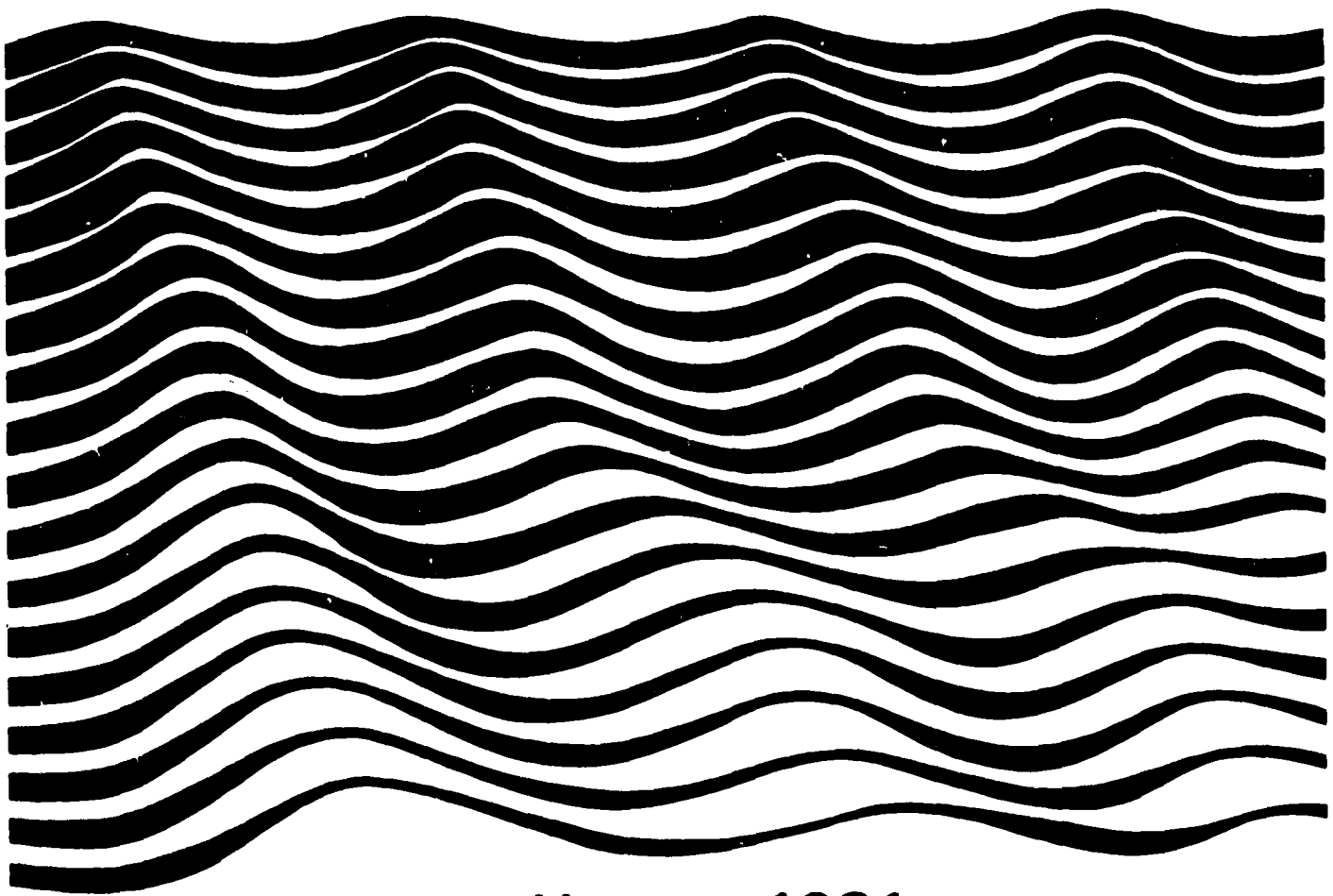
Unesco reports
in marine science 17

The coastal ecosystems of West Africa: coastal lagoons, estuaries and mangroves

A workshop report,
Dakar, 11-15 June 1979



Unesco, 1981

UNESCO REPORTS IN MARINE SCIENCE

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5	Marine science syllabus for secondary schools *Available in Arabic, English, French, Russian and Spanish*	1979
6	Organization of marine biological reference collections in the Mediterranean Arab countries *Available in Arabic, English and French*	1979
7	Coastal ecosystems of the southern Mediterranean: lagoons, deltas and salt marshes *Available in Arabic, English and French*	1979
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PREFACE

Unesco Reports in Marine Science are issued by the Unesco Division of Marine Sciences. The series includes papers designed to serve specific programme needs and to report on project development. Collaborative activities of the Division and the Intergovernemental Oceanographic Commission, particularly in the field of training and education, are also represented in the series.

