba Area industrial complex and other Government owned property comprise about 14% of the coast line. The good quality beaches to the south, amounting up to 40% of the total coast line, are being taken up and are not accessible to the public.

The criteria for siting of some of the major projects are outlined. These include urban development, tourism and recreation, ports and harbours, industry, off-shore mining and power stations. The impacts of the coastal activities on the marine environment are also reviewed.

INTRODUCTION

The coast is the area where the land meets the sea. The terms coastal areas and coastal zones are used to designate land areas that are associated with the sea and may include cliffs, dunes, beaches and even hills. The width of the coast or the distance to which it extends inland varies with the local topography, climate, vegetation and to a certain extent with the social customs. However, it is generally described as the land area that is affected by marine processes as tides and waves. The seaward limit of the coast is usually assumed to coincide with the beginning of the beach or shore, but common usage often includes nearby off-shore islands.

Coastal areas are the region in which the sea acts to alter the shape and configuration of the land. Changes may be rapid or slow. In general, coasts that are composed of soft, unconsolidated material such as sand, produced by relatively low energy process, may be subject to changes more rapidly than those made of rocks. A coast that is relatively young in terms of the age of the earth may be rapidly modified by the sea while a coast that is old may retain its land-derived characteristics. Absolute age is not really important, the demarcation is based on whether the characteristics are derived from the land or from the sea and it is possible to find both types of features along the same coast.

People also change beaches. Rivers are dammed to control floods and to generate power. When a dam is built, a great water lake is formed behind the dam. Sand, gravel, and rock that had once moved down the river to join the sediments at the coast are now deposited in the lake behind the dam and thus an important source of material critical to the continued balance of a beach has been removed. Although the downstream sediment supply is reduced, the longshore current continues to flow and carry suspended beach material away. The net result is a loss of sediment and sand to the beaches formerly supplied by the river and a retreat of the beach due to the scouring action of the coastal currents.

Coastal engineering projects may result in changes to a beach. Breakwaters and jetties are built to protect harbours and coastal areas from the force of the waves. The areas behind jetties and breakwaters are shelved allowing materials suspended by the wave action and carried by the longshore current to settle out. The outcome of this removal of material by the longshore transport process provides less material to the beach further down the coast. As the longshore current continues to flow, the next beach down the coast begins to disappear. Small-scale examples of this process are seen when groins, rock or timber structures, are placed perpendicular to the beach to trap sand being carried in the longshore transport. Such competition is often seen between onshore property owners where municipal action has been laxed, only to find that in doing so a chain of events has been triggered in the dynamic shore zone that results in the requirement for costly engineering solutions in order to solve newly created problems.

COASTAL DEVELOPMENT

Historically, people have always looked at the sea and most of the human settlement are built on the sea shores where food is abundant and opportunities for trade and transport are inviting. However, modern communities living on the shore with their industries, energy generating plants, transport facilities, recreational activities have created tremendous burdens on the coastal areas. Too much use, too many wastes discharged into small areas and at such a rapid rate have produced problems that can no longer be overlooked. These disadvantages can exceed the ability of the natural systems to flush themselves and disperse the contaminants into the open sea (assimilative capacity). Changes in the environment may seriously degrade and deteriorate their aesthetic and economic value and in some cases endanger public health.

The choice of an appropriate site for a project depend on a wide array of factors. Certain sites may be preferable to the developer in so far as they minimise transport costs for the material and finished products. Availability of power and water supply and other services essential to the efficient operation of the plant is also considered in the selection. Accessibility may be a major factor and proximity to populated areas may be critical for certain projects as the recreational facilities. Some sites may be preferable to the wider community interest in terms of the extent to which they may assimilate the environmental impact of the projects, provide needed services or have significant positive social and economic benefits.

The site characteristics differ significantly according to the type of project. In planning urban developments, the shoreline energy regime should be critically reviewed. The tide and waves, slope of the coast, longshore current and other dynamic factors may influence the erosional and depositional processes and hence the shoreline stability. Local weather and meteorological conditions such as wind direction, speed, rainfall and visibility may affect the integrity of an urban community through storm damage, interference with transport, maintenance of air quality and flooding by storm water rivers. Coastal water circulation influences the disposal of sewage and so affects the value of the shore for recreational purposes.

Planning recreational projects require the examination of many variables. These include the ambient water quality. Cleanliness, colour and water purity may influence its use for bathing, boating, water skiing, and hence will determine the recreational value of the shore. Shoreline energy regime and the waves, slope, tide, water level and other dynamic processes will influence the desirability of a shoreline for recreational purposes. Waves and currents cause potential danger to bathers or the need for a particular characteristic for a sport (e.g. surfing). The energy regime would also influence the stability of the shoreline and artificially created beaches.

Flora and fauna will affect the desirability of an area. Game fish should be present for sport fishing, poisonous fish should be scarce or absent for bathing beaches, slimes and heavy seaweed growth are undesirable and may be a deterrent to bathing. Bottom characteristics of the coastal area, its profile and type of material will affect boating and bathing. A steep profile can be dangerous for bathing where the same characteristics may be desirable for boating. Well populated or unique shore habitats provide touristic and scientific attractions as well as recreational opportunities. Shoreline type is quite important, certain forms of shoreline are more attractive for recreation and tourism than others. Sand beaches are attractive for bathing, surf fishing or strolling; mangrove swamps for nature study and fishing. Precipitous cliffs and rock-bound coasts as preferred for scenic views. Local weather and climate as winds, temperature, hours of sun shine, precipitation, visibility and dust storms, greatly influence recreational and touristic use of the premises. Upwelling, may cause nutrient rich waters to appear close to shore thus encouraging fishing sport, but may also bring colder water adjacent to beaches in certain seasons.

Residence time of contaminating substances, will be influenced by wind, tides, and currents. The nature and movement of sediments and its type is also important, a large proportion of potential pollutants become bound to soft sediments, and other physical characteristics of the marine environment.

Site characteristics for ports and harbours require adequate water depth. If dredging is required, it is expensive and has associated environmental effects. Approach geometry is usually necessary to approach ports and harbours through restricted waters and channels. Coastal water circulation influence ship handling and vessel safety and have a major effect on pollution dispersion. Tidal range influences accessibility to the port or harbour and also cargo handling. Excessively large variations create safety hazards and higher costs. Seabed characteristics as bottom profile and bottom type affect operation, costs and safety. Bottom profile relates to channel width, which if inadequate, requires dredging and may affect navigational safety. Bottom type affects the ability of anchors to hold, thus adding an element of cost as well as safety. Local climate mainly wind speed, wind direction and visibility should be considered. Ship handling may be adversely affected by winds and visibility. Shoreline energy regime and longshore currents may result in siltation around port and harbour structures requiring dredging. Wave condition as height, period and direction, can adversely affect the movement of vessels when approaching or when alongside a dock or pier.

The susceptibility of the shore to erosion will greatly affect its suitability for the siting of industry. The geological stability and nature of beaches, such as the existence of adjacent wetlands, barrier islands or coastal plain should all be considered in deciding the location of oil terminals, refineries, power plants and metallurgical plants and other industries that need efficient means of transport and large quantities of water for processing and cooling.

Coastal water circulation and conditions of water exchange off the industrial sites may greatly influence the practicability and cost of waste disposal. Ambient water quality is important if seawater will be used in fish processing. Fish processing wastes are objectionable. Wind characteristics should be such as to disperse stack emissions and odours effectively.

Siting of power plants may need thorough investigations of an extensive length of shore. Water depth is a factor to consider in relation to design and placing of water intake and discharges structures and when sea access is required, e.g. for supply of fuel. Currents will influence the sediment transport regime and may lead to erosion or deposition around physical structures. These will be important for the design and operation of the cooling water systems. Residence time may be critical if coastal water exchange is restricted due to presence of bars, reefs, islands in which case the efficiency of seawater cooling may be greatly reduced. Ambient water quality for cooling purposes is particularly related to its content of suspended and dissolved solids. The presence of marine life creates fouling or clogging in the seawater intakes and may interefere with the flow of cooling water. Antifouling measures will increase costs and the chemicals used may have impact on the marine environment. The quality of water will influence the vitality and growth rates of marine organisms in hatcheries, impoundments, embayments and other areas used for rearing fish and shellfish.

The presence of industrial effluent discharge points obviously represent a potential threat to quality of the distilled water. The impact of the plant itself on the ecology of the area, the terms of thermal pollution, chlorine released, increases in sediments as well as the effect of the above factors in combination with the mechanical shock as a result of entrainment of larvae and other planktonic forms should be assessed.

Depth is a major factor to be considered in siting mining for construction material (e.g. sand and gravel) depth greatly affects operating time, technological requirements and cost. Transport costs may be critical in assessing economic feasibility. The amount of overburden and propation of unwanted fine material will affect mining costs. Released fire material may cause undesirable turbidity and local habitat destruction. Shoreline wave height, wave period, wave direction, tidal range, littoral current, will influence mining efficiency, accessibility to a resource and the dispersion of sediment plumes with possible environmental and aesthetic consequences. Coastal protection problems may arise from mining for construction material offshore as they are likely to change the bottom geometry and hence the water circulation in the vicinity. Long term ecological changes must be carefully assessed when conducting cost-benefit analysis of such projects.

The native shoreline waves and longshore currents may be critical in siting mariculture projects. Facilities such as rafts, sea cages, or other impoundments are very susceptible to damage from waves and strong currents. Protected waters are usually more suitable for mariculture than the open coastal landforms.

Intensive agriculture (halophytes), the possibility of an area being irrigated by natural fluctuations of water level is an asset. Coastal climate may particularly favour certain crops. With respect to halophytes, excessive rain of fresh water runoff may dilute salinity below acceptable levels thus requiring provision for salt water irrigation. The need to protect growing areas and their embankments from erosion by wave action or longshore currents is an important siting factor.

KUWAIT COASTLINE

The shoreline of Kuwait (excluding the islands) extends to about 263km. This could be divided into two distinct areas, the relatively more open shores and the more quiet beaches of Kuwait Bay. A survey of land uses was conducted by the Environment Protection Department in which the type of land use and characteristics of the beach were documented at 64 points. The distance between the low and high water line, the slope of the beach and the type of soil was recorded in the areas that were not excavated, dredged or filled.

The type of beach and its composition is shown in Figure 1. It could be seen that the shores were predominantly of the mud type for about 90 km representing (31.7%) of the coastline.

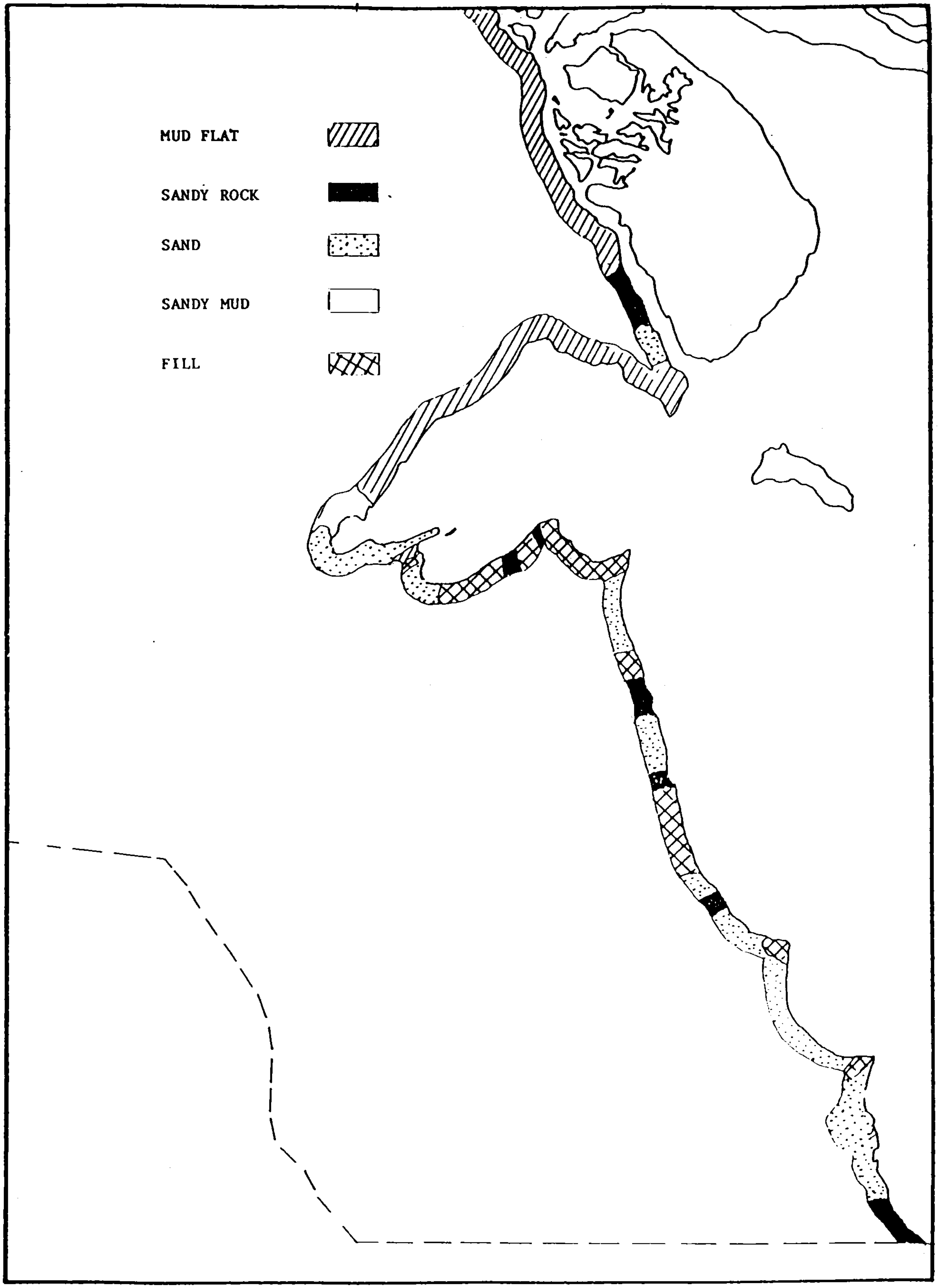

Figure 1. The type of coastal area along the Kuwait coastline.

