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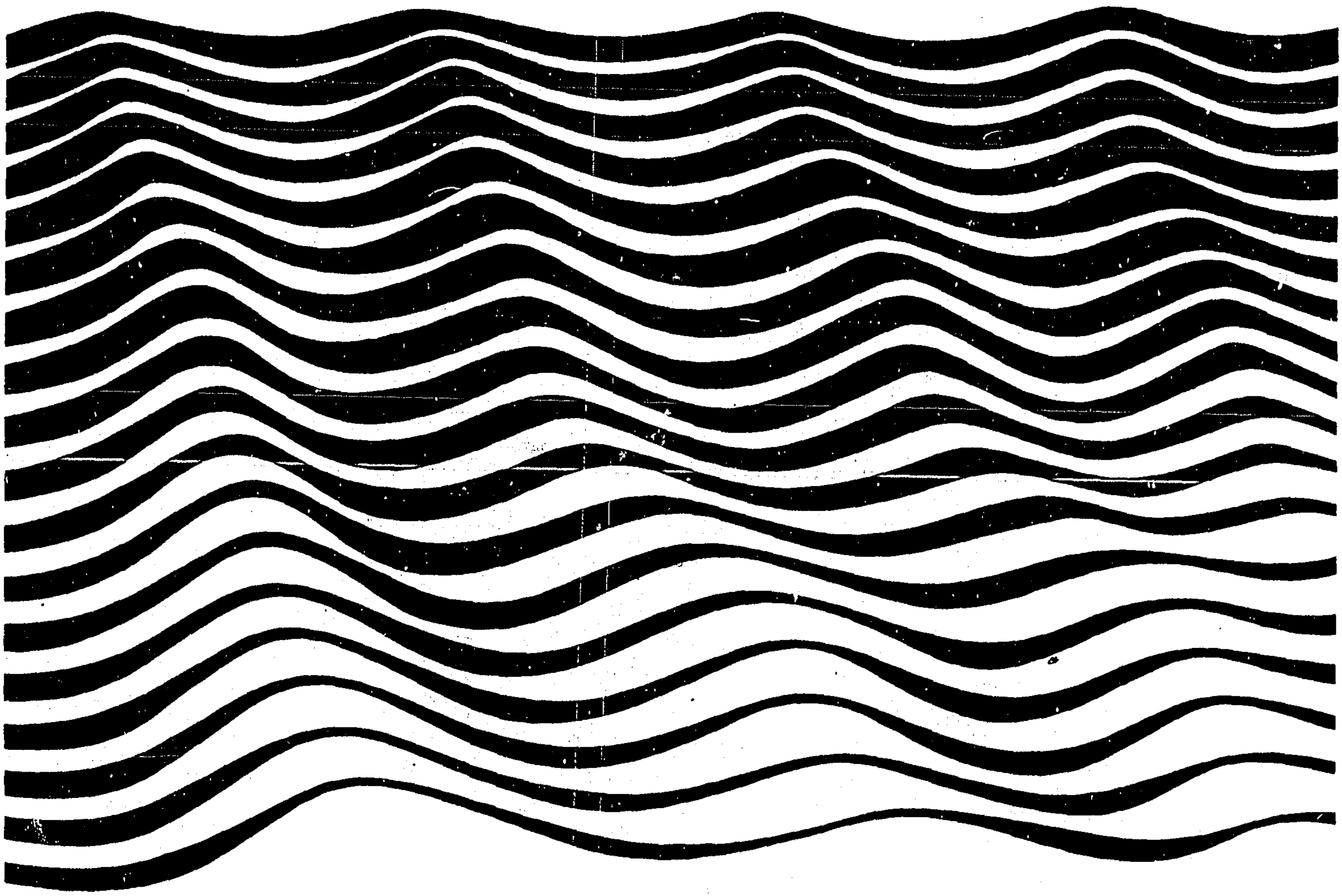
Marine science programme for the Red Sea

Recommendations of
the Workshop
held in Bremerhaven,
Federal Republic
of Germany



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UNESCO TECHNICAL PAPERS IN MARINE SCIENCE

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No.		Year	SCOR WG
9	Report on intercalibration measurements, Leningrad, 24-28 May 1966 and Copenhagen, September 1966; organized by ICES	1969	–
11	An intercomparison of some current meters, report on an experiment at WHOI Mooring Site "D", 16-24 July 1967 by the working group on Continuous Current Velocity Measurements. Sponsored by SCOR, IAPSO and Unesco	1969	WG 21
13	Technical report of sea trials conducted by the working group on photo-synthetic radiant energy, Gulf of California, May 1968; sponsored by SCOR, IAPSO, Unesco	1969	WG 15
15	Monitoring life in the ocean; sponsored by SCOR, ACMRR, Unesco, IBP/PM	1973	WG 29
16	Sixth report of the joint panel on oceanographic tables ans standards, Kiel, 24-26 January 1973; sponsored by Unesco, ICES, SCOR, IAPSO	1974	WG 10
17	An intercomparison of some current meters, report on an experiment of Research Vessel Akademic Kurchatov, March-April 1970, by the working group on Current Velocity Measurements; sponsored by SCOR, IAPSO, Unesco	1974	WG 21
18	A review of methods used for quantitative phytoplankton studies; sponsored by SCOR, Unesco	1974	WG 33
19	Marine Science Teaching at the University Level. Report of the Unesco Workshop on University Curricula – *Also published in French and Spanish*	1974	–
20	Ichthyoplankton. Report of the CICAR. Ichthyoplankton Workshop *Also published in Spanish*	1975	–
21	An intercomparison of open sea tidal pressure sensors. Report of SCOR Working Group 27: "Tides of the open sea"	1975	WG 27
22	European sub-regional co-operation in oceanography. Report of a working group sponsored by the Unesco Scientific Co-operation Bureau for Europe and the Division of Marine Sciences	1975	–
23	An intercomparison of some current meters, III. Report on an experiment carried out from the Research Vessel Atlantis II, August-September 1972, by the Working Group on Continuous Velocity Measurements: sponsored by SCOR, IAPSO and Unesco	1975	WG 21
24	Seventh report of the joint panel on oceanographic tables and standards, Grenoble, 2-5 September 1975; sponsored by Unesco, ICES, SCOR, IAPSO.	1976	WG 10
25	Marine science programme for the Red Sea: Recommendations of the workshop held in Bremerhaven, FRG, 22-23 October 1974; sponsored by the Deutsche Forschungsgemeinschaft and Unesco	1976	–
26	Marine sciences in the Gulf area - Report of a consultative meeting, Paris, 11-14 November 1975	1976	–
27	Collected reports of the joint panel on oceanographic tables and standards, 1964-1969	1976	WG 10

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Marine science programme for the Red Sea

Recommendations of
the Workshop
held at the Institut für
Meeresforschung,
Bremerhaven, Federal
Republic of Germany
22-23 October 1974

Sponsored by the Deutsche
Forschungsgemeinschaft
and Unesco

Unesco 1976

PREFACE

This series, the Unesco Technical Papers in Marine Science, is produced by the Unesco Division of Marine Sciences as a means of informing the scientific community of recent developments in oceanographic research and marine science affairs.