Designed to serve as a complement to the series Unesco Technical Papers in Marine Science, the Reports are distributed free of charge to various institutions and governmental authorities. Requests for copies of individual titles or additions to the mailing list should be addressed, on letterhead stationery if possible, to :

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I. INTRODUCTION, OBJECTIVES AND SUMMARY OF PRINCIPAL CHARACTERISTICS OF THE COASTAL ZONE OF WEST AFRICA

1. INTRODUCTION

For a number of years, and especially at the nineteenth and twentieth sessions of its General Conference, Unesco has emphasized the importance of coastal zones in the development of nations, these zones often being the most populous, the most used and also the most delicate in relation to the developments and uses to which they are subject.

Scientific study of these zones is a most urgent necessity. It is always multidisciplinary, owing both to the variety of the branches of knowledge involved and to the variety of scientific specialities brought into play. It always has a variety of implications regarding the human activities involved, such as navigation and port problems, trading, fishing and aquaculture, agriculture industrialization, town planning, public health, recreation and tourism, which are often sources of conflicting interests and of irreparable damage to the natural environment.

Viewing the problem in a world context and extending its activity with a view to establishing regional networks of advanced training and research programmes on the various ecosystems of coastal zones (such as coastal lagoons, estuaries, mangrove swamps and coral reefs), the Division of Marine Sciences of Unesco, in co-operation with the Man and the Biosphere programme, is at present concerned with the preparation and establishment of a pilot phase consisting of a few projects operating in each major region of the world on a trial basis. The aim of this approach to the regional networks is to give each region, from the scientific and technical angles, a wealth of practical experience and substantial background material for making decisions about the establishment of a complete regional network.

In addition, given the great complexity of coastal-zone ecosystems, Unesco has had to make a close study of the present state of knowledge regarding them, including their utilization by man and man's impact on them. This study has been begun and is being carried out in co-operation with the scientific community and, in particular, various committees of the International Council of Scientific Unions.

2. PURPOSE OF THE WORKSHOP

As part of its normal assignment, the Division of Marine Sciences of Unesco, in co-operation with the Man and the Biosphere programme, is planning to encourage regional activity relating to the coastal zones of West Africa in order to improve scientific knowledge of these environments, promote the training of scientific personnel to study them, and assist their governments in overcoming the social and economic problems associated with development of these zones.

It is intended that this workshop should, with the participation of a number of scientists and specialists from West African countries and with the assistance of a few foreign specialists, look closely at present knowledge about the West African zone and at research concerning it in order to say what has been learned and thence to identify what is still needed and what the main lines of future action should be.

It is desirable that the first part of this workshop should remain open for a paper and a discussion on all the ecosystems of the coastal zone, thus providing an opportunity of situating the problem in its general context. However, given the complexity of the environment in question, and for the sake of efficiency, it is essential that the second part of the workshop should concentrate on one or two ecosystems of the coastal zone that are of priority interest for the region (estuaries, coastal lagoons, mangrove swamps, coral reefs, beaches, etc.), as proposed in the provisional agenda, which would provide the subjects for two pilot projects in an experimental phase. It is also intended that the workshop should discuss fundamental matters regarding the preparation of these projects. So far as methods are concerned, the aim of these projects would be to start up a series of activities with a view to:

- making available to the pilot projects the findings of previous and current Unesco programmes, whether international or covering other regions, concerning the various subjects;

- facilitating exchanges of information on current research, legal provisions, human settlements, and the achievements of each country regarding environmental development and protection;

- developing specialist education, both at the advanced research level and at that of the training of personnel for management of the environment and of its resources;

- helping researchers to improve research methods applied to the environments in question, generally marked by conditions of saline and freshwater mixing;

- specifying possible uses of the natural resources of estuarine and lagoon environments in the context of the rational use and management of coastal ecosystems, with due regard to the relations between the various extension schemes and the consequences of human activities in the coastal zone.

