



UNITED NATIONS ENVIRONMENT PROGRAMME

*An ecological study
of the rocky shores on
the southern coast of Oman*

UNEP Regional Seas Reports and Studies No. 71

Prepared in co-operation with



IUCN



ROPME

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 fulfil 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 eleven regions^{1/} and has over 120 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

^{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, South-West Atlantic 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.

series of technical meetings of Government-nominated experts. 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,

- (a) 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/}
- (b) the Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution,^{4/}
- (c) the Protocol Concerning Regional Co-operation in Combating Pollution by Oil and other Harmful Substances in Cases of Emergency,^{4/}
- (d) resolutions on (i) interim secretariat, (ii) financial arrangements, (iii) steps to be taken for the establishment of the Marine Emergency Mutual Aid Centre, and (iv) co-ordination between the regional marine meteorological and environmental programmes.^{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. The ecological study of the rocky shores on the southern coast of Oman was one of these priority projects.

The study was entrusted to the International Union for the Conservation of Nature and Natural Resources (IUCN) under the general supervision of the Regional Organization for the Protection of the Marine Environment (ROPME) and the United Nations Environment Programme (UNEP). IUCN has undertaken the study in co-operation with the Oman authorities (the National Focal Point, the Directorate of Fisheries, the Directorate of Environmental Protection, and others).

The primary objectives of the study were to characterize the plant and animal communities found at selected sites and to estimate the abundance of the most common species.

This publication is an Abridged Report on the study. The detailed report of the study is contained in a volume of which only few copies have been produced and which are available at the Secretariat of ROPME, UNEP and IUCN.

^{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.

^{4/} Kuwait Regional Convention for Co-operation on the Protection of the Marine Environment from Pollution and Protocol Concerning Co-operation in Combating Pollution by Oil and Other Harmful Substances in Cases of Emergency. UNEP 1983.

ABRIDGED REPORT:
AN ECOLOGICAL STUDY OF THE ROCKY SHORES ON
THE SOUTHERN COAST OF OMAN

This report describes work carried out during 1983 as part of the Regional Organisation for the Protection of the Marine Environment (ROPME) Ecological Programme outlined by the Kuwait Action Plan. The studies have been conducted by the International Union for the Conservation of Nature and Natural Resources (IUCN) based in Gland, Switzerland, in cooperation with the United Nations Environment Programme (UNEP), and the Council for the Conservation of the Environment and Prevention of Pollution (CCEPP) based in Muscat, Oman.

The report describes a study of the littoral and immediate sublittoral ecology of Oman, with special attention being directed to the unusual rocky shore communities occurring in the Salalah region of Dhofar. Funding was available for seven and a half months. The project biologist (Dr. L. Baratt) spent two periods in Oman (February-June and September-October 1983) and was assisted at different stages by several taxonomic specialists and consultants.

The following work was undertaken:-

- i) a preliminary littoral zone habitat survey between Rakhyut (80 km west, along the coast from Salalah) and Sharbithat (approximately 260 km east, along the coast from Salalah);
- ii) detailed quantitative observations of the intertidal sublittoral fauna and flora at six Detailed Study Sites, two to the east and two to the west of Salalah, and one each at Masirah Island and Ras Al Hadd;
- iii) taxonomic studies and identification of the algae, polychaetes, molluscs, crustacea and echinoderms collected at the detailed studies and elsewhere. This section became the major element of this study because of the species were previously unknown from the region and some are new to science;
- iv) incidental observations on other marine and coastal flora and fauna (e.g. turtles, marine mammals);
- v) general observations on any environmental impacts apparently affecting the marine and littoral environment.

In order to explain some of the most important factors which may influence the seasonal distribution of plants and animals in both the littoral and sublittoral zones, a brief outline of the known physical and environmental factors has been included in the report. It must be stressed that there is no evidence at the present time to associate any of these factors with seasonal changes of the flora and fauna.

The rocky coastline of Dhofar is primarily composed of sedimentary limestones. These rocks, by their very nature, are soft and easily eroded by both wave and wind action, which tends to lead towards animals that prefer a burrowing existence. A small area of contrasting rock structure has been identified around the Mirbat peninsula, where the sedimentary rocks are replaced by much harder rocks, metamorphic in character. These hard rock formations produce many cracks and crevices in the rock structure, giving rise to flora and fauna more readily adapted to this kind of habitat.