These were mostly in the northern area or the Bay of Kuwait near Khor Al-Sabia. The distances between high and low water lines were generally between 100-600 m in most of its extent and was relatively wider in the Doha area. Sandy beaches were found in 33.3% of the coastline. The distance between the high water line and the Gulf Highway was most of the time in the range of 10-75 m except for some of the landfilled areas in which the fill was rising abruptly from the water line. Most of the sandy beaches were found on the open coastline extending from Ras Ajuza to the Saudi borders in the South with the better quality found in the southern region.

Rocky beaches or mixture of rock and sand were found in 13.3% of the beaches. Sandy mud beaches were not frequently seen, being limited to 3.3% of the coastline. However, landfilled area were slightly over 18% of the coast. The fill consisted of mixture of rubble from buildings demolition combined with variable proportions of concrete, blocks, gravel, lumber, brick tile, steel bars, rubber tyres, asphalt and household appliances.

The types of coastal development is shown in the map, Figure 2. The non-developed area is about 35% of the total. This is found mainly to the north and west shores of the Bay of Kuwait in the area extending from Sabia in the North to Kazma. This is mostly due to the nature of the coastal areas which is mud flats and Sabkhas. Being inaccessible, it is also not suitable for bathing, fishing or water sports.

The beaches designated for public recreational and touristic purposes constitute about 11% of the total coastline. This is mainly in the Water Front Region opposite to Kuwait City. The first two stages of the Water-Front project covering over 30 km have already been completed in 1987. A number of public beaches are located on the shores of the Gulf extending from Ras Al-Ard to El-Khairan which are run by the Tourism Enterprise Company.

The length of the coastline used up for the ports, desalination plants, hospitals and other facilities owned by the state constitute 14% of the coast. The hospitals are mostly at the Sabhah complex in Shuwaikh. Ports are found in Doha, Shuwaikh, Mangaf, Ahmadi, Shuaiba, Mina Abdulla and Al Zoor. In addition to that, there are about 20 marinas used for pleasure and fishing boats. Desalination plants are found at Doha, Shuwaikh and Al-Zoor areas. Plans are finalized to build another plant in the Subina area.

Private beaches owned by citizens or private organizations constitute 40% of the beaches. These are mostly used for building villas and weekend chalets. Villas are constructed in the area extending from Messila to Fahaheel. South of Mina Abdulla to El-Khiran, the coastline is almost completely taken up for summer resorts. A fence is usually built around the resort and extends to the water-line in a way to obstruct access to the beach by the public. Most of the chalets owners have pleasure boats for which slipways and private marinas are frequently built.

The study concludes that even as early as 1982, very little of the coastline was still available for development. The importance of the coast line for recreational activities cannot be over emphasized. Generally, very little opportunities are available for outdoor recreation. A recent investigation carried out by the Environment Protection Council showed that the lack of recreational opportunities was among the major environmental problems. This was mentioned by 82.0% of the population.

In Kuwait, bathing and boating for recreational fishing are probably the most popular forms of recreation. At present, most of the good quality beaches that could be used for swimming is taken up by 4% of the population. Taking the U.S.A. standards of 200-250 person/km; the total capacity of the Kuwait coastline would accommodate almost 1% of the population. This would require reclamation of the beaches to the north of Kuwait which is not economically feasible owing to their muddy nature.

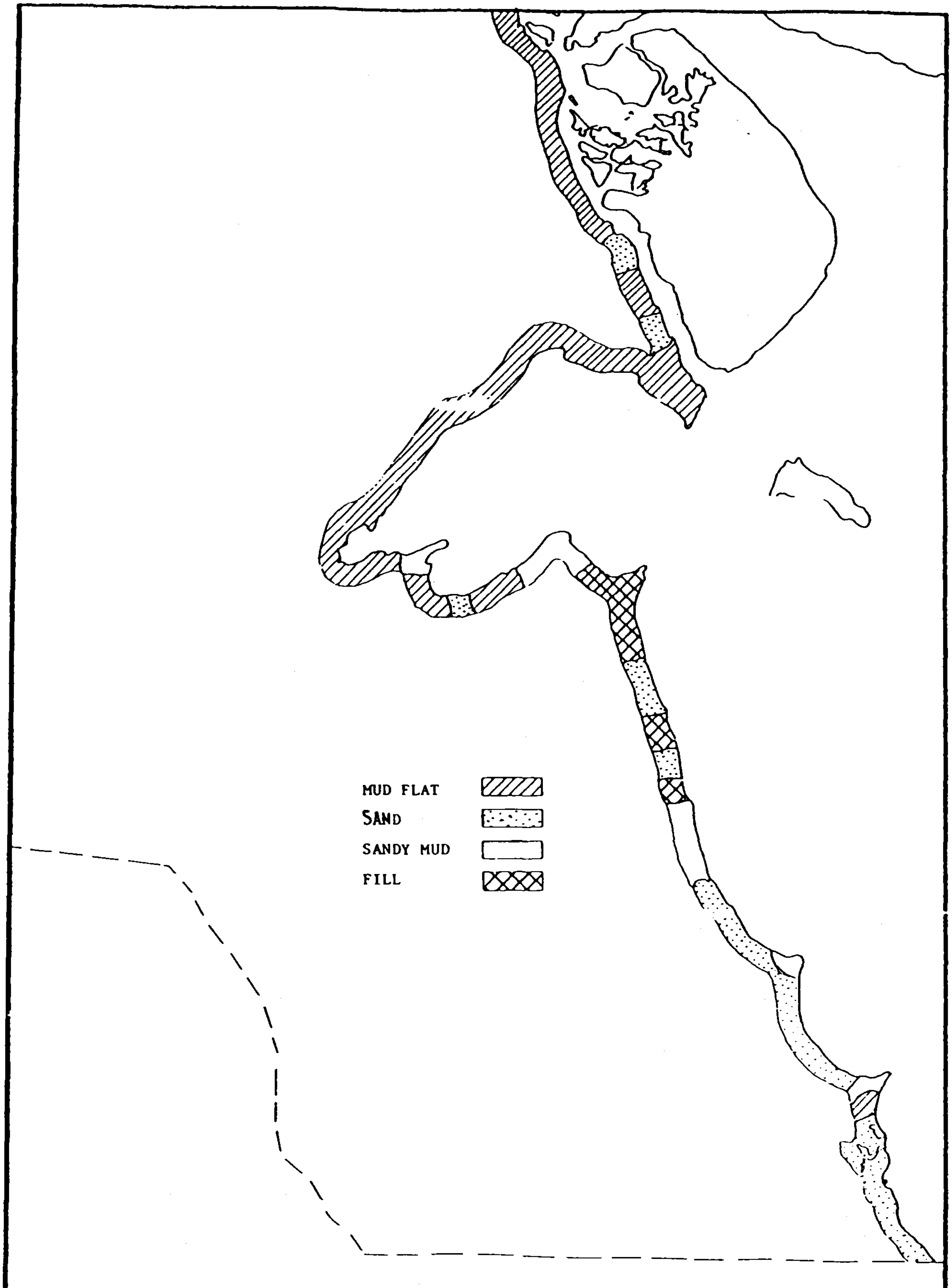

Figure 2. Types of development along the coastline of Kuwait.

The importance of the extensive mud flat in the shores of Kuwait Bay to the marine ecology in the northern Gulf region is well documented. A strip of the mud flat to the north and northwest of the Bay of Kuwait (Figure 3) has been proposed as a natural marine park. The justification was based on the area being a significant nursery for juvenile fish and shrimp, feeding area for migratory wading birds and a habitat for several unique marine species including the mudskipper.

A draft Amiri Decree is being reviewed by the legal authorities. The decree will provide for the designation of this area and for some of the coral reefs as protected areas. Activities that would or can be controlled, include drilling or mining operations and setting explosives, discharge of wastes or dumping of rubbish, trawling, collection of fish or other types of biota or other collection, discharge of firearms and operating vehicles on mud flats. Installation of permanent moorings or other permanent structures would require a permit from the competent authorities.

ENVIRONMENTAL IMPACTS OF THE TYPES OF COASTAL DEVELOPMENT

The impact on the marine environment by the various types of coastal development is summarized in the Leopold-type matrix (Figure 4). The wastes and changes in physical conditions resulting from the coastal activities related to each type of development is marked by an asterisk (*). The asterisk is put in brackets in case the effect is not of major magnitude. This and the subsequent figures (5-8) are adapted from a GESAMP Report (GESAMP, 1980) with slight modifications to render them more applicable to the ROPME Region.

Urban development will affect coastal areas through the discharge of sewage, urban runoff, garbage and inorganic solid waste disposed into the coastal area. Garbage may appear in the form of floating solid waste. Scum and oil and oily sludges may reach the marine environment by direct disposal or through runoff or with sewage. Odours, atmospheric contaminants and noise may be significant. Beach stability and shoreline processes may be interfered with by development. Sediment transport may be significantly affected if dredging or landfilling are involved. Pesticides used for human or gardening activities may reach the marine environment through aerial transport or with the runoff.

Tourism and recreation may result in similar impacts except for odours and atmospheric contaminants which are likely to be encountered. Marinas and harbours will mainly influence the water circulation, shoreline profile, wave conditions, beach stability, sea bottom conditions and sediment transport. Sewage, garbage, inorganic and floating solid wastes and oil and oily wastes are likely to result from the operation of the facilities. Dredge spoils may be a significant problem in the construction phase and whenever dredging processes for shipping lanes are practised.

Oil refineries and loading terminals will result in multitude of impacts. These include the impacts resulting from human domestic activities such as sewage, garbage, and the like. Specific impacts result from industrial waste and cooling water, oil sludge and scum and oil and oily wastes. Impact on the shoreline will depend on the extent of the coastal processes. Sea bottom conditions and sediment transport processes are not likely to be affected significantly. Wastes resulting from other industrial activities as paper and paper mills, metallurgic plants and fish processing lead to similar impacts except that cooling water and oil and oily wastes were not expected and the impact on the shoreline are not likely to be significant.

Mining for sand and gravel is likely to generate waste water, dredge spoils and dust. The impacts on the bottom and beach conditions and sediment may be significant. The effects of power stations on the marine environment have already been summarized.