3. PRINCIPAL VALUE OF THE STUDY OF COASTAL ZONES

The SCOR [*]/Unesco ad hoc advisory panel on coastal lagoons, followed by the Unesco/IABO[**] seminar on the present and future of research on coastal lagoons, September-October 1978, Beaufort, North Carolina, United States of America, emphasized the economic value and the scientific and technical aspects

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[*] SCOR : Scientific Committee on Oceanic Research

[**] IABO : International Association of Biological Oceanography.

of lagoon studies in temperate and tropical regions. A questionnaire was sent out to a great many institutions and laboratories all over the world which conduct research in this field.

Generally speaking, the strategy for the study and development of coastal zones could be divided into three successive stages:

a. Analytical approach

To gain a knowledge of coastal environments, the structural parameters of the various natural systems as yet unpolluted by man need to be defined and assessed so that they can serve as reference points. The situation of these systems should be such that they can also be used to indicate the natural evolution of physical or biological environments and interpret man-made changes in such environments.

These structural parameters concern :

. Geology and sedimentology :

- geological history of the littoral : structural trends,
- mapping of the principal sediment facies,
- nature and distribution of mineral and organic matter, in suspension and drifting,
- sedimentation and erosion.

. Physics and chemistry

- hydrology : currents, tides, climates,
- thermal variations,
- variations in salinity, pH and redox potential,
- chemistry of waters and of suspended particles,
- oxygenation, nutrients.

. Biology :

- systematic inventory of animal and plant species,
- distribution and specific diversity,
- growth, mortality and life cycles of the various species,
- biomass evaluation,
- genetic mechanisms.

b. Systemic approach :

Analytical studies should serve as a basis for studying the relations between the various components of the systems whose functioning it is wished to know and understand.

There are a great many such systems which are interdependent to a greater or lesser extent. Two examples are :

. Coastal sedimentary systems : sands brought down by rivers - extension of beaches through coastal drift - interruption of coastal drift - interruption of coastal drift through human agency or by river mouths - shoreline erosion of beaches.

. Ecosystems : mechanisms governing the production of eutrophic systems and the growth of species; breakdown of organic matter, and aerobic and anaerobic metabolism.

By means of this approach, progress can be made in three complementary directions towards application of this scientific knowledge :

- determination of ecophysiological strategies for the adaptation of plant or animal species, particularly those used by man;

- establishment of the quantitative balances of natural cycles : sedimentary balances ; evaluation in energy terms of the dynamic processes at work in exchanges of matter and energy at the various trophic levels in ecosystems ; evaluation of the impact of man's additions to and withdrawals from such systems ;

- theoretical model-building : such models are tools increasingly used for the third stage of these studies (below).

c. Utilization and management

Human intervention in natural ecosystems results in withdrawals from or additions to the ingredients of such systems.

The natural functioning of the various ecosystems may in some cases not be markedly modified or jeopardized by the removal or despositing of organisms or substances, so long as such operations are on a modest scale or offset by corrective additions or adaptations.

Beyond thresholds which should be determined, over-utilization or pollution destroys the balance of ecosystems and thereby rules out optimum utilization and regeneration of their resources.

On account of the complex interdependence of the various natural phenomena, management of the coastal zone requires a thorough knowledge of each of the ecosystems that go to form it and determination of the tolerance thresholds of such ecosystems with regard to the variations imposed on the natural parameters, together with decisions as to the best use for each of the natural regions concerned.

4. PRELIMINARY INVENTORY OF STUDIES ON, AND DEVELOPMENT OPERATIONS IN, THE COASTAL ZONE OF THE WESTERN SEABOARD OF AFRICA

People's Republic of Benin

The coastal zone of Benin is marked by an extensive shallow river and lagoon system, with localized mangrove swamps in coastal depressions separated from the sea by offshore bars.

The sandy shoreline, being subjected to strong coastal drift, presents problems of erosion and stability for the outlets of the river (Mono) and lagoon (Cotonou channel) system.

Preliminary analytical studies have enabled cartographic surveys to be made of certain characteristics of the coastal zone : sediments of the continental shelf ; morphology and geology of offshore bars ; soils and vegetation.

The systemic study being carried out by various national (university, fisheries service) or international bodies is as yet too fragmentary to serve as a basis for the rational management of natural resources and, in particular, of lagoon fishing. The coastal ecosystem is undergoing modification as a result of the closure of the Cotonou channel in 1978.