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FOREWORD

In 1974, Unesco was requested to support ALECSO's (Arab League Educational, Cultural and Scientific Organization) initiative to develop a regional scientific programme for the study of the Red Sea. Unesco provided the required assistance by convening a "Workshop on Marine Sciences Programme for the Red Sea", 22-23 October 1974, Bremerhaven, Federal Republic of Germany, which was attended by 23 scientists known for their scientific works on the Red Sea. The Workshop was organized by Unesco in collaboration with the German Research Society (Deutche Forshungsgemeinschaft). The report of this Workshop was used by ALECSO as a working paper in the "First Experts Meeting on a Regional Programme for Environmental Studies on the Red Sea and the Gulf of Aden", which was convened by ALECSO in Jeddah, Saudi Arabia, 25 November - 1 December 1974. Unesco, its Intergovernmental Oceanographic Commission (IOC) and the United Nations Environment Programme were represented in that meeting. The seven Arab States of the Red Sea and Gulf of Aden region together with Ethiopia cooperate in this regional multidisciplinary programme. The plan of action for 1975 required a number of preparatory studies to which Unesco and IOC provided some assistance. These preparatory studies were discussed in the ALECSO's Second Experts Meeting, Jeddah, Saudi Arabia, 12-18 January 1976. The Workshop results were also presented to the IOC *ad hoc* regional meeting on Training, Education and Mutual Assistance, Cairo, Egypt, 4-8 January 1976.

The conclusions and recommendations of the Workshop as presented here outline the status of existing marine scientific research on the Red Sea, the significant scientific problems that exist, a strategy for attacking those problems and the infrastructure and manpower needed to solve the problems. The analysis of scientific problems reflects the uneven knowledge of the Red Sea but also reflects the discipline distribution of the marine scientists who were able to participate in the Workshop. Thus problems of marine biology are more thoroughly discussed than those of other disciplines. However, an attempt is made to cover all aspects of the marine science of the Red Sea. It will be seen that the Red Sea represents a fascinating scientific challenge - one that is closely related to the exploitation of the marine resources of the Red Sea.

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1. INTRODUCTION

Sebastian A. Gerlach

Convener

The Arab League Educational, Cultural and Scientific Organization (ALECSO) took the initiative of formulating a co-operative regional programme for "Environmental Studies of the Red Sea", and, being one of the intergovernmental organizations represented in Unesco, asked for the scientific advice of the Unesco Division of Marine Sciences. German scientists have been engaged in various aspects of Red Sea Research during the past years, and, therefore, the German Research Society (Deutsche Forschungsgemeinschaft, DFG), agreed to co-sponsor with Unesco a workshop on a "Marine Science Programme for the Red Sea" to be held at the Institute für Meeresforschung (Institute of Marine Research) in Bremerhaven, F.R.G., 22-23 October 1974.

The terms of reference for this workshop were to elaborate the scientific ideas and plans for an interdisciplinary research programme on the Red Sea. Twenty-three scientists (Annex) from Egypt, the Federal Republic of Germany, France, Saudi Arabia, U.K. and U.S.A. who had experience and knowledge of Red Sea problems, participated in the discussions which included the scientific merit of the programme as well as possible economic implications, with a view to strengthening existing facilities and manpower in the region.

Several marine science activities have recently taken place in the Arab countries bordering the Red Sea. The Marine Biological Station at Ghardaqa, Egypt, which has a long tradition in marine research, has recently been reopened under the name "Institute of Oceanography and Fisheries, Ghardaqa, Red Sea, Egypt". A new "Institute of Oceanography" was established in 1971 at Port Sudan, Sudan, and a marine biological station belonging to the University of Khartum was built in 1973 at Suakin, Sudan. The recently-established King Abdulaziz University in Jeddah, Saudi Arabia, is planning an "Institute of Marine Sciences" in Jeddah. At the University of Jordan, Amman, a "marine science programme" was started in 1973. It is a multi-disciplinary programme encompassing all academic areas within the Faculty of Science. A Marine Science Station will be constructed in the near future at Aqaba. At the present time, the station is housed in a temporary building.

It is hoped that the marine science activities sponsored by ALECSO will receive support from the member states of this organization. The unique character of the Red Sea poses many scientific questions which, at present, the countries of the region cannot cope with alone. The questions, however, are so fascinating that they will attract research vessels and teams of experts from countries with wide oceanographic experience, if invited. The Red Sea programme, therefore, could set an example for cooperation.

A detailed plan for marine research in the Red Sea cannot be finalized until it is reasonably clear what financial and manpower resources can be made available. Therefore the suggestions of the workshop are scientists' visions of what should be done.

The convener had the pleasure to organize and chair the workshop on a "Marine Science Programme for the Red Sea" and it is his duty to summarize the results. He is extremely grateful to all participants for their contributions, especially to the rapporteurs of the committees who provided excellent papers for this summary report.

2. MARINE SCIENCE PROGRAMME FOR THE RED SEA

2.1. Strategy

A research programme for the Red Sea should be geared to understanding the particular problems of the region because of the immediate questions concerning the development and management of the resources and environment of the Red Sea. The implication of this basic strategy, however, is that many marine science problems of a more general nature have to be excluded, namely, problems which could be solved in any tropical ocean and on any tropical shore. Nevertheless, this strategy, which is necessary during the initial stages of the Red Sea research programme, should not discourage those research workers occupied with marine problems which are not included in the following catalogue of suggestions. In the countries of the Red Sea region, any engagement with marine science problems would be highly appreciated. The strategy must be to promote marine sciences, not to destroy existing activities with the pretext that they do not fit into the programme.