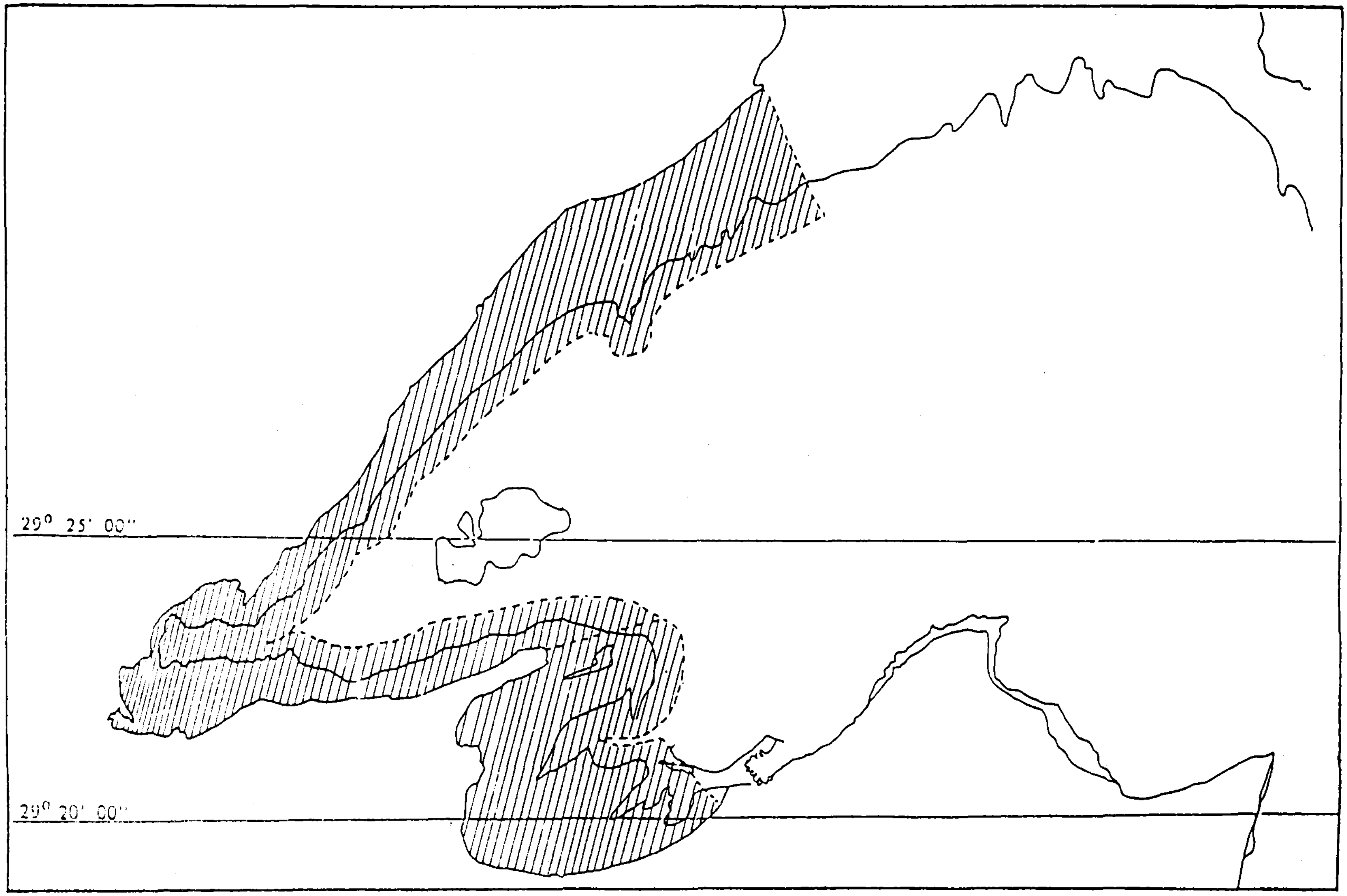

Figure 3. Location and extent of the proposed marine park in the Bay of Kuwait (Source: Morgan, 1986).

WASTES AND DIRECT CHANGES IN PHYSICAL CONDITIONS RESULTING FROM THE COASTAL ACTIVITIES / COASTAL ACTIVITY	SEWAGE	URBAN RUNOFF	GARBAGE	INDUSTRIAL WASTE WATERS	COOLING WATERS	ORGANIC SOLID WASTES	INORGANIC SOLID WASTES	SLUDGES	DREDGE SPOILS	DUSTS	FLOATING SOLID WASTES	SCUMS	OIL & OILY WASTES	PESTICIDES	ATMOSPHERIC CONTAMINANTS	ODOURS	NOISE	WATER CIRCULATION	SHORELINE PROFILE	WAVE CONDITIONS	BEACH CONDITIONS	SEABOTTOM CONDITIONS	SEDIMENT TRANSPORT
URBAN DEVELOPMENT	*	*	*				*		(*)		*	*	*	(*)	*	*	*		*		*		(*)
TOURISM AND RECREATION	*		*				*		(*)		*		*	(*)		*	*		*		*		(*)
PORTS AND HARBOURS	*		*				*		*		*		*				*	*	*	*	*	*	*
OIL TERMINAL WITH REFINERY	(*)		*	*	*		*	*	*			*	*		*	*	*		*		*	(*)	(*)
PAPER & PULP MILL				*		*	*					*		(*)	*	*	(*)	*			*	*	
METALLURGICAL PLANT				*			*	*		*		*			*	*	*				*	(*)	
FISH PROCESSING				*		*					(*)	(*)				*	(*)				(*)		
MINING FOR CONSTRUCTION MATERIALS				*					*	*								(*)	*[1]		(*)	*	*
POWER STATIONS					*		*[2]			(*)					*			*			(*)	(*)	(*)
MARICULTURE																*					(*)	(*)	
INTENSIVE AGRICULTURE[a]						*		*				*											
CONSTRUCTION PHASE			*				*		*				*		*		*	*	*		*	(*)	(*)

Notes:

a. In immediate coastal zone, e.g., rice paddies, sugarcane, halophytes, stock farming, horticulture
1. If carried out on beach or in shallow coastal water
2. If using solid fuel, e.g., coal

(This matrix relates the selected coastal area activities in the column on the left to the wastes they produce and to direct changes in the physical environemnt resulting form these activities).

Figure 4. Matrix between wastes and direct changes in physical conditions resulting from coastal area developments.

The effects of the waste discharged into the coastal area either directly or through aerial transport are likely to impact the marine environment. The major impacts are summarised in the matrix in Figure 5. The type and magnitude of the impact will depend on the type and rate of discharge, duration and the dynamics of the water body impacted. Sewage is likely to change the salinity, cause turbidity, change colour, reduce the dissolved oxygen (DO) content, and increase the biological oxygen demand (BOD). Both pH and temperature are probably slightly affected. However, nutrients, metals, other dissolved and suspended substances will be discharged into the coastal area. Biological pollution by microorganisms may cause public health problems. The distribution and diversity of fauna and flora will be affected according to their proximity to the point of discharge. The aesthetic value of the water will deteriorate markedly. Urban run off will cause similar impacts. However, the temperature, DO, BOD, nutrients and primary productivity are not affected to a great extent. Garbage will increase the organic load, cause turbidity and degrade the aesthetic value of the water.

Industrial wastes will affect almost all the variables except pollution by micro-organisms and the erosion of the coastline. Cooling water on the other hand, will mainly affect salinity and temperature. Minor impacts may result from dissolved solids, metals and antifouling agents. Chemicals as Cl_2 and halogenated compounds may affect the ecology of the water body. Organic solid waste will affect the turbidity, increase the level of nutrient, increase BOD and the level of dissolved solids. Impacts on flora, fauna and primary productivity may also be significant. Micro-organisms may pollute the water, and the aesthetic value may deteriorate significantly.

Inorganic solid waste causes turbidity, leaching of metals, affects the flora and fauna and causes deterioration of the aesthetic value. Sludges and dredge spoils will affect all the aspects with the exception of salinity,temperature, pH and micro-organisms. Floating solid waste will cause visual impacts and aesthetic problems and may constitute a safety hazard.

Detailed assessment of certain activities may be required. The physical changes induced by dredging (Figure 6) including water circulation, shoreline profile, wave conditions, beach stability, sea bed conditions and sediment transport will mostly cause erosion, depositions and accreation, turbidity of the water, deterioration of the aesthetic values and impact on the flora and fauna. These adverse effects were almost common to all the physical changes. Of less significant impacts were temperature changes, dissolved solids, nutrients and pollution by metals.

The third level of reactions is summarized in Figure 7. The impacts shown in the previous matrix are likely to influence the utilisation of the coast and may cause some types of activities to be abandoned. Tourism and recreation is likely to be affected by the water quality and the physical changes in the coastal area. Ports will be affected by salinity and temperature, the type of flora and fauna and erosions or deposition in the site. Commercial fishing is rather sensitive and is affected by most of the water quality parameters together with the physical impacts on the shoreline. Mariculture is sensitive and is influenced by the same factors mentioned for commercial fishing.

Siting a desalination plant will be influenced by salinity, turbidity, and temperature of water. The level of BOD, nutrients, other water quality variables, presence of microorganisms and the physical changes in the coastal line and their effects should also be considered.

	SALINITY	TURBIDITY	COLOUR	TEMPERATURE	pH	DISSOLVED OXYGEN	BOD	NUTRIENTS	METALS	OTHER DISSOLVED SUBS-TANCES	MICRO-ORGANISMS	FAUNA & FLORA	PRIMARY PRODUCTIVITY	EROSION	DEPOSITION & ACCRETION	
SEWAGE	*	*	*	(*)	*[1]	*	*	*	*	*	*	*	*		*	*
URBAN RUNOFF	*	*	*	(*)		(*)	(*)	(*)	*	*			(*)		*	
GARBAGE		*				*	*	(*)		(*)		(*)			*	*
INDUSTRIAL WASTE WATERS	*	*	*	(*)	*[1]	*	*	*	*	*		*	*		*	*
ORGANIC SOLID WASTES		*				*	*	*		*	*	*	*		*	*
INORGANIC SOLID WASTES		*							*			*			*	*
SLUDGES		*	*			*	*	(*)	*	*	*	*	(*)		*	(*)
DREDGE SPOILS		*	*			*	*	*	*	*		*	(*)		*	(*)
DUSTS		(*)	(*)						*			(*)	(*)		(*)	*
FLOATING SOLID WASTES									*			(*)				*
SCUMS			*						(*)	(*)		(*)	(*)			*
OIL & OILY WASTES		(*)	*			(*)	*		(*)	*	(*)	*				*
PESTICIDES										*		*				
ATMOSPHERIC CONTAMINANTS									*	*		(*)				*
ODOURS										(*)						*
NOISE										(*)						*
COOLING WATERS	*[2]			*		(*)			(*)	*[3]						
WATER CIRCULATION	*	*		*		*		*				*	*	*	*	
SHORELINE PROFILE		*		*[4]								*		*	*	*
WAVE CONDITIONS		*				*						*		*	*	*
BEACH CONDITIONS		*		*[4]								*		*	*	*
SEA BOTTOM CONDITIONS		*				(*)		(*)	(*)			*	(*)	*	*	*
SEDIMENT TRANSPORT		*				(*)		(*)	*			*			*	*

NOTES:

1. In estuarine and semi-enclosed conditions
2. If freshwater is used for cooling
3. Substances introduced to combat fouling, corrosion, et.c
4. Close inshore

(This matrix relates the waste and physical changes resulting from the selected coastal activities of matrix 1 to the resulting changes in marine environmental effects affecting other uses of the coastal area.

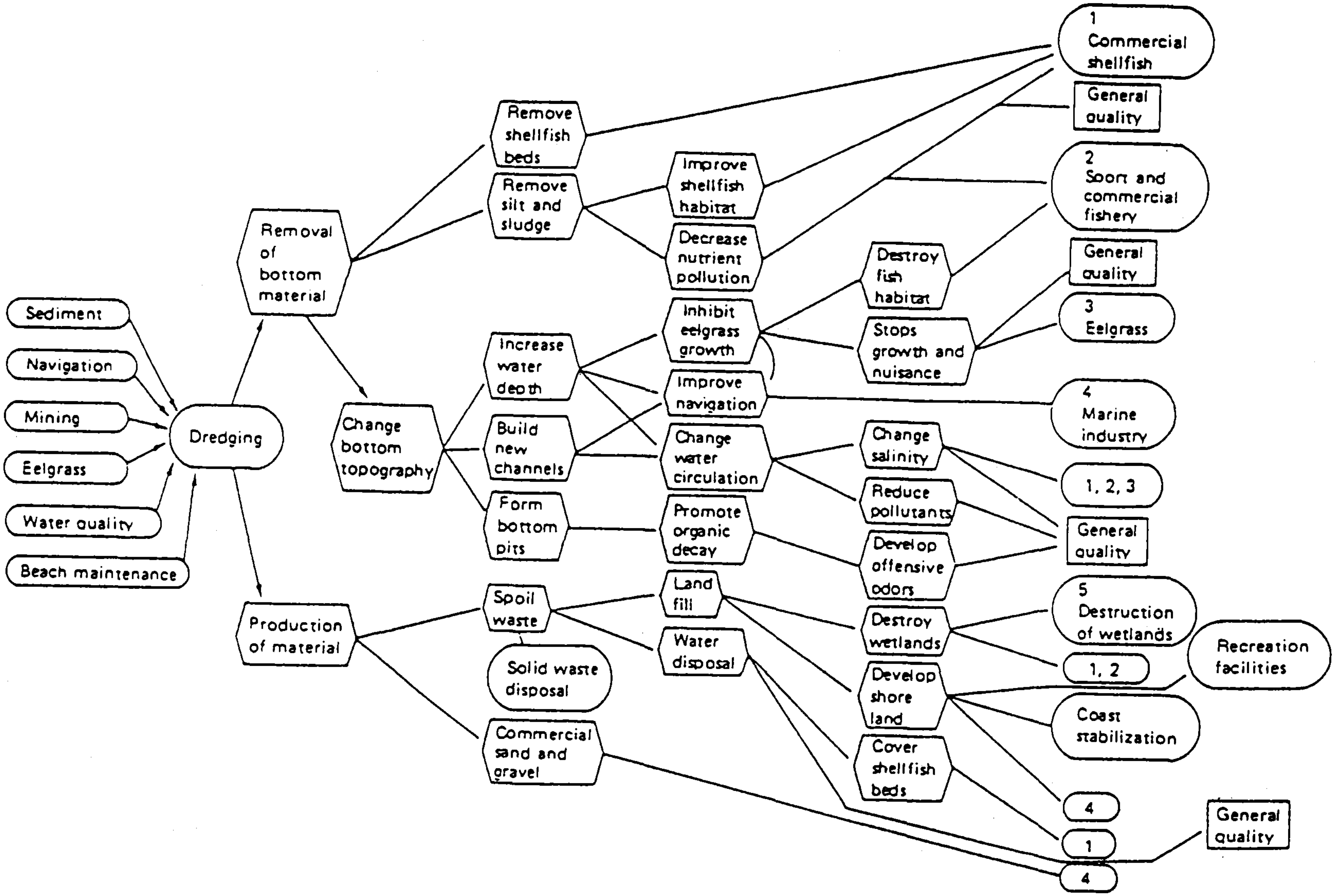

Figure 6. A network analysis of dredging (Source: Canter, 1977).