Of the other environmental factors which affect the Dhofar coastline, the most significant effect is produced by the prevailing monsoon gyre. The summer months are affected by the south-westerly monsoon winds whose net effect is to produce the coastal upwelling off Southern Oman. This upwelling brings cold, nutrient rich water from the deep ocean and produces a number of floral and faunal communities which are not typical of the Indo-West Pacific region, and indeed at least one of these communities is unique in international terms. Pockets of maximum upwelling have been identified on a preliminary basis, and these occur around the Sudh area and the Kuria Muria Islands. Temperature recordings made from these areas show that water temperatures are some 5°C lower than the rest of the study area; the reasons for this are still unclear, but it is thought that the sublittoral topography of the area may be responsible for maximising the upwelling in these very localised areas.

The low water temperatures, coupled with the input of nutrients into the system, are thought to be the primary factor affecting the algal distributions in the region. The fluctuations of these populations on a seasonal basis is one of the most important factors affecting the substantial fisheries of the region.

The habitats of the region have been described on a gross basis, in order to establish that the chosen study sites were representative of the general area. The classification of the marine habitats were described using one of two possible criteria:

- 1) The classification of critical marine habitats can be defined in the following manner: critical habitats are identifiable areas which are vital to the survival of a species at some phase of its life cycle, or to the survival of a community, because of the ecological processes which occur within it (IUCN, 1976). Critical marine habitats include feeding, nesting, breeding or nursery areas of marine animals; or major sources of food or nutrients for feeding areas elsewhere (e.g. mangroves); or areas that are particularly rich in species (e.g. coral reefs); or highly productive areas (e.g. seagrass beds); or areas of special scientific interest.
- 2) The coastal system can be further classified according to habitat, and this scheme can be used to designate specific characteristics of reserves (Ray, 1975). The southern coast of Oman undoubtedly falls into the coastal environment classified as "exposed", with both calcareous and non-calcareous rocky substrates, and unconsolidated substrates of low organic content.

In many other areas of the world the coastal associated and offshore environments are highly productive. Oman is no exception, but is productive in a markedly different way from the rest of the Indo-West Pacific province, with the possible exception of the Somali coast. In most tropical environments, seagrass beds, mangroves and coral reefs form the basis of energy production, and are of high economic and social value, and create a focal point for the wildlife of the region. In Southern Oman this role is performed by planktonic and benthic algal resources which are a consequence of the annual upwelling.

The littoral zone habitats present in the Salalah area include rocky shore, long wide sandy beaches, coastal cliffs, some of which are visually impressive and of considerable landscape value. The most diverse fauna were found on the boulder and cobble beaches, and were seemingly unaffected by seasonal changes. Diversity, then, generally decreased from the rocky shores to the sandy beaches to the khawrs and mangroves with the least diverse communities being found on the rocky shores, but these were undoubtedly of a seasonal nature.

The limited number of khawrs, most of which contain ecologically valuable mangrove or reed bed vegetation were recorded in association with the sandy beaches. These areas represent an important, if limited coastal wetland, and although they may not be significant in relation to the marine environment; they are, according to Gallagher and Woodcock (1980), of exceptional ornithological interest. In view of the considerable destruction of mangroves in other parts of the region (Sheppard, 1983) it was noted that the mangroves of Southern Oman are at present under little threat from development. Air borne pollutants are of minimal impact, and have only been detected west of Salalah at locations 1.3.2 and 3.

The detailed study sites were chosen by one of two criteria: either because they coincided with the proposed pollution monitoring sites to be established by the CCEPP, or because they were of special biological importance. Six study areas were chosen in all, four in the Dhofar area, and one each at Masirah and Ras al Hadd. These were:

- i) Mughsayl. A sedimentary rocky shore to the west of Salalah (16°52'20"N 53°46'15"E). This is probably the least disturbed of the accessible rocky shores in the western region. The intertidal flats are mainly colonised by a thick algal turf which supports a number of grazing organisms such as grapsid crabs, echinoids and gastropod molluscs.
- ii) Raysut. The site was chosen to correspond with the pollution monitoring programme instituted by the CCEPP. There were several possible sources of environmental impact although few deleterious effects could be detected on the shore itself which lay to the west of the port (16°55'40"E 53°46'15"E).
- iii) Mirbat. Of the two sites to the east of Salalah, Mirbat had the higher population density and extensive construction work was being carried out in the vicinity of the town which lay some 2 km to the north of the site (16°58'20"N 54°41'40"E). The substrate was composed of low lying metamorphic rock.
- iv) Sudh. The town of Sudh was also undergoing some fairly extensive construction work, but this was unlikely to affect the site which was some 5 km to the north-east (17°04'15"N 55°06"E). This area represented the epicentre of distributions of both the kelp plant Ecklonia radiata and the abalone Haliotis mariae and as such was the most interesting biologically.
- v) Haqi. On the eastern facing shores of Masirah Island and extremely exposed at the headland (20°21'20"N 58°47'50"E). Topographically, the area is very similar to Mirbat, the immediate foreshore being composed of low lying metamorphic rocks.
- vi) Ras al Hadd. The area was chosen for study because of its susceptibility to intermittent oil spills due to its location on the north-eastern tip of Oman (22°31'30"N 59°45'40"E). A different type of rock structure was found here - sedimentary sandstones; despite this the communities were reminiscent of those found on the sedimentary shores in the Salalah region. Some evidence of the effects of previous oil pollution were noted but it is not possible to quantify these results since there is no existing knowledge about the area for comparative purposes.

The work at the Detailed Study Sites in the Salalah region has shown that the rocky shores of Dhofar support a unique assemblage of flora and fauna. The influence of the south-west monsoon winds during the summer months creates major changes in environmental conditions in both the intertidal and subtidal zones; these occur largely as a result of the upwelling of cold nutrient-rich water. The study

has also shown that the animal populations of both the intertidal and subtidal regions are equally diverse, and it is apparent that several very complex ecosystems are in operation. Some seasonal differences in distribution, and species composition, have been observed, but as yet the interrelationships between the community members must remain a topic for further research.

Several gross changes in the composition of floral and faunal populations could be observed during the year. One major trend was the appearance of a luxuriant algal turf. The composition of the turf was fairly uniform at all the sites (with the exception of Mirbat), and the common shore species of Ulva, Enderachne, Pterosiphonia, Suhria and one unidentified species were universally encountered. It is not possible to comment on whether these species are present throughout the year, existing in the turf in a heavily grazed form, or whether they are opportunistic species present only during the post-monsoon period.

Some local variation in percentage cover of certain species was also observed. In many places algal cover was 100%, and extended well into the splash zone, enabled to grow in this position purely as a consequence of the extreme wave action during the monsoon. The dominance of the extreme upper shore algae was short lived, three weeks after the monsoon effect had abated much of the shore algae had become sun bleached and was contributing significantly to the detrital material present in the immediate offshore waters. Certain changes in species composition could be observed where exposure factors could be partially assessed. This exceptional growth represents a remarkable amount of production in a very limited amount of time, and is obviously influenced by a range of environmental factors.

Some significant differences in faunal distributions could also be observed on a gross basis. Two major changes occurred on the sedimentary rocky platforms. During the pre-monsoon period, fairly high densities of the sea urchins, Echinometra mathaei and Stomopneustes variolaris had been recorded. These were mainly found in deep rock pools or crevice underhangs on the sedimentary platforms. On examination of these same shores in the post-monsoon period, the echinoid populations had largely disappeared, and only the burrowing urchin Echinostrephus molaris remained.

On the sedimentary plateau at Raysut, extensive areas of mussel beds had developed in association with the algae. These mussels, Perna pictus, had previously been recorded at this site in the mid and lower shore zones, but only in very small numbers with at most, six or seven individuals in any one group. In Phase II, they appeared to be locally abundant, reaching 100% cover in some places. It is assumed that the mussels settle on the shore during the extreme conditions imposed by the monsoon, because at this time they would be free from predation by fish and echinoderms. However, it would be interesting to see if this is yet another annual cycle, or merely an opportunistic event.

Similar seasonal changes could be observed in the floral and faunal composition of the sublittoral zone. In general, the sedimentary sites of Raysut and Mughsay showed little change in community structure on a gross basis. The algal turf was largely dominated by fine filamentous algae, bound by sand particles, and occasional foliaceous reds e.g., Hypoglossum sp., down to a maximum survey depth of 16 m.