Taxonomy, physiology and life habits of animals and plants from the Red Sea are rather well documented, largely because many early explorers sampled the Red Sea, the most easily accessible tropical coral sea for European naturalists. There are numerous contributions from the Red Sea marine stations, and last but not least, many expeditions took some samples during their passage through the Red Sea on their way to Far East oceans. However, these were isolated activities which did not result in a coherent picture. Much more scarce are measurements of environmental parameters in the Red Sea ; many expeditions tried out their equipment while passing through the Red Sea, but published results are not numerous. The picture of water mass dynamics given under "2.2. Physical Oceanography" is derived from some very old, not very reliable data, and some spotlights of recent oceanographic research.

2.2. Physical Oceanography

Biological and geological research and the exploitation of the resources of the Red Sea must be based on a thorough knowledge of the dynamics of the water masses. The general picture of this unique sea is the following.

The Red Sea extends about 2000 km from the Strait of Bab el Mandab to the Gulfs of Suez and Aqaba; it has a surface area of 440,000 km^2, a mean depth of 524 m, and a maximum depth of 2,920 m. The Red Sea is connected with the Gulf of Aden via a 100 m sill about 125 km north of Bab el Mandab. The Southern Strait of Bab el Mandab is about 300 m deep and 27 km wide. North of latitude 19°, the average winds are northerly throughout the year. In the southern Red Sea, winds are controlled by the monsoon system of the Arabian Sea. From October to May (northeast monsoon), south-westerly winds of gale force predominate; from June to September (southwest monsoon), winds are from the northwest.

In winter, surface water flows with the wind from the Gulf of Aden into the Red Sea; as this water proceeds northward, it gets warmer and reaches a salinity of up to 40-42 °/oo. Evaporation averages 185 cm per year. In the northern part of the Red Sea, the high salinity water becomes cooler in the winter and therefore denser. It sinks from the surface to deeper layers of the Red Sea, generating a countercurrent directed southwards over the sill and through Bab el Mandab into the Gulf of Aden. This current can be followed for hundreds of kilometers in the Indian Ocean, off the Somali coast, at a depth of several hundred meters.

From June to September with northerly winds, the circulation pattern reverses. There is a surface current directed southwards over the entire length of the Red Sea, resulting in a surface outflow of warm high salinity Red Sea water into the Gulf of Aden. This creates a subsurface countercurrent of cold normal salinity water from the intermediate layers of the Gulf of Aden, which flows in through Bab el Mandab and over the sill, and penetrates at least 550 km into the Red Sea.

Below 200 m depth, the deep water in the Red Sea is nearly homogeneous down to the greatest depth (temperature 21.6°C, salinity 40.6°/oo). It originates from surface water which eventually sinks in the northern part of the Red Sea.

A proposal has been made to dam the Straits of Bab el Mandab in order to produce hydroelectric energy. Due to the large evaporation factor, the sea level of an enclosed Red Sea would become lower than that of the Gulf of Aden. The consequence would be an increase in salinity of the Red Sea, because the outflow of high saline Red Sea water would have been stopped, thus upsetting the salt balance. In consequence there could be a sharp reduction in the availability of living resources, and the production of fresh water from Red Sea water would become more costly.

The picture of Red Sea circulation given above is by no means solidly based on data; there are many gaps in the knowledge available, especially regarding seasonality. Future research therefore should be directed towards obtaining the missing data.

An essential part of any oceanographic research on water mass circulation (and for many other aspects of oceanography) would be an improved knowledge of the bathymetry. In particular, the region south of Hanisch Island should be the subject of a thorough morphological survey since every calculation of water exchange through Bab el Mandab must be based upon the dimensions of the sill.

Information is also needed on meteorological data both from land and island stations; WMO[1] "surface synoptic observations" are required. There are special problems of air-sea interaction in the Red Sea, caused by strong differences in local heating: an annual heat budget has to be developed. Because of the simple boundary conditions (i.e., little rainfall and advection of heat through just a narrow opening), the heat budget can be used to check the bulk formulas. In addition, the rate of evaporation should be measured in different areas and seasons.

A third essential would be the measurement of sea surface temperatures and sea level (by tide gauges) at various coastal stations, i.e., harbours and lighthouses.

These essentials are not an integral part of an oceanographic programme, but must be provided as technical services by special authorities. The main problems to be studied in the Red Sea are the large-scale horizontal and vertical circulation, and the water exchange with the Indian Ocean. Such studies should be supplemented by small-scale studies of specific regional and coastal phenomena. The following programmes are desirable:

2.2.1. Large scale variations should be measured by ships of opportunity; nearly any type of ship which runs from Suez to Aden, or on the opposite route, and can accomodate an oceanographer for the passage would be adequate for this purpose. With expendable bathythermograph equipment, thermoprofiles can be developed

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1) WMO : World Meteorological Organization

and synoptic meteorological data delivered, even while the ship runs at full speed. This would extend the use of commercial vessels as ships of opportunity for oceanographic measurements.

In each of the four seasons, there should be a cruise along the length and across the width of the Red Sea, with a fully equipped oceanographic vessel to complement the temperature measurements by a hydrographic survey using salinometers, not titration. for the measurements of salinity. Titration will still be needed if salinometers are unavailable. Data are especially needed for the summer season, because nearly all previous work has been done in winter.

2.2.2. Meso-scale variations should be measured in areas of special interest : there will be a cyclonic gyre in the northern Red Sea, but one should expect quite different structures in the southern Red Sea, due to the broad shelf. These measurements must be made from a research vessel with modern equipment so that depth profiles can be recorded continously.

2.2.3. Small-scale variations on the shelf in local coastal regions should be measured in specific areas in order to provide parameters for theoretical models. Research should be directed to the effects of the diurnal wind and tidal variations, and to the water exchange between the main water body of the Red Sea and the shallow water areas, including local upwelling processes.