USES OF COASTAL AREA / MARINE ENVIRONMENTAL EFFECTS RESULTING FROM WASTES AND PHYSICAL CHANGES (MATRIX 2)	URBAN DEVELOPMENT	TOURISM & RECREATION	PORTS & HARBOURS	OIL TERMINAL & REFINERY	PAPER & PULP MILL	METALLURGICAL PLANT	FISH PROCESSING	MINING FOR CONSTRUCTION MATERIALS	POWER STATIONS	INTENSIVE AGRICULTURE	COMMERCIAL FISHING	MARICULTURE	NAVIGATION	DESALINATION	SEA-SALT PRODUCTION (SOLAR)
SALINITY			*						*	(*1)	*	*		*	*
TURBIDITY		*							*		*	*		*	*
COLOUR		*													(*)
TEMPERATURE		*	*						*		*	*		*	
pH										(*1)		(*)			
DISSOLVED OXYGEN											*	*			
BOD		*									*	*		*	*
NUTRIENTS		*								(*1)	*	*		*	(*)
METALS		(*)					*			(*1)	*	*		*	*
OTHER DISSOLVED SUBSTANCE							*			(*1)	(*)	*		*	*
MICRO-ORGANISMS	*2	*2					*			*1	*	*		*	*
FAUNA & FLORA	(*)	*	*						*		*	*	*	*	*
PRIMARY PRODUCTIVITY		*									*	*		*	*
EROSION	*	*	*		*			*			*	*	*		
DEPOSITION		*	*		*			*			*	*	*		
AESTHETIC VALUE	*	*													

Notes
1. Growth of halophytes
2. If sewage organisms are present in significant quantities

(The environmental factors in the column at the left have been changed by the wastes and physical changes resulting from the selected coastal activities (matrix 1). The impact of these changes on other uses are expressed by the entries in the matrix.).

Figure 7. The potential impact of marine environmental affects on selected uses of a coastal area.

A summary of the three stages is given in Figure 8. The coastal activities, namely urban development, tourism and recreation, ports and harbours, and oil terminals, mining for construction material and power plants are shown on the left hand side. These activities will cause sewage discharge, industrial and cooling water discharge, dumping of inorganic waste and dredge spoils, pollution by oil and oil works and change the other conditions.

These wastes and physical changes will cause turbidity of the water, change the ambient temperature, cause pollution by metals, affect the flora and fauna, cause erosion of the beach and deteriorate the aesthetic quality. These again will affect the suitability of the site for recreation, building harbours, siting a power plant, commercial fishing and mariculture and desalination of the water.

A more specific example is shown in Figure 9. A power plant was selected. This is likely to cause changes in the water circulation and generation of inorganic solid waste. These in turn may cause turbidity, temperature changes, pollution by chemicals, which will affect the recreational possibilities of the coastal area, operation of ports, commercial fisheries, horticulture and operations of power and desalination plants in addition to possible formation of sabkhas in the shallow areas and to the long term ecological changes which again may affect other uses of coastal areas.

CONCLUSION

Mitigation of the environment impacts of any development, industrial or otherwise should consider the specific characteristics of the site, the assimilative capacity or the physical changes introduced by the project.

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COASTAL ACTIVITY × **WASTES / PHYSICAL CHANGES**

COASTAL ACTIVITY	WATER CIRCULATION	OIL & OILY WASTES	DREDGE SPOILS	INORGANIC SOLID WASTES	INDUSTRIAL WASTE WATERS	SEWAGE
URBAN DEVELOPMENT		*	(*)	*		*
TOURISM & RECREATION		*	(*)	*		*
PORTS & HARBOURS	*	*	*	*		*
OIL TERMINAL & REFINERY		*	*	*	*	(*)
MINING FOR CONSTRUCTION MATERIALS	*		*		*	
POWER STATION	*			*[1]		

EFFECTS

EFFECTS	WATER CIRCULATION	OIL & OILY WASTES	DREDGE SPOILS	INORGANIC SOLID WASTES	INDUSTRIAL WASTE WATERS	SEWAGE	DESALINATION	HORTICULTURE	COMMERCIAL FISHERIES	POWER STATIONS	PORTS & HARBOURS	TOURISM & RECREATION
TURBIDITY	*	(*)	*	*	*	*	*	*	*	*		*
TEMPERATURE	*				(*)	(*)	*	*	*	*		*
METALS		(*)	*	*	*	*	*	*	*			(*)
FAUNA & FLORA	*	*	*	*	*	*	*	*	*	*	*	*
EROSION	*							*	*		*	*
AESTHETIC VALUE		*	(*)	*	*	*						*

OTHER USES OF COASTAL AREA: DESALINATION, HORTICULTURE, COMMERCIAL FISHERIES, POWER STATIONS, PORTS & HARBOURS, TOURISM & RECREATION

Notes:
[1] If using solid fuel

(This matric overview selectively portrays the relation of the three matrices: Coastal Activities produce Wastes and Physical Changes causing Marine Environmental Effects affecting other uses of the coastal area.)

Figure 8. Matrix overview between coastal activities, wastes and physical changes, effects and other uses of a coastal area.

COASTAL ACTIVITY	POWER STATION	*	*[1]
	WASTES AND PHYSICAL CHANGES	WATER CIRCULATION	INORGANIC SOLID WASTES

WATER CIRCULATION	INORGANIC SOLID WASTES	EFFECTS	DESALINATION	HORTICULTURE	COMMERCIAL FISHERIES	POWER STATIONS	PORTS & HARBOURS	TOURISM & RECREATION
*	*	TURBIDITY	*	*	*	*		*
*		TEMPERATURE	*	*	*	*		*
	*	METALS	*	*	*			(*)
*	*	FAUNA & FLORA	*	*	*	*	*	*
*		EROSION		*	*		*	*
	*	AESTHETIC VALUE						*
		OTHER USES OF COASTAL AREA						

The other uses shown are selected as examples

Notes:

1. If using solid fuel

This matrix overview selectively portrays the relation of the three matrices: Coastal Activities produce Wastes and Physical Changes causing Marine Environmental Effects affecting other uses of the coastal area.

Figure 9. Matrix overview between coastal activities, wastes and physical changes, effects and other uses of a coastal area.

A REVIEW OF DREDGING AND LAND RECLAMATION ACTIVITIES IN BAHRAIN

by

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ABSTRACT

During the last 50 years, a number of sites along the coast of Bahrain extending from the northern coast of Bahrain down to the coasts of Sitra Island have been either dredged or reclaimed. Dredging and reclamation activities tend to aggravate the environmental problems in the above areas. These intensive activities have drastically affected the area causing siltation and turbidity of the sea water. In addition, it has caused irreparable damage to the inshore biosystem, with many corals being killed. In this paper, various dredging and reclamation activities and their effects in Bahrain are discussed. Several recommendations are also suggested.

INTRODUCTION

The State of Bahrain is an archipelago composed of thirty-three islands located in the ROPME Sea Area, with the Kingdom of Saudi Arabia to the west and Qatar to the east. The main island, Bahrain measures approximately 44 x 17 km (85% of the total state land area). Bahrain is the centre of most activities, it has the capital city (Manama), the primary port (Mina Salman), the oil fields, and the oil refinery. Muharraq, the second largest island in the northern group, is connected to Manama by a 2.4 km-long causeway. In addition, the international airport and the drydock are located on this island. To the east of Bahrain is Sitra, the third largest island and also connected to the mainland by causeway. Sitra, an industrial centre, has a large refinery and an oil reservoir, a port for the export of oil and an electricity generating station. The island of Um-al-Hassam is another large island among the northern group. It is now almost uninhabited but this is destined to change due to the Bahrain-Saudi causeway. More detailed general information on the State of Bahrain is mentioned elsewhere (Madany _et_ _al_., 1986).

The population of Bahrain, according to a census taken in 1981 (Bahrain Ministry of Information, 1985), was given as a 359,857 (Bahrain Ministry of Information, 1985), and an estimated population in 1985 is 399,528 (Raveendran and Zayani, 1986). A recent study on the future population suggests that by the year 2001, betwwen 561,000 and 680,000 people will be living in Bahrain, Muharraq and Sitra. It appears that there is a close correlation between the populated areas and industrial activities.

The discovery of petroleum in 1932 marked a turning-point in the economy of the state, and attracted people from their traditional industries. Unfortunately, oil production then fell significantly by 1981. This situation forced the country to adopt a policy of economic diversification in order to increase and vary the sources of income. The main emphasis was on inudstry, and later on commerce, fisheries and agriculture. The need to industrialize urged the government to create industrial zones away from the centres of population, and this has created difficulties due to the limited area of Bahrain. The rapid development and the shortage of land became a problem in Bahrain. This problem was addressed by dredging and reclamation operations.

Reclamation of land from the sea is relatively inexpensive in Bahrain because the sea is very shallow for a considerable distance from the shoreline. Approximately two meters of fill, readily available by dredging offhsore, is sufficient to raise the level above the high-water mark and permit development.

The first reclamation and dredging activities in Bahrain took place in 1930. During the last 50 years a number of sites along the coast of Bahrain extending from the northern coast of Bahrain down to the coast of Sitra island have been either dredged or reclaimed. These activities increased rapidly in the 1970s serving both industrial and residential purposes. It has been estimated that by 1982 more than 100 Ha of land was reclaimed and about 1,400 Ha dredged (Linden, 1982; Zainal, 1985). Recently, several new reclamation operations were carried out involving large areas such as the site for Gulf Petrochemical Industrial Corporation (GPIC) plant (60 Ha), an ore-pelletizing plant (64 Ha), and about 10 km of embankments constructed for Saudi Arabia-Bahrain causeway. Two more recent reclamation projects were completed, one at Sanabis on the north coast, and the other at Budaiya, on the north-west. The total reclaimed area from the two projects amounts to approximately 200 Ha. A change in the area of Bahrain in the last few years are reported in Table 1.

Table 1. Change in the area of Bahrain due to dredging and reclamation activities

YEAR	AREA, Ha
1975	66,187
1981	66,926
1983	68,498
1984	68,772
1985	69,086

METHODS AND MATERIALS FOR DREDGING AND RECLAMATION IN BAHRAIN

The network executed by various contractors for dredging and reclamation at various sites of Bahrain are summarized below:

North Sitra industrial area

The Sitra power station was reclaimed by dredging in the immediate vicinity to form a deeper underwater intake channel. It was carried out between January 1973 and March 1973. The power station reclamation was approximately 180 metres wide by 300 metres long in an average water depth of 1 metre. The dredging was in a channel approximately 40 metres wide and 500 metres long in an average pre-dredging water depth of 3 metres. The material dredged was caprock, sand, clay and soft limestone which are typical of Bahrain coastal geology. The better qualities of these materials were pumped ashore to form the power station site. A summary is reported in Table 2. The total reclaimed area is 242 Ha.