United Republic of Cameroon

The oceanic zone of Cameroon is little known. Likewise, the vast alluvial plain of the Wouri Province, which is sparsely inhabited, difficult of access, covered by marshy forests and mangrove swamps, and reputedly unhealthy, has yet to be surveyed. Only the estuarine part of the Wouri, developed for the port of Douala, has been systematically surveyed. Vast nature reserves have been delimited in the Sanaga delta, but they could be threatened by industrialization further up the river.

A multidisciplinary survey programme for the estuarine and lagoon zones of Cameroon, as part of the country's integrated development plan, is under consideration.

People's Republic of the Congo

The littoral of the Congo is relatively well known. A comprehensive hydrobiological study of the territorial waters is being drafted following 15 years of investigation by the ORSTOM centre at Pointe Noire. A detailed map of the sediments covering the continental shelf, prepared by the geologists of the University of Brazzaville, is in course of publication. Sea fishing, an important activity in the Pointe Noire area, is the subject of regular quality and quantity evaluations.

The coastal zone is very sparsely populated and very little known. The estuaries and the adjacent zones marked by saline and freshwater mixing are very extensive and unused. Very fragmentary surveys have been started on the mangrove swamps and on Loango Bay.

A study ought to be made of the possible future effects of oil pollution of the coastline from offshore operations.

Republic of Ivory Coast

As regards the open sea, detailed surveys have been made comprising mapping of the sedimentary cover of the continental shelf and a hydrological study of ocean currents as an aid to deep-sea fishing.

The highly developed lagoon system (Ebrié lagoon and its adjuncts) has for a number of years also been closely monitored as regards hydrology, biology, chemistry and pollution, with special reference to bacterial and chemical pollution of urban (from the Abidjan built-up area) or agricultural origin.

Industrial aquaculture trials are also being conducted by the Abidjan Oceanographic Research Centre, which also carries out various systemic studies co-ordinated by the Scientific and Technical Research Department.

The cutting of the Vridi channel in 1925 and the recent (1971) construction of the port of San Pedro are also good examples of site studies incorporated in a development scheme for the coastal region.

Gabonese Republic

There has been little surveying of the coastal zone of Gabon. It is marked by difficulty of access, the extensiveness of the marshy plains and mangrove swamps in the Ogoué delta region, and the considerable size of the estuary of the Gabon and of Mondah Bay. Analytical surveys are planned in order to complete the very fragmentary data available on fishing, the hydrology of the estuary and urban pollution in the Libreville area.

Republic of Ghana

The large area formed by the Volta delta, including the Keta lagoon, does not seem to have been studied scientifically. A recent survey of the biological, chemical and hydrological characteristics of the coastal lagoons was published by A. Kwei in 1977. A study programme is under way and concerns the populations of crabs (Callimates Latimanus) in the small Sakumo and Mikwe lagoons, in the Accra area.

Republic of Guinea

The relatively narrow coastal plain is made up of a complex system of delta formations, offshore bars and estuaries. Its lagoons are small. This zone has been the site of soil surveys and of hydrological and agricultural developments in trial areas covering over 40,000 hectares.

Coastal and estuary fishing has declined over the past few years, and the variety of species caught has likewise diminished. The causes of this decrease have not yet been ascertained. It is observed, however, that some rivers and beaches are highly polluted by waste material from the inland bauxite and iron-ore mines.

An Oceanography and Solar Engineering Institute is under construction. The university research laboratories of the Gamal Abdel Nasser Polytechnical Institute are co-operating with the Planning Department and the Fisheries Department in carrying out a systemic analysis of these problems.

Republic of Liberia

The lagoons of this country, the chief of which is Lake Piso, have not been surveyed. The risk of pollution of estuaries and shores by effluent from iron-ore mining in the interior should prompt a survey programme

covering the coastal strip.

Federal Republic of Nigeria

The coastal zone of Nigeria is marked by the size of the Niger delta and the existence of lagoons such as that of Lagos (connecting with the Porto Novo lagoon in Benin) and the Lekki lagoon.

Research on these environments marked by saline and freshwater mixing is being conducted by the Nigerian Institute for Oceanography and Marine Research and the Department of Biological Sciences at the University of Lagos. It concerns the larval stages of fish, fish farming, oyster farming, and shrimp migrations and fishing.

Research is being carried out on bacterial pollution in the Lagos lagoon.

Republic of Senegal

The coastal zone is being very actively surveyed in Senegal.