2.2.4. Bab el Mandab and the exchange of water between the Gulf of Aden and the Red Sea should be a main topic of the research programme. This exchange is basic to an understanding of the various balances within the Red Sea. A permanent mooring is suggested in the Strait of Bab el Mandab near Perim Island. This station should measure currents, temperature and salinity throughout the year. Data thus obtained should be complemented by periodic surveys across the Strait to map the current structure. A land base on Perim Islands would be highly desirable.

2.2.5. The formation of deep and intermediate waters in the northern Red Sea should be investigated, including a description of how deep waters spread and, eventually, leave the Red Sea. Deep water current measurements should be envisaged over a period of one year. If the currents are too weak to be registered by current meters available, it would be highly desirable to detect the residence time of deep waters with radioactivity measurements, monitoring the concentration of tritium and carbon 14, which derives either from natural processes or from atomic bomb experiments, twenty years ago. For this kind of research, it should be possible to obtain support through the current GEOSECS [1] Programme, so that the ships of this international programme take relevant samples on their way through the Red Sea.

2.2.6. Intermediate Gulf of Aden water of relatively low salinity is supposed to enter the Red Sea regularly in summer, between 50 and 80 m depth. This water most probably has a key importance for the nutrient budget of the Red Sea, and one should determine the yearly variability of this inflow, the amount of water transported and its horizontal distribution.

2.2.7. The outflow of Red Sea water into the Gulf of Aden and the spreading of this water in the intermediate layers of the Arabian Sea should be followed, and it should especially be ascertained whether it is seasonal.

In summary, less is known about the Red Sea water circulation than of almost any of the other secondary seas. Yet the boundary conditions are much simpler in the Red Sea, which has no river discharge, low rainfall and a shallow, narrow opening. Thus there exists a real opportunity to understand the balance of properties, and to measure it. In conclusion, all levels of research, from modest efforts to multimillion dollar programmes, are possible in the Red Sea and will provide exciting

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1) GEOSECS : Geochemical Ocean Sections Study

scientific results.

2.3. Chemical Oceanography

The concentration of nutrients and the balances between oxygen, carbon dioxide and carbonates are intrinsically related to the dynamics of water masses as well as to biological processes. It has been stressed in part 2.2., Physical Oceanography, that in summer there seems to be an input of intermediate water from the Gulf of Aden into the Red Sea. This water is rich in nutrients and is of the highest importance. There is evidence of an oxygen minimum (about 0.5 ml O_2 l) at 400 m depth in the southern Red Sea. This may result from the degradation of organic matters produced in the euphotic zone. Further, the extended coral reefs on the shelf of the southern Red Sea should fix quite large amounts of nutrients within their ecosystems.

From available data, we are able to formulate a picture of nutrient supply through the Strait of Bab el Mandab and a decrease of nutrients in the Red Sea from South to North. But this picture is very vague due to the scarcity of data and the insufficient knowledge of deep and intermediate water circulation in the Red Sea. To overcome this gap in our knowledge, measurements of nutrients and oxygen should be included in every hydrographic survey suggested in part 2.2 Physical Oceanography, especially along the axis of the Red Sea; in the Strait of Bab el Mandab; in the tongue of low salinity intermediate Gulf of Aden water; and on the small-scale range, as pertains to the water exchange between shallow depths and the main water mass. Devices are available which measure nutrients automatically, but under Red Sea conditions at the present time, standardized laboratory methods should be maintained for shipboard and land base use.

The main research question is the nutrient balance of the Red Sea and its limiting factors, i.e., if, under the seasonal variations of circulation, there is a gain of nutrients from the Gulf of Aden only in summer. A model of the nutrient balance must be calculated and, in order to do this, certain questions must first be answered, e.g., the extent of regenerations of nutrients along the coast in shallow water. An island experiment is suggested, for example on Sarso Island, Farasan Archipelago, which could be carried out simultaneously with research on small scale diurnal circulation patterns.

2.4. Productivity

Primary production of an ocean is expressed in terms of sunlight energy which is bound chemically by the photosynthetic process of algae. It depends on light supply (which is good in the Red Sea area, but the daily photo-period is relatively short as in all tropical regions), on nutrient supply (phosphorus, nitrogen, silicon, etc.), and on the abundance of algae which is influenced by environmental conditions, such as salinity and temperature.

Primary productivity has been measured via the oxygen balance of illuminated and dark samples, or, during the last few decades, via the carbon 14 uptake of labelled samples incubated at ambient light and temperature conditions. Unfortunately, it seems that no such measurements have been made in the Red Sea. Some data derived from chlorophyll measurements are the only hints as to the productivity of the Red Sea and these are insufficient. They give rise to the speculation that the Red Sea is a poor sea in terms of productivity, with a marked decrease from south to north. However, those few measurements available have been taken in isolation, and coherent data on plankton biomass are also missing. Therefore no real picture has emerged upon which an idea of the richness or poverty of the Red Sea can be based.

One should remember that prior to the International Indian Ocean Expedition the central part of the Arabian Sea was considered to be of low productivity, but proved to be rather rich, yielding exploitable stocks of pelagic fish. Therefore, any speculation on the productivity of the Red Sea should be postponed until further data are available. At present, the Red Sea is a blank on the world map of productivity . Hence a regular pattern of productivity measurements must be established. This should be done in the following ways:

1. Regular stations : At convenient localities where samples can easily be taken throughout the year at 7 or 10 day intervals, a number of parameters should be measured : carbon 14 uptake, chlorophyll, zooplankton (using standardized equipment, expressed in wet weight and dry weight), amount of suspended matter (seston), and light penetration. Of course, at the same time physical parameters and nutrients should be measured.

2. Seasonal cruises : There should be one extended cruise during each of the four seasons, covering the entire Red Sea and the Gulf of Aden. Measurements should be taken as listed under point 1. This programme should be run for three years, and then an evaluation be made to determine the further pattern of sampling.

3. Additional information : At certain stations, large non-quantitative plankton samples should be taken for species identification in order to evaluate food chains. Deep water and midwater plankton samples should be taken to obtain some knowledge about organisms below the photic zone ; bottom trawling and dredging should be undertaken for the same reasons. The temporal and spatial distribution of fish eggs and larvae should be determined.

The result of these investigations, after a few years, will yield a good supply of baseline data. From these it will be possible to determine any major fluctuations of biomass and productivity and to establish their possible causes.