Table 2

METHODS AND MATERIALS USED FOR DREDGING AND RECLAMATION IN BAHRAIN

TRACT	DATE FROM/TO	PURPOSE	DEPTH/TYPE OF DUMP/MATERIAL	QUANTITY	LAYER DREDGED	POSITION FIXING
Pipeline trench BAPCO	Dec. '71 - Jan. '72	New supply line	- Sand + coprock	20.000 m^3	-	Sextant
Mina Sulman Industrial Area + Channel	Jan. '72 - Jul.'72	Work area for Brown & Root	Approx. 0 - 3 m Coprock + mudstone	300.000 m^3	Approx. 6 m	-
Market Area	Jul. '72 - Apr. '73	Reclamation for Min. of Dev. & Engg.	Approx. 0 - 3 m Coprock, coral, sand	1.045.000 m^3	-	-
Sitra power station	Nov. '72 - Jan. '73	Recl. for Power Stn. + Cooling water channel	Approx. 3 m Coprock, mudstone	220.000 m^3	Approx. 5 m	-
Embassy Area Inter-Dhow channel	Jan. '73 - Aug. '73	Recl. for Min. of Dev. & Engg.	Approx. 2-3 m Coprock, mudstone	1.835.000 m^3	-	-
Habib Area	Sep. '73 - Oct. '73	Industrial recl. for Min of Dev. & Engg.	Approx. 2-3 m Sand, coprock, mudstone	196.000 m^3	Approx. 6 m	-
Bahrain Slipway approach channel+recl.	Aug. '73	Deepening approach to Slipway	Approx. 2-3 m Sand	40.000 m^3 (Approx.)	Approx. 1-2 m	-
Manama Market Extension	Feb. '75 - Jun. '75	Recl. for Min. of Dev. & Engg.	Approx. 3 m Sand, coprock, mudstone	1.000.000 m^3	-	-
Arabian Ship Repair Yard	Sep. '74 - Dec. '75	Drydock site + cause-way	Approx. 2-4 m Sand, coprock, mudstone	5.700.000 m^3	-	-
Sitra West Recl.	May. '75 - Jun. '75	Recl. for Min. Dev. & Engg.	Approx. 2-3 m Sand, coprock, mudstone	365.000 m^3	-	-
Muharraq/Juffair Recl.	Jul. '75 - Dec. '77	Recl. for Min. Dev. & Engg.	Approx. 0-3 m Sand, coprock	16.500.000 m^3	-	-
Mina Sulman Port Development	Mar. '76 - Oct. '77	Port Development	Approx. 5-6 m Sand, coprock, mudstone	5.500.000 m^3	Various	Toran
Mina Sulman Sandsupply	Feb. '77 - Jul. '77	Port Development	Approx. 3-4 m Sand (stockpiles)	1.300.000 m^3	Various	Toran

Mina Salman Port

The development of Mina Salman Port occurred through dredging associated with the deepening and re-alignment of the navigation channel from the entrance to Khor Al Qulaia to Mina Salman by the Ministry of Works, Power and Water. Special quality and filling immediately behind the quay retaining walls was dredged from an area of sea bed seat of the Sitra jetties of Mina Sitra. The reclaimed area and dredged materials are reported in Table 2.

South Al-Hidd and Asry Area

The total reclaimed area of South Al-Hidd and Asry is 592 Ha and has been used for various industries such as Arab Iron and Steel Company, Asry (Madany et al., 1986). The material required for site reclamation was taken from an area south of reclamation site, dredged to 13.7 m. The quantity of dredged material was about 6,100,000 m^3. The reclamation was done by first forming retaining bunds with tipped landfill to enclose the area, then hydraulic infilling with dredged material (caprock and limestone) to complete the area. Pipes were placed in the retaining bunds for the exit of water from the hydraulic filling which would carry a certain amount of fine materials and silt.

Gulf Petrochemical Industries Company (GPIC)

The petrochemical site reclamation was approximately 60 Ha and connected to Sitra by a 1250 m long access causeway. The material required for site reclamation was taken from an area situated between Bahrain Refinery (BAPCO) and Aluminium factory (ALBA) jetties. Two channels were dredged, one for cooling water; the depth of the water in it is about 7 m, and its length is about 3.5 km. The other channel is an alternative one to the existing fisherman's channel which is filled in some parts with the reclamation material. The quantity of material used is approximately 110,000 m^3.

Bahrain - Saudi Arabia Causeway

The 25 km causeway represents a major engineering achievement in terms of cost, amount of materials involved and technology. Built at a total cost of US$ 564 million, it is the biggest structure of its kind in the world, and one of the biggest projects undertaken in the Middle East this decade. A total of 345,000 cubic metres of concrete, 160,000 tonnes of cement, a mass of reinforcing steel, 47,000 tonnes, well over seven million cubic metres of sand-fill and more than three million cubic metres of protective stones has gone into the project (Gulf Mirror, 1986; Gulf Daily News, 1986). The causeway comprises 5 bridges and 7 embankments. The bridges vary in length from betwwen 950 and 5,150 metres, with solid embankments having been made between the spans in the shallower reaches of the ROPME Sea Area. All the bridge components were designed for prefabrication, the main components being hollow concrete piles measuring 3.5 m in diameter, a wall thickness of 0.35 metres in lengths of up to 40 metres. A concrete head was placed on the pile and the box girders complete bridge sections - were designed to rest on rubber bearing blocks. Cantilever girders span the distance between the piles. The underside of the bridges range from 5 metres above sea level to 15 metres at certain navigation spans through which shipping can pass. However, the main shipping route will see vessels clear 28.5 metres of headroom. The span itself is 150 metres with an 80 metres side span.

A project of this size has a profound effect on the environment and marine life. The shallow and almost landlocked ROPME Sea Area is especially vulnerable. This will be discussed in the next section.

Dredging and reclamation activities in Bahrain could be summarized as follows:

- The total area reclaimed was approximately 900 Ha.
- The total area dredged was approximately 1,350 Ha.
- The overall quantity of dredged material is more than 60,000,000 m^3
- Most of the material dredged were sand, rock, caprock, clay and soft limestone
- Most dredging works were carried by cutter suction dredgers and some with tailor suction dredgers
- The positioning for the dredging was carried out by Sextant, Toran, Theodolite, Distomot or electromagnetic equipments

Future planning for reclamation, an area of 70 Ha south of Al-Hidd is approved by the governmental authorities. This is in addition to what has been discussed above. Furthermore, three areas, south of Arad, (60 Ha), northwest of Muharraq and north Budaiya are under consideration for dredging and reclamation as shown in Figure 1.

THE IMPACT OF DREDGING AND RECLAMATION

Land reclamation and dredging in Bahrain have caused irreparable damage to the inshore bio-system with many corals being killed. Some of the largest corals are over a hundred years old and will probably never manage to re-establish on a silted site, as it has been reported by several workers. Sedimentation can also be caused by bad planning. Building solid jetties in certain configuration alters the natural flow of the water and therefore causes sedimentation in small areas.

The potential environmental impact of coastal activities, such as dredging and land reclamation operations presently carried out in a concentrated area seriously threaten the fishery of coastal and offshore waters, and could harm the productivity and quality of the marine ecosystem as a whole. The shallow nearshore areas that are presently destroyed by dredging and reclamation are the most diverse and productive ones in the sea; the seagrass beds and the coral reefs. It is not only the areas directly dredged or reclaimed that are affected, but the much larger areas where siltation takes place or which are affected by changes in currents, etc. It seems likely that the death of extensive coral reef areas outside the northern coast, have been caused at least partly, by increased turbidity of the water due to dredging and reclamation far away from these reefs. The extensive beds of seagrass along the coast have a central role as a nursery for shrimp and a number of fish species. Destruction of these sea grass beds is bound to affect the fishery for these organisms.

The shallow bottoms around Bahrain consist mainly of seagrass beds, mixed rocks, and sand bottoms. This is specially the case between Muharraq and Manama and around the coast of Sitra. These areas have been subject to extensive development activities (Anonymous, 1976). Large areas of these shallow bottoms have been directly affected by dredging and land reclamation which are expected to continue.

The importance of sea-grass beds for the marine environment are:

1. They form a major food source for many important fishes, shellfish species, dugongs, etc.

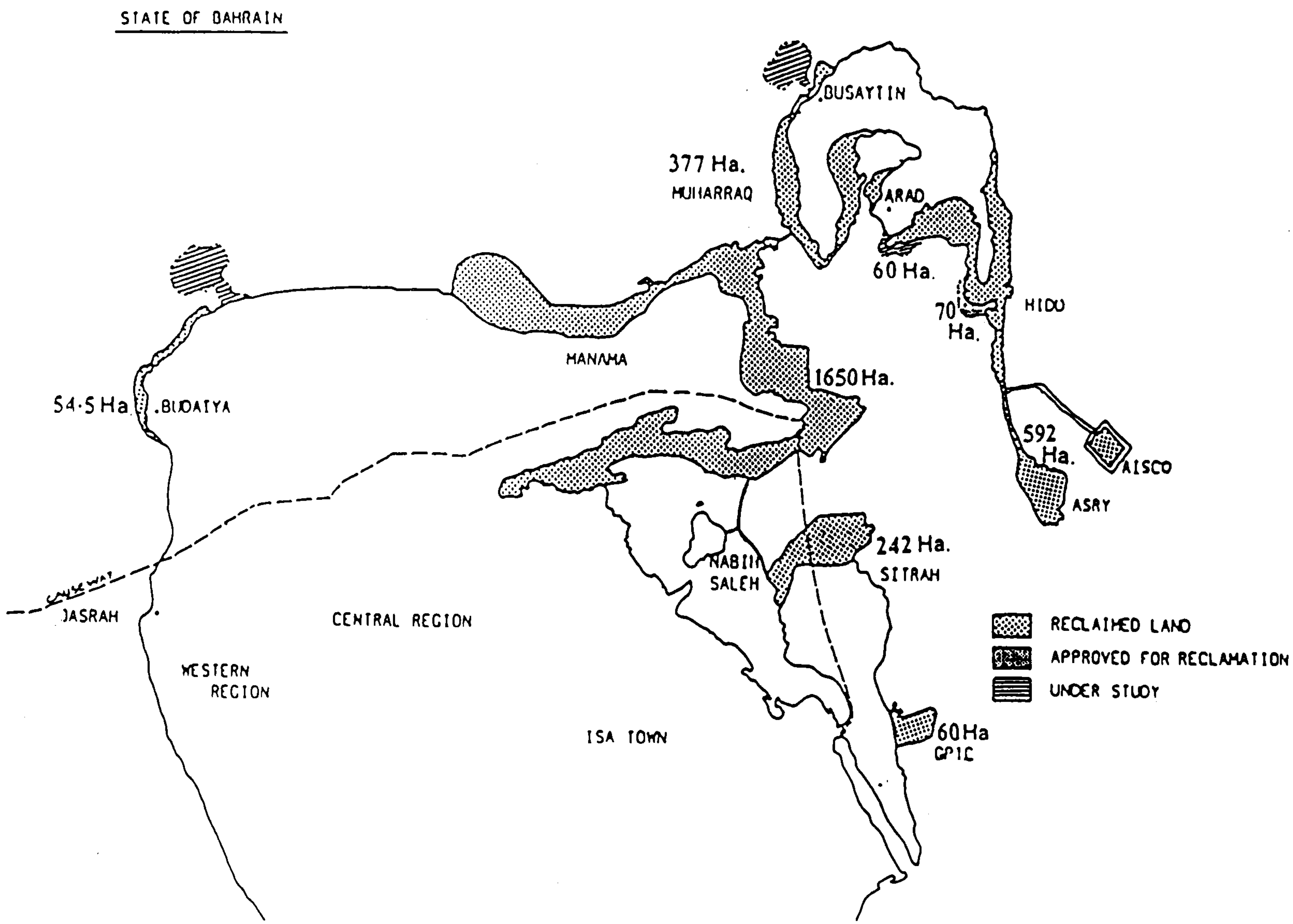

Figure 1. State of Bahrain reclaimed areas

2. They provide shelter to the vulnerable young fish of many species, such as commercial shrimp species.

3. They form attachment sites for many organisms, such as the pearl oyster.

4. They help in consolidating bottom topography, absorbing the energy of waves of tidal currents, and removing sediments from the water.

Mixed rock and sand bottoms provide an extremely wide variation of environment. They form habitats for a large number of different organisms including shellfish such as crabs, and a variety of fishes such as Moharras, Breams and Goat fish.

Some of the major effects of dredging and land reclamation are:

1. Damage to the spawning grounds of the various marine species which lay their eggs on the bottom.

2. Damage to the seagrass beds.

3. Damage to the substrate on which fish live.

4. Removal or alteration of the benthos which form the main source of food for many commercial fish species.

5. Increased turbidity locally, irritating or clogging fish gills, interfering with visual feeding and inhibiting photosynthesis.

6. Increase in siltation, alteration of the character of the sediments on spawning grounds and interference with egg development.

7. The discharge of the fine material during dredging operations may result in the release of toxic compounds previously buried in the sediments.

8. Damage to barrier traps, long lines, pots and other types of fishing nets.

CONCLUSIONS

The Environmental Protection Committee (EPC) of Bahrain, has put rules and regulations to control dredging and land reclamation projects before implementation (see appendix 1). However, some projects were carried out without the permission of EPC, due to the lack of legislations to support the regulations.