The sublittoral flora of the Sudh region is unique in a number of ways. The major components of this zone are large brown (Fucallean) algae, which are predominantly represented by two species with distinctly different distribution patterns. One species, common in the shallow sublittoral zone, forms dense beds in association with several Sargassum spp.; its identification is still unknown and may

represent not only a new species but a new genus of algae. The second species, which dominates the deeper sublittoral, is a true "kelp" species, Ecklonia radiata, and has hitherto been reported only from New Zealand, Australia and southern Africa, this being the first record from the northern hemisphere. The associated underflora is dense and diverse, comprising a remarkable 90+ species to date, the visually dominant species being the erect coralline algae, Amphiroa anceps. It must be remembered that the present study was limited in both time and locality and in all probability a much higher diversity exists in reality. However, perhaps the most interesting feature of the Sudh kelp forest is its seasonality. In all upwelling-induced kelp ecosystems known from other parts of the world, the plants can be found throughout the year. The uniqueness of the Dhofar system lies in its total annual decline and recovery with the life cycles of the relevant species being completed in a time span of only six months.

The changes in the faunal populations were much more difficult to assess due to the algal dominance; however, an associated population of filter feeding organisms, such as sponges and tunicates were present and had not previously been recorded. The abalone populations showed a marked increase in the shallow sublittoral zone at most of the sites visited. This tends to support the theory of migration into the area possibly from deeper water, or a growth rate that is equally as spectacular as that of the algae. Several changes were noted in the composition of the fish populations although these were not recorded quantitatively.

The main report contains detailed qualitative assessments of the major taxonomic groupings found in Dhofar, some of the findings are summarised briefly below:

i) ALGAE....

1. The presence of a number of warm temperate elements within the northern Indian Ocean, an area which is normally characterised by tropical and sub-tropical species.
2. The presence of the kelp Ecklonia radiata in the sublittoral off the Mirbat plan is of significance in world terms, being the only recorded location outside Australia, New Zealand and South Africa for this species. The underflora associated with Ecklonia is also of great interest.
3. Algal diversity in some habitats (rock platforms, Ecklonia community) is particularly high. The Ecklonia community is outstanding for diversity of Rhodophyta, and obviously many more species remain unrecorded. Over 200 species were recorded for the survey area.
4. The Dhofar area contains biogeographical boundaries separating distinct floras.
5. The gross changes in macroalgal biomass, pre- and post-monsoon, contribute significantly to the total energy budget of the area.
6. It must be emphasized that the conservation value of the area is high, with (on the basis of preliminary results) a unique and possibly very localised community developing as the result of cold water upwellings after the monsoons. Of intrinsic interest on purely scientific grounds is the Ecklonia community, apparently unique in the northern hemisphere.

ii) CORALS....

1. These are a depauperate non reef forming assemblage of common widespread Indo-Pacific species.
2. The corals are limited by the cold waters of the seasonal upwelling, and luxuriant algal growth prevents settlement of the larvae.
3. They appear largely as encrusting formations - an obvious adaptation to environmental stress. Branching forms are poorly represented.
4. A comparison of the corals of the Inner Gulf of the Kuwait Action Plan Region, Hong Kong and Southern Oman, reveals remarkably similar genera.

iii) MOLLUSCA....

1. The littoral fringe contains three commonly represented species, Modiolittorina pyramidalis, Nodiolittorina natalensis and Littorina kraussi.
2. The most dominant mollusc of the eulittoral zone was the gregarious oyster Saccostrea cucullata which, together with Tetraclita and other barnacles, forms a conspicuous belt.
3. Herbivorous grazing gastropods are the most dominant trophic category of the eulittoral molluscs and, of these, limpets are by far the most abundant.
4. The several species of Neritidae are the most common of the other grazing gastropod molluscs.
5. Predatory gastropods are represented by three species from the Muricidae.
6. In the lower intertidal the molluscan faunas are more diverse but individual species are less abundant.
7. A number of shallow sublittoral species Haliotis mariae, Trochita, new species, Turbo, new species and Ergalatax contracta, appear to be restricted in distribution to the Mirbat-Sudh area.

iv) CRUSTACEA....

1. The commonest crustaceans on the boulder beaches with little macroalgal cover tend to be small xanthids.
2. Bedrock shores with a more extensive algal cover tend to favour the large grapsid crabs Grapsus albolineatus, and the crevice dwelling Eriphia sebana smithii, may be common locally.
3. Species associated with the algal populations have been found only in the post-monsoon phase e.g., Dehaanius scutellatus.
4. The number of species has increased from 70 to 110 between the pre- and post-monsoon periods respectively.
5. The species found conform to the expected situation of high diversity and low endemism.

v) ECHINODERMS....