2.5. Fisheries

Although controversial, some experts suggest that there are great, untapped fish resources in the Red Sea ; however, there is no fishing on a considerable scale anywhere in the Red Sea. Some assessment as to the potential of this resource is urgently needed. The physical nature of the Red Sea precludes any large scale trawling operations, hence the main fishing operation would be pelagic, eventually in the midwater region.

There should be cruises of exploratory fishing to determine which stocks are large enough for exploitation, and the best method of fishing. At present, there is no basis for a decision as to which part of the Red Sea is best suited for fishing. Virtually nothing is known about the stocks of pelagic fish in the Red Sea.

Pelagic fish, such as sardines, anchovies, mackerel and tuna, usually undertake large scale migrations ; their movements are determined by water currents. Aerial observation would be a very valuable tool to identify shoals of pelagic fish and to follow their migration patterns.

Some pelagic fish depend on shallow water as nursery grounds. In addition to the deep water exploration of fish stocks, a survey on coastal fishes should be conducted in connexion with other oceanographic operations in the seas around coral reefs. It must not be forgotten that there can be small, but lucrative fisheries for prawns, lobsters, sharks and molluscs in certain areas. Consideration should also be given to small scale mariculture programmes.

If any substantial fishery emerges from productivity analyses and experimental fishing, it is essential to determine how much can be removed from the sea without depletion of the stocks. Most probably, the present yield from the sea can be substantially increased so that Red Sea investigations will be rewarding not only scientifically, but also economically. On the other hand, one should realize that a pelagic fishery in the Red Sea will call for substantial capital before it can begin. To evaluate the risks of such capital investment, hydrographic, chemical and productivity assessments as well as successful experimental fishing must be made.

2.6. Biogeographical Distribution

From data available, it can be concluded that in the Red Sea there are fewer animals and plant species than in the Indian Ocean ; this should be substantiated by comparison, both between the Red Sea and Indian Ocean and between local areas. Furthermore, there is evidence of a decrease in species from south to north in the Red Sea. The reasons for this decrease could be manifold and have yet to be assessed. A similar decrease in nutrients may be parallel, although elevated temperatures and salinities in the middle, and very high salinities in the northern Red Sea may be the cause. One should also mention that there seems to be a biogeographical boundary north of Tiran.

Species composition largely influences the productivity pattern at all trophic levels ; for example, it is strange that during summer there seem to be just a few planktonic diatoms flourishing in Red Sea waters. The geographical distribution of organisms should be registered wherever material is available. This material includes phyto- and zooplankton samples taken during hydrographical cruises, as well as samples taken through experimental fishing and bottom trawling. It further includes samples and census data taken during studies of reef ecology and in studies around marine biological stations.

If evidence accumulates in favour of the hypothesis that elevated temperatures and salinities are the cause for an impoverished fauna and flora in the Red Sea, ecophysiological and culture experiments should be made, comparing Red Sea organisms with populations derived from the Mediterranean or the Indian Ocean. It is well known that for many organisms the range of environmental conditions occurring naturally in the Red Sea (i.e., up to 42°/oo salinity, 35°C temperature) is, if not lethal, then at least sub-optimal. The question is whether Red Sea populations are specially adapted (so that they could endure even more severe conditions), or live very close to the limits of existence. Results will also have a significance in relation to questions of thermal and high salinity brine pollution.

There is the question of species endemic to the Red Sea. Do they live in the Red Sea by virtue of special environmental conditions or as a consequence of the geological past of the Red Sea? In addition, the passage through the Suez Canal imposes interesting questions of biogeography and animal dispersion including their changes with time, for which existing populations must be monitored.

Finally it should be emphasized that nearly no data exist on the benthic fauna living on the bottom of the main trough of the Red Sea. New data would be very welcome because the Red Sea is unique, in that even in the greatest depths, close to 3,000 m, water temperatures are above 21.6°C. The cold water deep sea fauna of the Indian Ocean have no chance of colonizing the warm deep waters of the Red Sea, and one should expect to find eurybathic species living there. Macrobenthos could be very scarce. Therefore one should include meiobenthos studies, keeping in mind that in the Indian Ocean, the biomass of the small animals belonging to the meiobenthos equals that of larger macrobenthic animals.

Should deep sea animals be found in the Red Sea, its northern part would be an ideal place for experiments on the effects of water pressure on sea life, because the water is of about equal temperature from surface to bottom, so that temperature changes would not interfere with distribution.

2.7. Migration of Organisms through the Suez Canal

The Suez Canal may not be of great significance to the water balance of either the Red Sea or the Mediterranean. In contrast, since its construction 100 years ago, this man-made canal has become the site of a large scale experiment on biological migration between those two bodies of water, due to the faunistic and floristic differences between the two seas. Migration of these organisms is greatly influenced by the salinity and temperature of water, direction and strength of currents, and the nature of the bottom of the Suez Canal and its Lakes, the Bitter Lakes and Lake Timsah. Moreover, the current system in the Suez Canal is unique and does not show the two layer exchange of water observed in sea straits. For all these reasons, a detailed programme for a thorough study of the Suez Canal will be rewarding not only for those interested in the Canal as a unique body of water but also in terms of biological studies in the Eastern Mediterranean and the Red Sea.

2.8. Taxonomy

Oceanographic research in the Red Sea will result in large collections of plants and animals. They have to be determined to species level to answer many of the questions included in the programme. Taxonomic research therefore should be encouraged and existing capacities strengthened. The promotion of taxonomic research on marine organisms, however, implies a long-term programme. It takes about five years for a good scientist to become so familiar with a reasonably large group of organisms that he can claim to be a competent taxonomist. A special programme for taxonomists, allowing for continuity, is recommended.

Of course, there are more taxonomic groups to deal with than the Red Sea countries can ever hope to get competent taxonomists for ; therefore the future of any research founded on taxonomic studies lies in international cooperation. No single country anywhere in the world has specialists for every group. Taxonomists in Red Sea countries should be encouraged to study those animal and plant phyla which are particularly relevant to their area, but also they can be encouraged to study these which are under-represented, in terms of existing taxonomists, from a world-wide standpoint (as long as their efforts are not dissipated).