Thus, uncontrolled dredging and land reclamation operations represent a real threat to the marine resources of Bahrain. Present and future plans for these activities are bound to cause negative effects. Apart from the damage to the ecosystem in the dredged or reclaimed areas, such operations, which are poorly planned and uncontrolled, can also cause extensive damage over large areas not directly subjected to the operations in question. In addition, dredging and reclamation most likely affect the general current pattern over large areas. Reclamation of shallow productive bottoms may affect the coastal productivity as a whole if such areas are, for example, key areas for the juveniles of commercially important marine species (Price and Vonsden, 1983; Anonymous, 1976). In addition, a considerable area of dredged or reclaimed areas will be subject to heavy fallout of fine particulate matters which may present hazards to the planktonic and coral reef communities in particular. The coral organisms are extremely sensitive to increased turbidity of the water as they depend on and are adopted to the avilable light penetrating the water for their survival (Johannes, 1975: Ray and Smith, 1971; Hubbard, 1973; Dahl, 1973). It can also be concluded that local effects may arise from alterations in behaviour induced by turbidity clouds or disturbance of the bottom. These would be changed in the patterns rather than losses of stock but might, nevertheless, reduce fishing success by preventing the concentration of fish or by presenting local fishermen with an unfamiliar distribution of their largest species. Local effect on shellfish, particularly sedentary species, can be profound, rendering the habitat unsuitable or smothering the fish with fine material.

In conclusion, uncontrolled and poorly planned dredging operations, as well as land reclamation, may seriously affect the general condition of the water ecosystem, leading to deterioration of the environment as a whole.

RECOMMENDATIONS

1. Rules and regulations put by EPC are not sufficient to control reclamation activities. It must be supported by legislations from the State of Bahrain.

2. It is recommended that several investigations should be carried out in the shallow waters around Bahrain in order to identify areas of high sensitivity and productivity. The studies may include the following:

    (a) Detailed inventory of the character of the benthic ecosystem around Bahrain. Major fauna abd flora elements should be studied along transects from shallow to deep bottoms. Samples of epi- and in-fauna should be analyzed with regard to abundance and diversity. Particular attention should be paid to the presence of grass beds and coral reefs. Areas of importance for the local fishery should be identified.

    (b) Investigations of the location of the major spawning and nursery grounds for shrimp and fish in nearshore areas. Particular studies should be carried out to locate the areas of importance for the juveniles of the commercial shrimp species. Species composition of the catches should be observed as well as the size distribution.

    (c) Productivity studies of the major habitats. Standing crop and standing stock of flora and fauna should be analyzed during different seasons of the year. Growth measurements of the leaves of the plants should be conducted.

    (d) Investigations of the migration pattern among the commercially important shrimp species. Through tagging experiments the major migration routes for the different species should be studied.

3. Environmental education relevant to the management of the marine environment should be continued, and public environmental awareness should also be promoted.

ACKNOWLEDGEMENTS

The authors wish to thank the Environmental Protection Committee, Bahrain, for providing valuable information relevant to this review.

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APPENDIX I

STANDARD MONITORING ACTION BY ENVIRONMENTAL PROTECTION TECHNICAL SECRETARIAT (EPTS) PRIOR TO AND DURING RECLAMATION TO ENSURE COMPLIANCE OF CONSTRUCTION PROGRAMME TO ENVIRONMENTAL REQUIREMENTS

Initial assessment of areas of direct impact (i.e. dredging and reclamation zone) with respect to critical marine habitats, industries, any immediate water quality requirements for sewage outfalls etc. where possible this would be based on existing information within EPTS files and database system. Where information is not sufficient, some detailed field work may be required prior to commencement of contract.

Prior to commencement and during the reclamation phase EPTS will undertake whatever monitoring it feels may be necessary. This will depend on the potential impacts to the marine habitat and to local industries and may involve oceanographic and/or ecological studies. Reclamation consultants would be expected to reasonably assist wherever possible in aiding the EPTS personnel with such studies. These monitoring studies may well continue beyond the construction phase into a suitable 'setting' period.

Whenever necessary, EPTS may ask for a meeting with reclamation consultants and interested parties to clear up any problems arising and to discuss the status of the project.

A brief final report on the acceptability of the finished project will be produced for the Environmental Protection Committee (EPC) by the EPTS. This will run to more detail and discussions where an environmental problem has been identified prior to or during the course of the project.

Details required of proposed reclamation projects prior to approval by EPC:

1. Full details of area of reclamation (location, extent) and area proposed for sand-winning including m^3 of material involved.

2. Boreholes required at sand-winning sites to assess percentage of silt in reclamation material (by granulometric analysis). Silt samples should also undergo chemical analysis.

3. Full details of methodology to be employed during construction, e.g. type of dredger, transportation of materials (method), precautions against excessive silt return to water column (bunding, wash-boxes, armouring or degree of slope around perimeter), drainage, area of silt ponds remaining.

4. Purpose of reclamation (i.e. requirements for housing, plant construction, roads, etc.).

5. Prior to approval the EPTS will contact any interested parties which it may feel should be involved (e.g. Fisheries, Water Resources Bureau, Local Industries, etc.) to get their comments or concerns with regard to the project.

Most of the above will be covered in the EPTS standard dredging permit which all companies/consultants are required to complete prior to EPC approval.

PERMIT APPLICATION FOR DREDGING/LAND RECLAMATION

1. Name of company performing actual work

Contact (Name and Title)

Telephone No.

Mailing Address - P.O. Box ___________

Street Address - Area ______________________ Road # _____________ Block # ________

Bldg. # _______________________ Flat # _________________________

2. Is this work being performed under contract? Yes/No

If yes, Name of Contract Administrator)
)
(Ministry, Company, Association etc.)

Contact (Name and Title):

Telephone No.

Mailing Address - P.O. Boc ____________________

Street Address - Area _________ Road # ________ Block #_________

Bldg. # ______________ Flat # ______________

3. Location of Project - Attach map (1:10,000) showing project boundaries, latitude and longitude, starting contours, fish traps, final contours, and location of drainage channels, sewers, bridges, roads, or any other significant structures.

4. Purpose of project ____
____
____

5. Project Start Date _______________________ Completion Date ____________________________

6. Quantity of material to be dredged ____ m^3

7. Method of dredging____

8. Chemical analysis of dredged material. Complete Table 1 or attach data sheet and laboratory report.

9. Water current pattern and velocities at/around the dredging/reclamation area. Attach hour data for two consecutive tidal cycles.

10. Quantity of material to be landfilled ______________________________ m^3

11. Type of material to be filled:

    1. Dredged material
    2. Desert fill
    3. Building rubble (describe)

    4. Other (describe)

12. Methods employed to avoid siltation, or other adverse effects in the project area.

13. Suspended solids content of discharge water ______________________________ mg/L

14. Total sediment load discharged to the acquatic environment ____________________ m^3

15. Number and location of fishtraps (Hadra) in the project area that are likely to be either directly or indirectly affected.

Signature: ....Title: .... Date: ....

DESCRIPTION OF MATERIAL TO BE DREDGED

		Site-1	Site-2	Site-3	Site-4	Site-5
Test bore #.						
Location	Latitude					
	Longitude					
Date						
Particle size distribution (%)						
	< .075 mm					
	.075 - .150 mm					
	.150 - .300 mm					
	.300 - .600 mm					
	.600 - 1.18 mm					
	1.18 - 2.36 mm					
	2.36 - 4.75 mm					
Phenols (ppm)						
TOC (ppm)						
Petroleum hydrocarbons (ppm)						
pH						
Arsenic (ppm)						
Cadmium (ppm)						
Chromium (ppm)						
Copper (ppm)						
Mercury (ppm)						
Nickel (ppm)						
Lead (ppm)						
Zinc (ppm)						
Cyanide (ppm)						
Chlorinated Hydrocarbons (ppm)						

Name of laboratory performing
the above analyses

Contact Name and Title

Address

Telephone No.

SESSION V

ENVIRONMENTAL PLANNING AND MANAGEMENT OF COASTAL AREAS

COASTAL RESOURCES DEVELOPMENT CONTROL AND ENVIRONMENT MANAGEMENT

by

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ABSTRACT

Coastal regions provide one of the best environments for examining the relationship between development and environmental management. Any form of development will have some form of environmental impact, but environmental destruction relating to development could be avoided through adequate control based on a full understanding of the ecosystem and its capacity. The present paper provides actual examples of development projects which had or expected to have impacts on the marine and coastal ecosystems nearby or far away from the site of the project, with a view to indicating the complexities of planning for coastal regions. It is concluded that environmental management cannot be successful without thorough understanding of the environmental process, which can only be achieved by combining the many disciplines involved to acquire a comprehensive view of the impact of development, and to present this in a balanced and clear manner to the decision makers

INTRODUCTION

The purpose of town and regional planning may be considered as providing guidelines for development to meet the anticipated future requirements of the population (Dix, 1982). These needs may be considered in terms of the methods of accommodating future growth and development while at the same time preserving valuable resources and maintaining good environmental quality. In the majority of cases this process inevitably involves some element of compromise, further elements of development control and environmental management. For a variety of reasons which will be discussed in this paper the coastal region provides one of the best environments for examining the relationship between development and environmental management. It is not the purpose of this introductory paper to delve into the structure and details of what makes up coastal development plans but rather to examine those factors which make the coastal region such an important and fragile area which imposes the requirements for adequate environmental control on the planning process. It also attempts to indicate the need for a multidisciplinary approach to understand the complexities of the system, and describes some examples of combining the needs for development with environmental management.

DEVELOPMENT AND ENVIRONMENTAL QUALITY

For the past two decades or more there has been increasing concern over matters of ecology and conservation, and associated with this increasing public alarm at the damage caused by

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environmental pollution and loss of natural resources in the form of continued damage and depletion of ecosystems. To many, the view is that the pressures of economic growth and development and the burgeoning increase in population can only lead to disastrous results and further environmental degradation. Others take the view at the opposite end of the spectrum that something is bound to happen which will remedy matters or that nature will look after itself in some way. The truth of course must lie somewhere between these two extremes and relates to our understanding of ecology, conservation, environmental management and development control.

Any form of development will inevitably have some form of environmental impact and it is the job of those planning and controlling the development to ensure that the impact is such that it can be accommodated by the environment that receives it. Measurement of the environmental impact can take many forms and it is not intended here to describe how this is achieved but rather review the approaches which can lead to proposals which can reduce those impacts to acceptable levels. It is not being suggested that all ecosystems are equally robust or that it can be presumed that there will always be a method of manipulating the environment to allow development to take place. It must be recognized that some ecosystems are so fragile that any form of development could result in their loss. Unfortunately, there is a plethora of examples of environmental destruction relating to development many of which could have been avoided if there had been adequate control based on a fundamental understanding of the ecosystem and its capacity in the first place.

DEFINITIONS

In order to pursue the arguments in this paper it is necessary to provide the context in which certain terms are used. Principal confusion often arises by what is meant by 'ecology' and 'conservation'. Ecology can be defined as the science which deals with the relationship between living organisms and their environment. The term was first used by Ernst Heackel in 1873 and has been recognized in scientific circles for many years. Its general usage came about some considerable time later, in the past few decades, in particular since the United Nations Conference on the Human Environment held in Stockholm in 1972 (Lord Ashby, 1974).

Conservation can be defined as the wise use of our natural resources. In the context of this discussion it must require an understanding of ecosystem function and its tolerance to impact. As indicated above it must be recognized that some ecosystems are so fragile that conservation may legitimately take the form of preservation, a term with which it is often confused.

Pollution is generally better understood but not always recognized. While not one of us would knowingly stand in recognizable sewage all day, many people happily bathe in sewage contaminated water on the sea shore and breath some 26,000 times a day inhaling filthy air because they do not recognize the presence of the pollutant (Arvill, 1976). As all development has social and economic consequences many have come to the conclusion that anything that changes the delicate balance of ecology can be considered as pollution. Yet, there is likely to be almost no pollution that does not arise from some process that benefits man in some way.

Inevitably resolving the complex problems of development and pollution takes place in what can be called the political arena and it is up to us as professionals from different disciplines to ensure that the decision makers are provided with the best possible sources and interpretation of data in order that they can carry out the process of environmental accounting.

COASTAL ZONES AND PRESSURE FOR DEVELOPMENT

It is important for those involved in coastal planning to consider why the coastal area should be identified as a separate development zone from that of land or sea. It is in fact the area where the two major zones meet and the characteristics of the sea zone mix inextricably with the land zone, i.e., what happens on one part must inevitably affect the other. Similarly whatever happens in the coastal zone may have serious repercussions on the land or sea zone.

It should be evident to the environmental manager that what is required is a series of balances between man's requirements and desires, the need to meet the inevitable demand for development and the need for environmental protection.

In this context the coast represents a uniquely rich reserve of interacting resources including oil, gas, power generation, food and natural environments. As a result of its potential as a major facility for communication, trade and contact, it provides the economic opportunities for commerce, industry and tourism. An indication of the pressures put on this habitat are provided by the fact that by 1990 it has been suggested that 75 percent of the population of the United States of America will live in this corridor where the land meets the sea or the Great Lakes (Coates, 1985).

IMPACT ON THE COASTAL ZONE BY ACTIVITY IN THE LAND ZONE

It has already been noted that activity in the land zone remote from the coast can have severe impacts on the coastal environment and its economy. One of the best examples is provided by the construction of the Aswan High dam in Egypt.