1. The abundance and distribution of echinoids is dramatically altered between the pre- and post-monsoon phases.
2. Three species of urchin appear to be fairly ubiquitous throughout the region in the pre-monsoon phase; all of these are common Indo-West Pacific species.
3. The echinoderm list for Southern Oman indicates that it is fairly typical for the faunal province as a whole.
4. Of the species present, 35% were new records for the Arabian Sea.
5. The Mirbat peninsula clearly has a more diverse echinoderm fauna than the region to the west of Salalah.

It can be seen from the above information that the diversity of both the littoral and sublittoral zones is another very interesting feature of the overall ecology of the area. Although only a relatively short time has been spent surveying the area, and the floral and faunal lists must of necessity remain incomplete for the moment, a preliminary breakdown reveals over 200 species of algae, over 200 species of mollusc and over 120 species of crustacean. This magnitude of diversity is likely to be far greater than any temperate water kelp dominated system, and although no figures are available, it is likely to be comparable with, if not greater than, other upwelling induced algal systems. Some groups are obviously not so well represented. The corals for example, are surviving on the very limits of their environmental tolerances; nevertheless, there are 17 genera recorded so far. It is difficult to give reasons for the relative paucity of the echinoderm group (Velimirov, et al., 1977). It must also be remembered that the majority of collections have been made only on rocky shores, and as yet, other substrates remain unsurveyed.

The abundant algal resources in Southern Oman are largely responsible, either directly or indirectly, for the extensive fisheries in the region, i.e., fin, abalone and crayfish.

There is little detailed information on the ecology of the abalone in the area. Its limited distribution is closely linked to the similarly limited distribution of the kelp, which may well constitute a major food source of the abalone. However, it is known from other abalone populations that a feeding preference towards certain types of algae is shown. In general, green algae are preferred to reds, and reds are preferred to browns. This being the case, association of abalone beds with kelp forests may well be coincidental since the understory flora of coralline reds is also known to be necessary for the settlement of juvenile abalone. The extensive coralline understory in the Sudh region is ideal for such settlement and may be one of the most important factors governing recruitment to the population, and community distribution. In addition this species also shows a marked habitat preference, retreating into underhangs, cracks and crevices, so that the sublittoral topography of the metamorphic rocky area provides a more suitable habitat.

A programme of research on Haliotis mariae would require seasonal, quantitative sampling with mark-recapture tagging experiments to determine growth rates and population densities. Seasonal gonadal samples would also be required to determine reproductive cycles, and gut samples to determine diet.

Spiny lobsters are omnivorous feeders, eating almost any animal material they can scavenge or capture, and occasionally ingesting seaweeds (Chace and Dumont, 1949). It seems likely, therefore, that the abundant algal resources of Dhofar constitute a major food supply for the spiny lobster, and may partially explain the obvious success of this organism in the region. It is recommended that a thorough study of the feeding habits of this species be undertaken to assess the relative importance of different food organisms.

Presumably where conditions are favorable, age and size at maturity will be correspondingly adjusted. George (1968), in a survey of Panurilus species of Western Australia, infers that juveniles require turbid waters for optimal development and that the adults require cooler, clearer waters. It would seem, therefore, that the upwelling region of the south-east coast of Arabia has optimal conditions for spiny lobster development and reproduction.

Little impact on the marine environment was noted during the study. However, the principal construction work that may have affected the marine environment of the area has been the building of the port of Mina Raysut. The sublittoral area to the east of the port was used as a dumping ground for waste materials. Although the increased sedimentation resulting from such dumping and infilling is usually very damaging to marine life, in this case the artificial reefs that have formed have apparently been colonised by the large scallop Chlamys townsendi. These scallops have a rapid rate of growth and it is possible that this species might prove suitable for scallop farming at this and other sites. Also, there is no clear evidence from our data from the Detailed Study Site at Raysut that this shore, located on the far side of the headland to the west of the port, has been affected by the construction of the port. However, the prevailing currents are from the south-west so that silt and waste generated by the construction work would normally have been carried along the shore to the east, but no opportunity has arisen to examine the sublittoral zone in this area.

- Although little impact on the marine environment was recorded, damage to the equally remarkable and unusually productive terrestrial flora was more evident, emphasizing the need to institute a management policy designed to protect the renewable resources and landscape and recreational value of the whole coastal zone. In particular, it is recommended that a coastal zoning scheme should be established, assigning different uses to different sections of the coast.