2.9. Coral Reefs

In the Red Sea, coral reefs flourish in a variety of shapes and locations fringing reefs, wall reefs, patch or pillar reefs, Scharm reefs and atolls - with numerous species of corals, coral fishes and other animals and plants of the coral reef biotope. In the Red Sea, one finds the northern-most coral reefs of the world. It would be worthwhile to study the zonation of reef types and of the reef biocenosis from south to north, in which direction environmental conditions change towards the extreme.

The power of man to alter his environment has reached a stage where at times environmental changes have proceeded faster than the understanding of their ecological character. In the Red Sea area, coral reefs are threatened partly by oil spills, to which they seem to be particularly vulnerable, and by the impact of foreseeable tourism. Special impact by amateur divers is perceivable at Chardaqa, in the Gulf of Aqaba and in the area surrounding Port Sudan, where some portions now are guarded against intruders. Given the beauty of coral reefs, especially in the Red Sea, and the trend of modern tourists towards adventuresome holidays, an increasing degree of such water activities must be expected in the future. In fact, the underwater world might be a main tourist attraction. Those wishing to promote tourism as an economic potential in the Red Sea region must protect the nearby coral reefs from the beginning. Reefs in the Caribbean have been subject to such extensive spear fishing activity that the larger coral reef fishes have almost disappeared, while in contrast one can still observe a variety of large fish in the Bermuda reefs, where harpooning was not allowed. This difference influences profit from tourism in that area at the present time.

It must be remembered that the multiple uses and values of coral reefs often conflict and must be carefully managed. Such uses and values involve reef fisheries, aesthetic value relative to tourism and recreation, existence of important gene pools of organisms, value as natural breakwaters, potential for mariculture, scientific values, etc. Some reefs should be completely protected against any human influence in order to conserve the Red Sea coral reef gene pool for future generations. At the other end of the spectrum, after careful judgement of issues, other reefs no doubt can safely be managed in such a way as to allow many uses. Some should be protected as attractions close to touristic centers or close potential touristic centers. Many coral reefs, of less scientific interest and less beauty, or far away and difficult to control, should be left as they are, or changed into mariculture ponds, etc. Protection, conservation and use will have to be wisely balanced and will require extensive environmental knowledge.

Coral reef scientists should start a survey to classify the reefs on both shores and islands of the Red Sea. For a general orientation, satellite photos (taken twice a day for the northern Red Sea and fairly inexpensive) and aerial mapping would help, but a special aerial reef survey is suggested. Preference is given to a helicopter team which can make quick scuba diving reconnaissance in places of interest.

Some of the coral reefs classified for protection should be objects of more thorough ecological investigations. Provision should be made of permanent or temporary land bases close-by, from which, at the same time, physical, chemical and productivity parameters can be measured and the necessary bathymetric and sedimentological background information be gathered.

Special importance should be given to the sedimentological problems in the coral reef areas. In extremely arid areas, one can expect the complete absence of mineral fractions which may be found in the shallow sediments close to the run-off of desert flows and wadi fans. The fauna and flora associations should be investigated in order to construct a biophysiographical model of Red Sea types of coral reefs, including the selection of indicator species. This will help to classify coral reefs in the course of the general survey recommended above.

From the productivity aspect, many questions remain open regarding the role of coral reefs biota, e.g., the amounts of nutrient and of plankton removal from the sea water, the amount of biomass fixed in the coral reef community and the organic matter or energy released into the water.

2.10. Geology

The history of the Red Sea in the geological past is a major clue to an understanding of the distribution of organisms in the Red Sea, the formation of special types of coral reefs, and the morphology of the present day sea floor.

Evidence of alterations in the geological past can help us anticipate what will occur in the future. For example, cores from the deep drilling of the "Glomar Challenger" in the Red Sea show various periods when very high salinity conditions must have prevailed in the Red Sea.

Very large thickness (several kilometers) of elastic sediments and Miocene evaporitic salt and sediments underly the flanks of the Red Sea. Under the central trough (700-2900 m depth), the sediment thickness is very much less and probably overlies or is intruded by basalt implaced through sea-floor spreading.

During the Miocene age, the Red Sea was isolated from the Indian Ocean, but was possibly connected with the Mediterranean which, at the same time, was an evaporite basin. In the Pliocene period, connexion with the Indian Ocean was re-established. Sea-floor spreading was reinitiated at the end of the Pliocene age, and resulted in the formation of the main trough of the Red Sea. In some places, Miocene evaporites and dark shales rich in organic matter and metals have come into contact with Red Sea water. The discovery of hot, high salinity brines with a high mineral content in some deep areas of the Red Sea was of world-wide interest, and concessions for exploitation have been negotiated. Oil may exist in the deeper structural basins and metals and phosphorites in shallow water sediments. Therefore, Red Sea geological and geophysical research activities combine scientific and economic interests. A research programme should be developed according to the following lines :

1. Survey of the sub-bottom structure of the shelf using a 3.5 kHz air gun or sparker equipment, together with magnetic measurements. Most probably this survey will need the cooperation of a company specialized in exploration.

2. Survey of the sediments, initially based upon a broad pattern, but later followed by detailed traverses on the shelf, with the application of texture mineralogy, geochemistry and interstitial water analysis. This survey may place a special emphasis on important economic aspects, but will at the same time provide data on the Red Sea history and its rate of sedimentation, which in some parts of the southern Red Sea seems to rank among the highest values in the world.

3. Nearshore studies of beaches, sediment sources, sediment transportation and the delineation of living coral reefs. This type of work, in addition to bathymetry, is especially important in the vicinity of existing or planned harbours, navigational channels and mariculture structures. Such studies help the coastal engineer to decide which plans will be the most economic, because he can then take into account the dynamics of the sea rather than continue practices which may conflict with nature.

4. Sea-floor studies of the main trough, with the intention of investigating an area of sea-floor spreading, and in search of more hot brine mineral resources. Sedimentological aspects of this work should be undertaken in cooperation with biologists who explore the deep water fauna, in order to obtain interdisciplinary insights into productivity and sediment structure. Because of the depth (700-2900 m), a research vessel specially equipped for deep-sea research is necessary.

5. Effects of sea level changes should be investigated by bathymetric, morphological, sedimentological, and faunistic analysis, including assembling all available information, as well as ascertaining past positions of beaches and coral reefs (which indicate past sea levels).

6. <u>Development of a geological model</u> of the Red Sea concerning its origin and evolution and the presently active geological and geophysical mechanisms, by integration of all data available. This type of approach could lead to the delineation of potential mineral resources, e.g., heavy mineral enrichment in Pliocene and Miocene sediments.