Most of the population of Egypt live in the Nile Valley where nearly all of the country's agricultural industry is found. The dam was built to provide electrical energy for the growing industry and to provide irrigation water. At the same time the dam enabled control of the annual floods which transported valuable topsoil the length of the country to be deposited in the delta region. Despite the advantages of flood control and power generation there are many problems attributed to the dam construction.

One of the major effects is seen hundreds of miles away on the coast. The once thriving sardine fishery of the delta region and the waters beyond has virtually disappeared and this has been attributed to the lack of imputs of nutrients to the coastal ecosystem caused by the reduced and controlled flow of the Nile. A further consequence which has yet to be proved but which is giving rise to great concern in the city of Alexandria is the continued rise of the water table. It has been suggested that this may in part be due to water seeping under the dam into the Nile valley radically altering the drainage patterns, influencing soil salinity, and potentially changing the patterns of marine life in the coastal lagoons.

These changes may not be disastrous and it must be acknowledged that without the dam Egypt would have suffered severely in recent years of poor precipitation. It does however indicate the gaps that can exist in our knowledge of the long term impact of major development in areas some considerable distance away.

COASTAL DEVELOPMENT AND IMPACT ON THE SEA ZONE

The impact of coastal development on the sea and inshore waters is much more readily observed than the problems described above. A further example of this is provided by Egypt.

The city of Alexandria was founded by Alexander the Great. Some 30 years ago it had a population of 1 million. As a result of industrial development in recent years Alexandria now hosts 40% of the country's industry. In addition, the rising population of Egypt creates a demand for importation of food. In 1981, 5 million tonnes of grain alone were imported through the port of the city. This extra port activity, increased industry and general growth of the national population has resulted in the population of Alexandria to rise to nearly 3 million people.

At its current rate of development it is extremely difficult to maintain the growth in infrastructure to support the population. One of the basic needs is to provide adequate sewerage and sewage disposal. The sea has always been seen as a readily available waste disposal and treatment system. It is legitimate to assume that it does have some capacity for accepting and treating waste provided that the system is not overloaded.

In Alexandria nearly all of the waste water is discharged to close inshore waters each day. It is obvious to the casual observer that the result of this is gross pollution of the shores and the bathing waters. As the city provides the main tourist resort for the country the public health consequences and economic consequences of this pollution are very serious indeed. New sewage treatment plants and disposal systems are being planned and commissioned but answers are complicated by the fact that a fierce argument is raging which is attempting to resolve the conflict whether to treat the sewage and put it into the Mediterranean via a long sea outfall, or return the effluent to land which represents an important recovery of an essential resource to supplement Egypt's ever increasing demand for irrigation water.

INSHORE WATER DEVELOPMENT AND COASTAL DEVELOPMENT

Some forms of development can take place on both the land and in the nearshore waters. At Yanbu al Sinaiyah on the Red Sea coast of the Kingdom of Saudi Arabia, extensive development has taken place to provide an oil and gas transportation facility. The complex involves components of petrochemical industrial development, urbanization and construction of port facitilities. The latter have been constructed as two oil terminals connected to the land from the deeper water by causeway.

Of great significance to the coast in this area are the coral reefs. It was recognized that these not only represent a great natural history resource but also provide the shoreline with its first line of defence against the energy of the sea. Additionally, these reefs ensure the existence of a further natural resource, the mangrove areas. These habitats are also rich in species supporting significant populations of breeding, overwintering and passage migrant birds and thus are important to the whole coastal marine ecosystem. The mangrove areas are only permitted to develop and sustain themselves because the presence of the coral reef defence provides the necessary shallow sheltered water that the plants need to propagate and survive.

While there are many ramifications to this development the ecological impact of the inshore water development has been mitigated to a large extent by ensuring that the causeway construction removed only small sections of the reef system.

COASTAL HYDROELECTRIC POWER GENERATION

Harnessing the tides is a process seen by many to be a non-polluting source of renewable energy. One of the main requisites is to identify the location of sufficient tidal flow.

The most likely location for this can be found in estuarine situations.

For the past two years a study of the potential for such a development on the Mersey estuary in the United Kingdom has been underway and it provides a good example of the complex environmental issues that arise in considering a proposal of this type.

The Mersey estuary is situated in the industrial north west of the country. The Mersey is one of the most polluted estuaries in Europe receiving large quantities of treated and untreated sewage from the conurbation of Liverpool and Birkenhead at its mouth in addition to the treated wastes carried down river from the industrial towns upriver. Its configuration resulted in port developments which were highly significant in maintaining the U.K. as a major trading country. The same configuration of a large shallow estuary which exists through a narrow mouth is seen as providing a highly suitable location for tidal barrage power generation. The environmenatal implications are extremely complex and a selection of these are provided as examples.

While it can be argued that the development would provide a much needed boost to the economy of one of the most depressed areas of the country, there is a very powerful lobby against the proposals from those involved in nature conservation. One of the striking features of the estuary is that while its pollution problems are great it has become, over the past two decades, one of the most important European sites for overwintering birds. Creation of a tidal barrage will undoubtedly affect the roosting and feeding resources for the birds because it will raise the mean low water level. From this point of view it has been necessary to initiate a large scale study which not only examines the importance of the estuary itself, but also its role in relation to the ecology of the adjacent Dee and Ribble estuaries.

Further problems arise from the increased residence time of pollutants in the system which will result in reducing its efficiency as a waste disposal facility which is already overloaded. This has resulted in the Water Authority, the agency responsible for waste water disposal, to review the implications of bringing forward their programme for waste water management in the region not just in the immediate locality.

The decline of the industrial base and changes in industrial practice have resulted in reduced water abstraction from the groundwaters of the region. The net result of this has been a significant rise in the water table which in turn has put increased pressure on those responsible for maintaining the underground railway system of the conurbation. It is feared that construction of a barrage will exacerbate these problems by increasing the head of water in the estuary. Similarly the impact of the development on surface water drainage is also giving rise to concern.

These and other problems are superimposed on the socio economic aspect of the development and are subject to investigation in what must be considered to be one of the largest environmental impact assessments to be carried out in Britain.

CONCLUSIONS

This paper has attempted by use of a limited number of examples to indicate the complexities of planning for coastal regions. As in all cases of development it requires aspects of development control based on an understanding of environmental management. The latter cannot be successful unless a thorough understanding of the environmental processes is obtained. This can only be achieved by combining the many disciplines involved to acquire a comprehensive view of the impact of development in this zone and to present this in a balanced and clear view to the decision makers.

In recognizing the highly fragile and vulnerable nature of the coast it has to be appreciated that there will always be a shortage of information, resources or time relating to the appraisal process. Yet development does take place. Coastal planning therefore requires proposals which have some facility for adjustment included so that variations from predicted results can be accommodated as development proceeds and changes in growth occur.

This is a challenging concept which can only be achieved if adequate recording of events and monitoring of changes occur. This also infers that planning and the development process cannot be considered separately and that the planning process should be sufficiently flexible to take into account and resolve the problems induced by unpredicted economic demographic and environmental changes as they arise.

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WORKSHOP DISCUSSIONS AND RECOMMENDATIONS

OPENING SESSION

General discussion

The floor was open for general discussion of the introductory presentation. Queries were made concerning the importance of mangrove areas vs. mudflats, and it was noted that mudflats may well be as equally productive. The possibilities for mangrove transplantation were recognized, but it was considered unwise to try to introduce such a species into an area such as Kuwait where it does not exist as this may upset the natural balance of the ecosystem.

It was noted that people are a component part of the ecosystem. The money for management and protection does not just come from biologists. We need to explain the economic and social significance of the environment to those who are concerned with controlling finances. This led on to the requirements for education and public awareness so that the man-in-the-street and particularly the future generations are well educated in the need to protect the environment.

The concept of environmental enhancement by coastal development led to interesting discussions on the use of artificial structure for increasing diversity and improving fisheries. This raised some philosophical questions whether we should be trying to create artificial environments or to protect the existing ones. The general consensus of opinion was that in all cases we should protect existing environments, but where we need to develop the coastline it should be done in a positive manner so as to improve rather than destroy.

The problems of trying to manipulate the environment without sufficient knowledge were highlighted by using the Dee estuary near Liverpool, U.K., as an example. A once thriving port and fishing harbour was ruined by introduction of *Spartina*, a rapidly growing estuarine grass that blocked the estuary. Although the area is now of significant scientific importance as a bird sanctuary, the fishery and port have been lost. Some of the problems with fish-farming in the Region were discussed. The need to protect existing fisheries was noted as being a priority over developing aquaculture. The commercial viability of the pearl-oyster industry was considered and projects in Bahraini waters were used as an example. It was agreed that the financial returns from fishing natural pearls without exploiting the rest of the animals could never compete with the cultured pearl industry.

SESSION I

CHARACTERISTICS, ASSESSMENT AND MANAGEMENT OF MARINE AND COASTAL HABITATS IN ROPME SEA AREA

General Discussion

The Session continued with a general discussion and questions appertaining to the previous presentations. These included queries about the total transport of sediments in Kuwait waters. It was pointed out that Kuwait had one of the highest dustfalls compared to anywhere else in the world. The question was raised as to how lead in such dust might affect marine life and it was shown that lead, mercury and other heavy metals could cause severe problems if they got concentrated in the food-chains.

The effects of sewage outfalls on the characteristics of the ROPME Sea Area was another topic of interest and involved discussions on the effects of eutrophication, high ammonia levels in sediments, anoxic sediments, etc.

Tidal flows and their effects on salinity, especially around Bahrain, required some further explanation as did the very low values of nutrients for this area.

The discussion continued on to the importance of primary productivity in Regional waters and whether an increase in nutrients would not in fact be beneficial. It was dicided that such increases in the input of nutrients as might result from sewage disposal can upset the balance and although the end result might be an increase in biomass the net result is usually a decrease in diversity. Toxic phytoplankton blooms were used as an example of such an undesirable end product.

The discussion finally came to the subject of remote sensing by satellite and the question was raised whether other ROPME Member States had the capability for it. It was pointed out that Saudi Arabia would soon have an on-line Data Receiving Station and that the Kuwait Institute for Scientific Research (KISR) was developing satellite data processing facilities. On the subject of whether satellite imagery was preferable to using fixed-wing aircraft, the participants were informed that fixed-wing work would be more time-consuming and costly and probably less accurate, as well as prohibited for security reasons in a number of ROPME Member States.

Discussion on this subject concluded with the expert pointing out that the satellite's role in characterising the marine environment could not be isolated from the need for sea-truthing. In the end it was a rapid assessment technique which could be used for limited monitoring on the large scale but needed detailed field-work to supplement it. On the other hand, it was now an acceptable and proven methodology which could be utilized throughout the ROPME Sea Area not only for characterizing habitats but also for bathymetric studies, research into sediment levels, sea surface temperatures and salinities, monitoring oil pollution and industrial outfalls, etc.

SESSION II

ISLAND ECOSYSTEMS AND OTHER CRITICAL HABITATS

General discussion

It was asked whether there was any record of egg-collecting from the tern colonies. This has been a major problem in Bahrain where the figures for nesting white-cheeked terns has been reduced over the last 4-5 years from over 4,000 to less than 400. It was mentioned that there was no evidence for this in the nesting colonies in Kuwait, but that many adult birds were frequently shot over the nest.

In answer to a question on what sort of disease affect mangroves, it was pointed out that the two main infestations were from scale-insects on the leaves and from boring organisms such as beetles and *Teredo* worm.

A question was raised regarding the sand 'halos' that forms around reefs separating them from the closely-associated seagrass beds, and it was suggested that these might be caused by wave-action as the deeper grass communities rise up to meet the shallower coral heads. It was further pointed out that the production of coral sand at the edge of the reef might effectively form a rain of sediment preventing the grass from developing. It was agreed that all these were possible but repeated that there was strong experimental evidence supporting the theory that it was grazing fish living in coral community but feeding in the grass beds.

In an attempt to compare the ecosystems in the ROPME Sea Area with those in the Pacific, it was pointed out that the major differences were:

(a) The obvious aridity of the ROPME Sea Area.

(b) The species richness was considerably less in the ROPME Sea Area.

(c) There was a paucity of biotopes within the Region due to strong natural stresses (e.g. temperature and salinity).

(d) The threats to such communities as the coral reefs were different. In the Pacific *Acanthaster planckii* (the Crown-of-Thorns Starfish) was a serious problem as was the El-Nino effect which caused reductions in sea levels for relatively long periods exposing the shallow reefs.

It was then pointed out in general discussion that one needs to make recommendations and to educate people on the importance of environmental management. Most legislation arises from disasters (*i.e*. a country will pass a law after a disaster has occurred) in order to prevent its occurrence in future. This is not the correct way. Prevention is always better than cure.

A question was raised if the protected zones shown for Saudi Arabia had been drawn purely on ecological grounds or in conjuction with the physical planners. It was pointed out that these were not exclusion zones and that their conception had allowed for a lot of flexibility with regard to future planning and development.