Detailed mapping has been carried out of the sedimentary cover of the continental shelf. The dynamics of ocean waters and fishing activities have been closely studied for many years. Synopses and systemic interpretations are provided by researchers at the Dakar Thiaroye Oceanographic Research Centre (CRODT).

Surveys under way at the Centre concern :

- sea-fish populations concerned by deep-sea fishing;
- coastal sea-fish populations;
- bottom-dwelling populations fished on the Senegalese continental shelf;
- non-industrial coastal fishing and its economic impacts;
- the biology of cephalopods;
- relations between the physico-chemical characteristics of the marine environment and those of the coastal zone;
- development of computer-based programmes for processing statistics on fishing and analytical data regarding the physical features of the coastal environment.

The Institut Fondamental d'Afrique Noire (IFAN) is conducting more specialized research in conjunction with the national parks department, regarding the surveying and protection of the fauna of the Senegalese littoral.

The University of Dakar is taking part in this activity in the fields of zoology, botany, geology and geography.

Two major development projects are under way :

- Management of the Casamance Valley, the aim being to increase areas suitable for rice-growing. However, the hydraulic structures contemplated are liable to impair shrimp development.

- Water management of the Senegal River. Study of the ecological impact of this development on the evolution of the coastal zone at the river mouth, and in particular on the St Louis nature reserve, is in the hands of the Senegalese Agricultural Research Institute (ISRA).

A project for an ecology and marine biology education centre is being prepared by the University of Dakar.

Republic of Sierra Leone

The research activities of the Institute of Marine Biology and Oceanography (Fourah Bay College, University of Sierra Leone, Freetown) concern the estuaries, bays and coastal waters around the Freetown peninsula. They cover the marine biology of species of mullet with a view to their aquaculture, together with oyster farming and shrimp fishing.

The two coastal lagoons (Lake Mape and Lake Mabesi) are generally beyond the reach of saline water, and aquaculture trials are being conducted in them.

Togolese Republic

The coastal system is made up of a straight sandy coastline, with a strong eastward drift along the coast fed by the Volta delta in Ghana. Behind the low sand-bars extends a series of small, generally freshwater lagoons which communicate with the small coastal rivers. The main unit is Lake Togo. Development operations have concerned the cleaning of the lagoons in the Lomé urban area and construction of an artificial port east of Lomé. There are analytical surveys of the biological, physical and chemical characteristics, the species fished, and so on, in the coastal region, but they are as yet incomplete. Systemic studies are contemplated as a back-up for a general development scheme for the coastal strip and for the planning of its agriculture, fish-farming, tourism and industry.

II. AGENDA

Monday 11 June 1979

9h30

Welcome speech by Mr. B. Haidara, Director of the Unesco Regional Bureau for Education of Africa

Opening address by Mr. J. Diouf, Secretary of State for Scientific Research of the Republic of Senegal

Introductory remarks by Mr. M. Steyaert, Division of Marine Sciences of Unesco, Paris, France

Election of the members of the Bureau of the Workshop:

. Chairman :	Mr. L. Sauger (Senegal)
. Vice-Chairman :	Mr. A. Samba (Senegal)
. Rapporteurs :	Mr. C.I.O. Olaniyan (Nigeria)
	Mr. A. Klingebiel (Consultant Unesco)

10h30

Morphology, geology and sedimentology of the coastal zone of West Africa

. Chairman :	Mr. S. Diop
. Rapporteurs :	Messrs. Moussavou and A. Klingebiel

- Mr.J.F. Makaya

  The congolese continental shelf and its sediments.

- Mr. E.S. Diop

  A method for study and determination of the different taxonomic groups in the estuarine areas : the Saloun and Casamance as an example (Senegal)

- Mr. J.B. Moussavou

  The coastal zone of Gabon

- Mr. A. Klingebiel

  An example of the mobility of the coastal line : the coastal system of Togo and Benin

15h

The fresh-salt water interface, The displacements of the coastal zone during the quaternary

. Chairman :	Mr. S. Diop
. Rapporteurs :	Messrs. L.G. Lerest and D.E.B. Chaytor

- Messrs. J. Monteillet and J.C. Rosso

  Distribution during present term and during the quaternary of the molluscs in the region valley of the river Senegal.