2.11. Pollution

As the coastal area of countries bordering the Red Sea have relatively low populations and industrial involvement, at the present time, the pollution impact upon the Red Sea, as a whole is not extensive, although the Red Sea will share the low-level world-wide, air-borne pollution from heavy metals and chlorinated hydrocarbons. Of course, in the vicinity of larger ports and coastal towns there are local problems, but with present-day knowledge and technology, it should be fairly simple to detect and counteract local pollution wherever it interferes with the proper use of the sea, e.g., reduces the amenities for bathing and beach life, or impairs hygienic conditions for mariculture. A special problem of marine pollution from oil shipping and harbour wastes exists in the Gulf of Suez and the Gulf of Aqaba. A scientific survey and control programme for the Suez and Aqaba regions should be developed especially to fight oil pollution. In addition, some pollution in the Gulf of Aqaba can be attributed to phosphate dust.

At present, in 1974, the Red Sea is virtually free of oil pollution (except as noted above) because there has been no large amount of shipping through the Red Sea since the closing of the Suez Canal in 1967. Assuming that the Suez Canal will be reopened in 1975, one can expect a rapid increase of shipping with consequent oil pollution and increasing oil concentrations in Red Sea waters, sediment and organisms. Oil pollution is likely to remain a permanent threat to the Red Sea, because the increased marine transport of oil will continue to involve spills and accidents, in spite of all preventive measures approved by the Inter-governmental Maritime and Consultative Organization (IMCO).

A programme should be started to monitor the levels of man-introduced hydrocarbons in a coral reef community, a shelf sediment community and a deep sea community (if there is any of reasonable biomass). In the programme, petroleum constituents, primarily hydrocarbons, in sediments and selected organisms, should be analyzed. Such studies may be carried out within the framework of the Integrated Global Ocean Station System (IGOSS) Pilot Project on Marine Pollution (Petroleum) Monitoring in the Red Sea. The distance of the southern Red Sea from direct pollution sources other than oil could be an argument for recommending this region as a site for base-line monitoring stations for other parameters. Such a base-line study would be a valuable contribution to the Intergovernmental Oceanographic Commission's Global Investigation of Pollution in the Marine Environment (GIPME).

The extent to which metal concentrations in hot brines at the bottom of the Red Sea influence metal concentrations in the more superficial water should be assessed by means of water analysis. This research should be done before any mixing operation starts which will inevitably tend to increase metal pollution in the Red Sea and which, therefore should be carefully controlled. Consideration should be given to careful prevention and control of such pollution.

3. IMPLICATIONS OF THE PROGRAMME [1]

3.1. Dimensions

As mentioned earlier, marine science research in the Red Sea is composed of elements ranging from modest efforts to multi-million-dollar programmes, and it is a political decision as to which dimensions and time scale a Marine Science Programme for the Red Sea should have. Many of the scientific problems mentioned in this report could be solved within a rather short period of time by coordinated international oceanographic research. However, it is preferable to envisage a long-term schedule, because (1) as certain questions are answered, new ones and perhaps unpredictable perspectives will arise, and (2) the marine science capacity of the region is still in its development stage. Therefore, the terms of reference for the programme should encourage the development of marine sciences in the region. This means many years of education and training to create the necessary regional manpower and infrastructure. It should be noted that marine research is an integral part of this educational process. The following suggestions are made according to the programme envisaged in this report, and with a period of about 10 years in mind.

3.2. Infrastructure Requirements

Open-sea oceanography has to rely on certain facilities which normally are not considered as integral parts of the basic scientific programme. Three specialized essentials should be provided :

1. Navigation aids are needed for any type of oceanographic research, but they are, as well, essential to maritime traffic through the Red Sea, especially following the re-opening of the Suez Canal. Thus it can be hoped that an electronic navigational aid such as the Decca navigator will be installed. This system should likewise cover those regions of the Red Sea which normally are outside the main routes.

2. Geodetic and bathymetric surveys, using modern navigational aids, are urgently needed, because existing charts of the Red Sea are based on old surveys which are of low quality by modern standards. Amongst other things, this is due to the prevailing atmospheric conditions which did not allow accurate astronomical navigation. A re-charting of the Red Sea should be part of the Marine Science Programme, or could be done outside the programme by hydrographic offices. As this task will require many years of work, areas of special interest should be given priority, such as the sill region between Hanisch and Perim Islands, and coral sea areas close to localities selected for scientific research.

3. Tide-gauges and Meteorological Stations should be established wherever supervision is possible, e.g., by the harbour authorities or lighthouse-keepers, to provide basic data for the calculation of the Red Sea water budget.

3.3. Supporting Institutional Requirements

The programme as envisaged will be carried out by the various countries of the Red Sea, with the aid of developed countries. In addition to regional activities, there are some basic institutional requirements for the entire Red Sea region :

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1) The recommendations of the Workshop presented in the following sections are intended to assist the countries of the region to solve the marine science problems of the Red Sea. However Unesco wishes to point out that the Member States concerned should carefully evaluate these recommendations in light of their economic and social conditions in order to establish national and regional priorities for their development of marine sciences.

1. A Coordination Unit is necessary to plan and execute the various activities and implications of the Programme, to maintain contact with foreign and international agencies, and to organize cruises which cover the entire length of the Red Sea.

2. A Data Centre should register those data measured in execution of the programme which can be processed and stored, in close cooperation with the World Data Centres A [1] and B [2].

3. A Reference Library should be established to collect a full set of scientific publications available for the Red Sea region and other documents. It should sponsor activities to work out bibliographies and review papers on aspects of Red Sea marine science. In this context it should be mentioned that there are already excellent reviews on the Plankton of the Red Sea (by Y. Halim, 1969) [3], on Physical and Chemical Oceanography of the Red Sea (by S.A. Morcos, 1970) [4], and on Fishes of the Red Sea (by G.A. Botros, 1971) [5], available in the series "Oceanography and Marine Biology" (George Allen and Unwin Ltd., publishers, London), and that the editor, Dr. H. Barnes, is looking for a competent scientist to review benthic life in the Red Sea.