A question was raised as to how to protect coastlines from oil spills particularly in Qatar and Bahrain which always suffer badly due to the general current regime in the ROPME Sea Area. The answer was that the area needs increased tanker safety, more control over refineries and a selection of sites for protection. The cautious use of dispersants was noted. Prevention was considered to be the only answer and the requirement for protective measures in the event of a catastrophe.

In Bahrain sensitive industries such as power stations and desalination plants have their water intakes permanently protected by booms, and skimmers are always ready and available. Where spills do occur and impact on the beaches, there is a selective requirement for beach clean-up. In many cases it is better to let nature take its own course as attemps to defoul may cause the oil to return into the water column or be buried in the sediments. However, sensitive areas of the coast which are used by fishermen or for recreational purposes may need immediate attention. The difference between chronic and impulsive pollution was noted. A one-off spill may cause short-term, immediate damage but the chronic, continuous effects of hydrocarbons, etc. in the water column (i.e. from the washing of ballast tanks) are more harmful in the long run to sensitive organisms and communities such as corals and seagrasses. ROPME Member States are in the process of ratifying MARPOL 73/78 requirement for efficient reception facilities, and the National Oil Spill Contingency Plan has already been finalized by some Member States, and is in the stage of finalization by others. In the event of a major spill there is no time for polite letters or numerous phone calls. Action is required immediately, and an existing pathway needs to be established for inter-country co-operation. In many countries it is a legal requirement for such a Contingency Plan to be drawn up by the Companies before they start exploring for oil.

Finally, the need for legislation to enforce such requirements and recommendations was once again expressed and agreed on.

SESSION III

ENVIRONMENTAL HEALTH ASPECTS OF COASTAL AREA ACTIVITIES

It was requested to comment further on the statement that reclamation was a necessity in Bahrain in the light of the fact that large areas of land in the centre and south of the island were unused and that even in the habitated areas there was still plenty of land available. It was stated that people did not want to live near the industrial areas and that industries should not be sited near habitation. However, it was concluded that the real reason is the economic factor. A square metre of land in the diplomatic area of Manama could cost hundreds of Bahraini Dinars while the same area would only cost 1-2 Bahraini Dinars to reclaim from the coast. Also, a lot of unused land in Bahrain was already owned and the owners would not part with it except for large sums of money. It was felt that many of the reclamation problems were not caused so much by industry or commercial development which generally sought the permission and advice of the Government Environmental Protection Committee but private sector very often ignored any such requirementes.

The Session was closed by a summary speech where it was commented that the presentations had been very informative with discussions on the characteristics of the ROPME Sea Area marine habitats and the natural stresses under which they exist. Everybody agreed that there is the urgent need for legislation to combat the growing effects of pollution, as well as to protect the marine environment. Comparisons with other areas in the world had been most helpful. The treatment of land-based wastes and the consequences of such treatment and disposal at sea or on land had been discussed. The Session had been concluded with a thought inspiring discussion on the pros and cons of reclamation and whether it was really necessary. It was noted that the proceedings had inspired all the representatives from ROPME Member States to consider the overall coastal development problems.

SESSION IV

ASSESSMENT OF DEVELOPMENT ACTIVITIES AND THEIR IMPACT ON COASTAL AREAS

General discussion

It was noted that the only sensible approach to the correct guidance on coastal development was for the planners, government environmental protectors and, where possible, the public to be involved in the conceptual stage at the beginning of the whole process.

It was identified that all environmental impact assessments are being simplified and not just repetition of all previous environmental impact assessments. On that it was commented that it would be useful to have a case study to demonstrate this within the ROPME Region. It was felt that the only way to achieve a simplified approach to environmental impact assessment was to limit the number of questions that needed to be answered. In the vast majority of cases where an environmental impact assessment was required most of the questions have already been answered in previous environmental impact assessments for similar projects or for similar areas.

SESSION V

ENVIRONMENTAL PLANNING AND MANAGEMENT OF COASTAL AREAS

General discussion

To the question whether the Blue Plan can be applied to the ROPME Region, the reply was "Yes" in principle, but not necessarily following the same lines.

It was stated that the Blue Plan might be a good position from which ROPME might develop its own environmental and development plan.

The need to make environmental sacrifices in order to make development progress was discussed with reference to the loss of a sardine fishery due to the construction of the Aswan High Dam. One member commented on the lack of foresight and monitoring which could have predicted such an event. It was added that the Master Plan Team for Alexandria recognizes the rapid growth in the area and there is an attempt now to establish a monitoring and controlling system in order to review such plan. This situation is also apparent in other areas of the world. In U.K., such flexibility exists by having policies rather than strict laws and pollutant levels. Individual situations are reviewed and reviewing of policy is a common event. In summation, one should review the development strategy every five years and this review cannot function without information from environmental and development monitoring.

The comment of an expert that the Aswan High Dam had disastrous effects within the Mediterranean was not accepted and it was felt that the word "disaster" was not right. It was pointed out that without the Dam, the effects of vis-a-vis agriculture and flooding could well have been disastrous. The High Dam has been one of the best schemes for averting floods and droughts in Egypt.

Various types of environmental legislations were discussed and then commented again on the "disaster" approach and how if people die from envrionmental problems the legislation is passed. It is evident that even the World Bank realizes the financial and economic importance of the environment and is now providing financial support for coastal zone management.

It was pointed out that hydroelectric development in Surinam had resulted in the flooding of a rain-forest. This decision was made on economic grounds. The unforeseen effect was rapid decay of vegetation leading to rapid anoxic build-up with consequent growth of water hyacinth which clogged the intakes of the hydroelectric project. To remove these plants, herbicides were sprayed and to deal with expanding mosquito populations, D. D. T. was added. This was carried down-stream destroying a fishery upon which thousands of indigenous Indians relied totally for their food supply. The subsequent cost of clean-up was enormous. The sad fact was the lack of involvement of scientific expertise at the decision-making level which could have avoided this.

It was felt that engineering students should be better educated in the need for environmental concern so that they recognize the importance of including these aspects in any development plans. It was pointed out that this is now happening slowly in U.K. and in some other Western countries where it is realized that the environment is an economic issue.

The quality of the environment in which we have to live is now being recognized as an important factor by the planners and developers.

Examples of short-term decisions were given using the Aswan High Dam and the industries that were developed around it. Also, the sewage problems of Alexandria was mentioned again with government bodies being reluctant to decide whether to put the sewage into the sea or on the land. Consequently, no decision is made and the problem continues to get worse. So there is a case needing judges and not more experts, somebody to make a firm decision. Legislation needs to be based on expert knowledge but also needs to be flexible enough so as not to be out-dated too rapidly by changing situations or evidence. What is needed is not so much governmental personnel than statesmen with foresight and vision. In future, economic and environmental actions need to work in harmony. The developing countries as a whole are entering a major dilemma. In forty years time the distribution of the populations around the world will have reversed due to massive population increases in the southern third world and reduced population in the northern areas of Europe, etc. The Southern third world gets its technology and develops its resources from the northern developed world and the two are no longer compatible. In other words, the problems need to be seen in the context of the socio-economic structure existing in the area.

After the aforegoing presentation, it was commented that the people who are making the environmental decisions within government are often in that position for their ability to be a politician and not for their environmental knowledge or ability.

One member, who was a former Minister in an environmental role, was asked about his attitude and he outlined the problems of fighting bureaucracy. He also emphasised the need for a political force such as public opinion.

Over recent years the concept of environmental awareness has undergone considerable progress, especially within the public sector. It is felt that this will naturally progress to a more official commercial and governmental level.

It was asked to comment on the problems of passing legislation on a regional level rather than national level. The answer was that with regard to the "Blue Plan" specific recommendations were made for both national and regional legislation but that this legislation had to be accepted and designed on a national level.

RECOMMENDATIONS

H. E. Dr. Abdul Rahman A-Awadi, Acting Executive Secretary of ROPME, felt that there must be certain specific recommendations appertaining to the Coastal Area Development Workshop. We need to encourage certain activities and discourage others. There must be co-ordination between those with a vested interest (e.g. the oil industry) and those who are trying to protect. He recommended that scientists should get together more regularly within the ROPME Sea Area (i.e. those people who are collecting the data should meet regularly) to discuss their works. Furthermore, he recommended the need for coastal zoning.

The Representative of UNEP's OCA/PAC urged the Workshop participants and experts to have an elaborate discussion with a view to reaching substantive conclusions and concrete recommendations relevant to the different coastal area development in the ROPME Sea Area. He indicated that having listened to the presentations made during various Sessions of the Workshop, we should have a comprehensive overview of the ecological and developmental characteristics of the Sea and coastal area of ROPME Region. This could provide the basis for formulating relevant recommendations which should be specific and action-oriented.

It was identified the presence of a great deal of data within the Region and that there should be as much co-operation as possible between the ROPME Member States. There is a need for an interdisciplinary co-ordination between Member States. Legislation has been recognized as being essential to supporting a coastal zone management policy. The requirement for more environmental awareness within the Region both within public and commercial sector was recognised as being essential. It was suggested that a coastal zone management policy was of paramount importance and that most of the other recommendations fall within this framework.

The Rapporteur gave a description of the proceedings, and read out the main points of concern arising from the Workshop:

- The need for national and regional coastal zone management plans.

- The need for an inventory of habitats, industrial development and areas of sensitivity from each Member State.

- The need for frequent professional contacts between scientists within the Region.

- The need for more environmental awareness, both in the commercial and in the public sector.

- Priority should be given to protecting existing environments whenever possible, but where coastal development is necessary, then it should be undertaken in a positive way.

- The need for a better understanding of seasonal and cyclic variations within the regional ecosystem so as not to confuse such variations with the effects of coastal development.

- The dangers of developing laws and regulations appertaining to the coastal zone without sufficient input from those experts who most fully understand that area.

- The "Blue Plan" for the Mediterranean and other such Coastal Zone Management Plans should be studied with a view to identifying the elements of their strategy which could be applied to the ROPME Sea Area.

- The ROPME Sea Area is obviously under unusual natural stress from extremes of temperature, salinity and sedimentation. Coupled to this, coastal development is rapidly expanding, especially in the petro-chemical industry. In consequence, the environment of the ROPME Sea Area is in no position to absorb any further man-made stress and there is evidence that it may already be undergoing severe deleterious effects. This situation should not be allowed to continue to the point where it may be irreversible.

- Much of the world's legislation arises from disasters. It is only after such a disaster occurs that a law is passed to prevent its occurrence. Prevention is better than cure.

- Where environmental issues are concerned in management plans, the planners should involve all interested parties such as governmental bodies and environmental protection authorities at the conceptual stage to provide appropriate input into these plans.

- Co-operation between the Member States is vital and contingency plans such as the Oil Spill Contingency Plan must be laid down and implemented <u>before</u> any castastrophes occur.

- Environmental problems cannot be isolated from economics and very often it is necessary to compromise rather than isolate the environmental bodies from those with industrial and economic interests.

- Environmental impact assessment should be brief, unlaboured and not repetitive.

- Finally, and most importantly, coastal zone management and the positive guidance of coastal area development is impossible and impractical without the relevant legislation to support it. The only way that signatories to the Kuwait Action Plan of the Kuwait Regional Convention (1978) and its related Protocols can save their coastal areas from potential damage is to develop legislation within their own countries. This legislation must be endorsed by the environmental bodies with the ability to legally control and guide coastal development and coastal zone management. The need for such legislation is paramount and overdue if we are to prevent the marine environment of the ROPME Sea Area from developing signs of irreversible loss and destruction if, in fact, this is not already the case.

- Subsequently, the floor was opened for discussion prior to the development of recommendations. After elaborate discussion by the Workshop participants and experts, the following recommendations were formulated:

- Being aware that the Kuwait Action Plan "sets forth a framework for an environmentally sound and comprehensive approach to coastal area development, particularly appropriate for this rapidly developing Region";

- Bearing in mind that the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution recognizes "the need to develop an integrated management approach to the use of the marine environment and the coastal areas which will allow the achievement of environmental and development goals in a harmonious manner", and taking note, in particular, of Articles VI, VIII and XI of the said Convention;

- Considering the points of concern identified by this Workshop, recognizing the serious threat imposed by coastal development on the already-stressed environment of the ROPME Sea Area;

- Convinced of the need to develop a comprehensive strategy for the protection of the coast and coastal zone of the ROPME Sea Area;

The Workshop has noted the general lack or insufficiency of legislation and regulation concerning coastal development within the ROPME Member States. The Workshop, therefore, recommends that:

- There should be legal requirements for environmental protection to be incorporated into any coastal development and that developers must consult with the responsible body or bodies (i.e. Environmental Protection Councils or Committees) in Member States at the inception of planning.

- All coastal development should incorporate a code of practice or principle of minimum detrimental environmental impact on the coastal environment.

A system for the exchange of data and information between Member States is a necessity. ROPME should initiate such a system and organize regional meetings to allow the scientists working within ROPME Member States to exchange views and information and to compare data. These meetings should occur on a regular, informal basis and be held on a rotational basis within Member States, and should include relevant site visits within Member States.