- Mr. E.S. Diop

The continental shelf offshore the estuary of the Saloum and of the islands of Gandoul and Betanti (Senegal). Study of the sediments and of the evolution of the recent quaternary

- Mr. Ch. B. Gaye

The problems of the intrusion of the salt waters into the coastal aquifers of the littoral of African Sahel.

- Mr. A. Klingebiel

Study of the hydrology and sedimentology of the estuaries.

Tuesday 12 June

8h30 — Mixohaline ecosystems

. Chairman : Mr. C.I.O. Olaniyan
. Rapporteurs : Messrs. L.G. Lerest and D.E.B. Chaytor

- Mr. L. Lemasson

Evaluation of primary production and energy pathways in a coastal lagoon

- Mr. G.S. Zabi

General presentation of lagoon Ebrié (Republic of Ivory Coast)

- Mr. V.A. Jacq

Possible contribution of sol microbiologists to the mangrove management projects

- Mr. S.W. Nixon

Mathematical modelling in estuaries and coastal lagoons

- Mr. M.A. Mensah

Hydrology and fisheries in lagoons and estuaries of Ghana.

15h — Biology, ecology and living resources in the coastal zone

. Chairman : Mr. P. Lasserre
. Rapporteurs : Messrs. B.A. Mamadou M'Bare and C. Dossou

- Mr. J. Picaut

Variations of water temperatures along the West Coast of Africa

- Mr. C. Dossou

  Some observations on the living organisms of the Lake Nokoue (Popular Republic of Benin)

- Mr. F. Gerlotto

  Biological cycle of Ethmalose in the lagoon Ebrié

- Mr. F. Verdeaux

  Fisheries in lagoons of Ivory Coast. Sociological aspects and ways and means of exploiting the natural environment

- Messrs. J.M. Ecoutin, J.B. Amon Kothias, J.R. Durand, F. Gerlotto, J.P. Hie Darg and R. Lae

  Fishery statistics in Lagoon Ebrié (Republic of Ivory Coast)

- Mr. J. R. Durand

  Investigations in lagoons of Ivory Coast

- Mr. A. Samba

  The artisanal fishery in Senegal

- Mr. P. Freon

  Note on the coastal ecosystem of South Senegal : importance and interest to study the marine coastal zone

- Mr. D. Charbonnier

  Presentation of the F.A.O. representative

Wednesday 13 June

8h30 — Pollution, exploitation of coastal zones

. Chairman : Mr. D.E.B. Chaytor
. Rapporteurs : Messrs. G.S. Zabi and J.F. Makaya

- Mr. C. Marius

  Ecology, utilization and management of mangroves of Senegal

- Mr. L.G. Lerest

  Shrimp fishery in Casamance (Sénégal)

- Mr. Ph. Dufour

  Research programme on the consequences of pollution on the ecology of the lagoon Ebrié (Republic of Ivory Coast)

15h — Plenary

- Chairman : Mr. M.A. Mensah
- Rapporteurs : Messrs. C.I.O. Olaniyan and A. Klinbegiel

General discussion on the priorities to be retained for a preliminary regional project

Establishment of two working groups

Friday 15 June

8h30 — Meeting of the Working Groups to prepare the preliminary projects and the recommendations

11 h — Plenary

- Chairman : Mr.M.A. Mensah
- Rapporteurs : Messrs. C.I.O. Olaniyan and A. Klingebiel

Discussion of the reports of the Working Groups and definition of the priorities to be retained for the preliminary regional project

15h — Plenary

- Chairman : Mr. L. Sauger
- Rapporteurs : Messrs. C.I.O. Olaniyan and A. Klingebiel

Discussion and adoption of "Proposal for regional research and training programme on the coastal lagoons, estuaries and mangroves of West Africa" and of the "recommendations"

17h — Closure

Allocution by Mr. L. Sauger, Director of I.S.R.A., representing Mr. J. Diouf, Secretary of State for Scientific Research of the Republic of Senegal

III. PROPOSAL FOR REGIONAL RESEARCH AND TRAINING PROGRAMME ON THE COASTAL LAGOONS, ESTUARIES AND MANGROVES OF WEST AFRICA

1. Objectives

The aim of the programme is to undertake a sound scientific study of the coastal ecosystems, in particular lagoons, estuaries and mangroves, including its adjacent area, with a view to ensuring its beneficial management and its ultimate protection.