Bibliographical lists on the Red Sea are available in the "List of Articles" of Smithsonian Institution [6], U.S.A. , and the ALECSO monograph on Aquatic Resources of the Arab Countries [7].

4. A Reference Collection/Sorting Centre for the Red Sea organisms should operate as a focus for taxonomic research activities. Its special task would be the promotion of taxonomy regarding marine organisms in Red Sea countries and to establish contacts with taxonomists abroad.

3.4. Land-based Laboratories

It will be necessary to establish several marine science institutes, at least more than one, to provide a regional coverage of the Red Sea area. Each institute should be multidisciplinary in its composition, with a staff of about 50, and should be affiliated in some way to a university. A minimum size seems important to achieve a permanent scientific discussion and to make economic use of high-cost facilities like research vessels. Affiliation to a university seems important because in the years to come the education of specialized manpower has to be an activity of highest priority. The goal can only be achieved if special curricula are worked out in context

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1) World Data Centre - A, Oceanography
National Oceanic and Atmospheric Administration
U.S. Department of Commerce
Washington, D.C. 20235
U.S.A.

2) World Data Centre B
Molodezhnaya 3
Moscow 117296
USSR

3) Halim, Y., 1969, Oceanogr. Mar. Biol. Ann. Rev., Vol. 7, p.231-275

4) Morcos, S.A., 1970, Oceanogr. Mar. Biol. Ann. Rev., Vol. 8, p. 73-202

5) Botros, G.A., 1971, Oceanogr. Mar. Biol. Ann. Rev., Vol. 9, p. 221-348

6) List of Articles, Computer Produced Regional Bibliography, Eastern Mediterranean Red Sea and Suez Canal, Smithsonian Institution, U.S.A., 1969 (Unpublished Manuscript)

7) Aquatic Resources of the Arab Countries, Ed. A.A. Al Kholy, Arab League Educational, Cultural and Scientific Organization (ALECSO), Science Monograph Series, No. 1, p. 452, Cairo, 1972, (in Arabic).

with the curricula of other sciences taught within universities. Furthermore, close contact with a university provides an infrastructure which would motivate scientists from Arab countries working abroad to return to Red Sea countries, accomodate foreign experts and their families, and generally provide the intellectual climate needed.

With several marine science institutes, there may be a specialization towards biological, physico-chemical or geological problems. However, it should be ensured that institutes keep their multidisciplinary character both to ensure a broad education and to facilitate the solving of the complex regional problems.

Small shore stations should be established in areas of special interest, i.e., on Perim Islands, to monitor the water exchange through Bab el Mandab, and in the coral sea, e.g., in the Farasan Archipelago. These stations may operate for only a few years until the completion of specific research projects. Long-term permanent installations in very remote areas without any infrastructure would impose unsurmountable human problems for the staff.

3.5. Research Vessels

Each marine science institute should have at its disposal a medium-sized multipurpose research vessel, in addition to skiffs and small local craft for near-shore use. Such vessels would also be necessary at Perim Island during that period of time when the suggested permanently moored chain of sensors for temperature and current measurements would operate in the Strait of Bab el Mandab. The size of a vessel could range between about 100 to 400 gross tons, 25-40 m length ; it should be suited for cruises of a few days and should accomodate at least six research workers. Equipment should allow deep sea measurements with light gear, and geological and fisheries research on the shelf.

For expeditions along the axis of the Red Sea, one larger, ocean-going research vessel is necessary. Many aspects of marine research require an extended cruise in each of the four seasons, which will keep the ship busy for about four months per year. The rest of the ship's time could be spent in deep-sea work and for special research projects. In the southern Red Sea, heavy weather predominates during many months of the year ; therefore oceanographic research in this region is not possible with medium-sized research vessels. A ship of about 1,000 gross tons, equipped to work some weeks at sea without shore facilities, and with accomodation for at least twelve research workers seems necessary. It should have characteristics and instrumentation enabling it to join international marine science activities outside the Red Sea.

Management of research vessels will be rather difficult in the Red Sea area, because there are not many shipyard facilities available for repairs and maintenance ; a special study should be devoted to these problems. Oceanographic research vessels depend largely upon the quality of their officers and crew. Therefore, a special training programme is needed to create the manpower for the research vessels.

Ships of opportunity should be used for the large scale investigation of Red Sea circulation. For instance, temperature profiles can be measured by expendable bathythermographs from any vessel at full speed, and as the Suez-Aden shipping route follows the main axis of the Red Sea, such ships can provide a good sequence of stations.

Research vessels from countries with wide oceanographic experience should be invited to participate in the Marine Science Programme for the Red Sea, by direct contact with the relevant institutions. After the Suez Canal re-opens, research vessels from France and from Woods Hole Oceanographic Institution and Scripps Institution of Oceanography (U.S.A.) intend to pass the Red Sea on their way to the

Indian Ocean. They could be motivated to undertake some research in the Red Sea and to put some training facilities at the disposal of Red Sea countries.

It was announced during the meeting that Woods Hole Oceanographic Institution is ready to send a research vessel for research work and training in the Red Sea region and is willing to cooperate in implementing a training course in one of the Red Sea countries to be followed by training on board the research vessels.

3.6. Manpower

A programme of education and training has to be developed at all levels : technical, undergraduate and postgraduate. This programme will need assistance from other countries, via international or bilateral projects. If educational programmes in marine science are begun at the universities in the region, visiting scientists might be invited to lecture on special subjects of oceanographic research. To enhance contacts between research workers, scientists conducting studies in the region, or visiting conferences, should inform the Unesco Division of Marine Sciences. It may be possible for international organizations to make optimal use of the experts' presence in the region by, for example, arranging lecture series or informal training. Of course, all means of assistance should be investigated : fellowships, training courses and foreign experts working in the region.

UNESCO-DFG Workshop

"Marine Science Programme for the Red Sea"
Bremerhaven, Federal Republic of Germany, 22-23 October 1974

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8	Incorporated with Nos. 1, 4 and 14 in No. 27	1968	WG 10
10	Guide to the Indian Ocean Biological Centre (IOBC), Cochin (India), by the Unesco Curator 1967-1969 (Dr. J. Tranter)	1969	–
12	Check-List of the Fishes of the North-Eastern Atlantic and of the Mediterranean (report of the third meeting of the Committee, Hamburg, 8-11 April 1969)	1969	–
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