A practical approach to this problem is to develop a suitable coastal zoning scheme involving the recognition of at least four classes of zoning.

- (a) Sections of the coast of outstanding fisheries, scientific, scenic or recreational value. It is suggested that these should be established as national or marine parks or reserves, following IUCN guidelines and criteria.
- (b) Sections of the coast of above average value from the point of view of renewable resources, landscape and recreation where any residential or commercial development should normally be prohibited.
- (c) Sections of the coast of moderate value from the point of view of renewable resources etc., where mainly residential developments may be permitted but only under suitable environmental guidelines following careful studies of potential impacts to the environment.

- (d) Sections of the coast of limited value from the point of view of renewable resources etc., within which industrial and commercial developments tend to be concentrated although, even here, suitable environmental protection regulations should apply in order to prevent such impacts from spreading to other zones.

Areas containing renewable resources of kelp, fish, crayfish, vegetation or grazing land should be protected from damage by development or pollution, as should scenic areas of recreational and social value.

Because the coastal zone of Dhofar encompasses a variety of habitats, and is subjected to a most of unusual set of environmental conditions which produce a unique assemblage of plants and animals, it is an area which is considered to be worthy of greater scientific as well as conservation efforts. Appropriate research may be considered under three headings:

1. Species Distribution.....Much of the present work has fallen into this category and obvious extensions to this are in the further identification of species, the investigation of more sites especially within the Sudh area, and to diversifying the study into other habitats, i.e., sand, boulder and mud.
2. Environmental Factors.....Factors such as temperature, light, turbidity, nutrients, salinity, water movements and exposure must be monitored in order to identify the trigger mechanisms involved in switching on seasonal growth patterns and those which govern distribution.
3. Ecological Interactions....The biomass and primary production of both the benthic and planktonic components of the algal systems should be studied together with the biomass of the primary, secondary, etc. consumers. In this way energy transfer and key transfer routes can be assessed with a view to isolating the dominant components of the system. Resource partitioning within these dominant components may well provide valuable information for the management of potentially economic resources, e.g. abalone versus sea urchins.

In conclusion, the intertidal and sublittoral rocky shore communities of the region are of considerable scientific interest. In addition to this, the algal communities are known to be highly productive, supplying cover and food for commercially important species including crayfish, abalone and many demersal fish. Consequently it is considered that there is need to study this habitat further and establish management guidelines for ensuring its protection.

PUBLICATIONS IN THE UNEP REGIONAL SEAS REPORTS AND STUDIES SERIES

- No. 1 UNEP: Achievements and planned development of UNEP's Regional Seas Programme and comparable programmes sponsored by other bodies. (1982)
- No. 2 UNIDO/UNEP: Survey of marine pollutants from industrial sources in the West and Central African region. (1982)
- No. 3 UNESCO/UNEP: River inputs to the West and Central African marine environment. (1982)
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- No. 7 UNIDO/UNEP: Industrial sources of marine and coastal pollution in the East African region. (1982)
- No. 8 FAO/UNEP: Marine pollution in the East African region. (1982)
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- No. 11 IUCN/UNEP: Conservation of coastal and marine ecosystems and living resources of the East African region. (1982)
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- No. 15 UNEP: Guidelines and principles for the preparation and implementation of comprehensive action plans for the protection and development of marine and coastal areas of regional seas. (1982)
- No. 16 GESAMP: The health of the oceans. (1982)
- No. 17 UNEP: Regional Seas Programme: Legislative authority. (1985)
- No. 18 UNEP: Regional Seas Programme: Workplan. (1982)
- No. 19 Rev. 2. UNEP: UNEP Oceans Programme: Compendium of projects. (1985)
- No. 20 CPPS/UNEP: Action Plan for the protection of the marine environment and coastal areas of the South-East Pacific. (1983)

- No. 21 CPPS/UNEP: Sources, levels and effects of marine pollution in the South-East Pacific. (1983) (In Spanish only)
- No. 22 Rev. 2. UNEP: Regional Seas Programme in Latin America and Wider Caribbean. (1985)
- No. 23 FAO/UNESCO/IOC/WHO/WMO/IAEA/UNEP: Co-ordinated Mediterranean Pollution Monitoring and Research Programme (MED POL) - Phase I: Programme Description. (1983)
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