Among those objectives is underlined the necessity to assemble fundamental data on these ecosystems, in order to ensure :

- a rational exploitation of the natural biological production
- aquaculture
- the protection of certain particular ecosystems
- implementation of co-ordinated management plans.

2. Themes of priority

In addition to national programmes, regional scientific co-operation of a multidisciplinary nature has been envisaged on two particular ecosystems :

a) Coastal lagoons :

i) a basic understanding of this type of ecosystem needs to place emphasis on studies of :

- water movements,
- seasonal cycles,
- nutrient cycling,
- sedimentology, geomorphology and cartography,
- biological productivity.
- physiology and behaviour of important organisms.

ii) the programme must consider in priority the acquisition of basic knowledge necessary to develop the aquaculture and to combat increasing pollution.

iii) studies should include the problems related to the communication between the lagoon and the sea as well as littoral drift and erosion.

One or more aspects of the above studies which may be undertaken should be seen as part and parcel of an overall "energy budget" of the lagoon.

b) Estuaries and mangroves :

Research themes and areas where knowledge must be increasing have been listed as follows, in an approximate order of urgency :

i) Evaluation of biomass; nutrient budget (mobilization, circulation, fixation); determination of the mechanisms and evaluation of primary, secondary and tertiary productions.

Emphasis is put on the importance to establish a permanent monitoring of the seasonal and multi-annual variation of some of the fundamental parameters of those ecosystems.

ii) Understanding of water circulation and sedimentology in estuaries. Importance to monitor these factors.

iii) Evaluation of the impact of development undertaken or planned on the estuaries and adjoining areas, particularly mangroves.

iv) Thematic cartography of estuaries and mangroves in order to obtain a general description and the possibility to compare these systems on the West Coast of Africa. The maps will include geological and hydrogeological characteristics.

v) Modelling of estuarine systems.

vi) Mechanisms of chemical and biochemical exchanges within estuaries and mangroves.

vii) Metabolism and mechanisms of adaptation to mixohalin environment.

viii) Scientific basis for the creation and management of natural reserve parks, national or regional.

3. Human potential and scientific training

Considering the fundamental and multidisciplinary aspects of the studies on the coastal ecosystems, the workshop emphasizes the necessity to create research teams composed of adequate number of scientists (6) and technicians (12).

However, some countries are in a position to determine their priorities and, taking into consideration the existing scientists, indicate their needs in terms of training.

Taking into consideration these needs, the Workshop requests that regional training courses of short and medium duration be organized in order to train specialists which will have to execute the programme. As much as possible, the training courses will be held within facilities in the region.

Regional training courses requested :

a) training course on ecology of coastal ecosystems,
b) training course on methodology and techniques for measurements,
c) specialized training course on sampling statistics and modelling and monitoring of living resources.
d) training course on techniques for cartography, teledetection, photogrametry, bathymetry and quaternary geology.
e) training course on estuarine and mangrove management.

4. Information and documentation :

It has been emphasized the need in each country to be able to follow the development of the programme and to get all the scientific information required.

It is requested to Unesco :

a) to promote the diffusion and exchange of documentation and of available information within the region;

b) to facilitate the information and documentation exchanges between specialists in the area;

c) to distribute to scientific teams working within the programme bibliographical information on the themes selected and available regularly in the world.

IV. RECOMMENDATIONS

- Considering the importance of coastal ecosystems for the development of the countries of West Africa;

- Noting that ecosystems with high productivity are complex and particularly sensible to pollution and mismanagement;

- Stressing the fact that an adequate understanding of these ecosystems is essential for a rational utilization of its natural resources together with its conservation;

- Recognizing the existence of an infrastructure in terms of laboratories and researchers in several countries,

the Workshop recommends :

to Unesco :

a) to call on the national authorities and on the other relevant international institutions, with a view to organizing in the West African region the regional training courses mentioned above;

b) to study the possibility to organize pilot projects on scientific themes of recognized priority or fundamental interest, in support to research activities undertaken by one or several countries, within the framework of the regional programme.

to UNEP :

a) to consider the urgency to establish a regional network of pollution monitoring in the lagoons and estuaries, with a view to taking measures and samples on a regular basis, the analysis and study of which will be organized at the regional level with the participation of specialized laboratories from the region or outside the region.

b) considering the increasing pollution risks, request UNEP to undertake immediately a first exhaustive survey of percentage of pollutants,pesticides and heavy metals, in order to have available for the future, levels of reference corresponding to unpolluted areas.

to the Governments :

a) to consider the global and complex nature of the coastal ecosystems, the close interdependency of its different parts, and

b) to organize multidisciplinary national commissions of experts in charge of reviewing the management plans for the coastal zone, in order to prevent the overexploitation, the pollution and to co-ordinate the studies of impact.

ANNEXE I
ANNEX I

LISTE DES PARTICIPANTS

LIST OF PARTICIPANTS

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ANNEX II : ADDRESSES DELIVERED AT THE OPENING AND CLOSING SESSIONS OF THE WORKSHOP

Speech of welcome given by Mr. B. Haïdera, Director of the BREDA, at the opening session of the Workshop on Coastal Ecosystems, Particularly Coastal Lagoons and Estuaries on the West Coast of Africa

Mr. Secretary of State,
Delegates,
Ladies and Gentlemen,

It gives me great pleasure to welcome you all to Dakar, and I should like to express my warmest thanks to Mr. Jacques Diouf, Secretary of State for Scientific and Technical Research in the Republic of Senegal, for agreeing to preside over the opening session of this Workshop on coastal ecosystems.

His presence here today demonstrates his own personal interest, as well as that of the Government of Senegal, in the problems to be examined in the course of this Workshop.

Despite their importance to the economic and social life of the region, research carried out on the coastal zones has hitherto been only partial and limited in scope. To my knowledge, this is the first time that such a large number of specialists have met to consider the problems of the coastal ecosystems of west Africa, an event which is, in itself, worthy of note.

Your Workshop provides an ideal opportunity of assessing existing information on the coastal ecosystems of West Africa, of remedying any shortcomings and of furthering scientific collaboration between specialists interested in the region. It is my belief, moreover, that a comprehensive review of the various ecological, economic and social aspects of these ecosystems will lead to conclusions, of the greatest importance for the future of all the zones concerned.

Unesco has, as you know, in the course of recent years, given considerable prominence to problems regarding the rational exploitation of natural resources. An integrated pluridisciplinary approach, such as that laid out in the contents of the agenda, is the only possible means of achieving an objective of this sort. In fact, the rational exploitation of such fragile and complex ecosystems as the coastal ecosystems could be undertaken, only on the basis of reliable scientific and technical data which takes account of the different components of the ecosystems.

As mentioned in the introduction of the Workshop presentation document, the aim of the Workshop is to define the most urgent needs of research in this field and to assist in the implementation of the ways and means required to meet these needs.

As Director of the Regional Bureau of Dakar, it gives me great pleasure to welcome you to this Workshop, and you may rest assured that no effort will be spared to help you carry out your work in the best possible conditions.

May I wish you a pleasant stay in Dakar and offer you my best wishes for a successful meeting.

Address given by Mr. Jacques Diouf, Secretary of State to the Prime Minister, responsible for scientific and technical research in the Republic of Senegal, at the opening session of the Unesco Workshop on Coastal Ecosystems.

The coastal zones (estuaries, deltas, lagoons, mangroves and littoral zones) are of prime importance to man. It is, in fact, at the point of contact between land and sea that the greatest concentration of marine resources occurs, most of them present at levels lower than 100 metres. It is here that, miraculously and continuously, nature replenishes these resources, through the utilization of the beneficial effects supplied by the deposits brought down by the rivers and of the rising of deep sea waters. It is here, too, that man has chosen to create some of the leisure activities, essential to his well-being.

Unfortunately, it is also at this point of contact between the sea and the land, that the greatest concentration of harmful effects arises, resulting from such human activities as fishing, urbanization, industrialization and pollution, either coastal or brought to the coast from the hinterlands.

The richness of resources present in the coastal zones and the well-being of their population depends ultimately on the balance which is achieved between these two factors.

The problem, therefore, consists in studying the evolution of coastal zones and in controlling it, for the greater welfare of all. The scientific study of coastal zones has emerged as an essential step towards achieving this aim.

Unesco has accordingly spared no effort in tackling this problem, for the greater well-being of humanity.

In the name of the Government of the Republic of Senegal, I would like to welcome to Dakar all the delegates attending the Workshshop on coastal ecosystems.

West Africa undoubtedly offers an ideal area of research. There is an abundance of mangroves, estuaries and lagoons. Many have already been damaged by human activities, but a certain proportion are still unspoiled and provide an invaluable source of information as regards their original resources and are therefore useful as points of reference.

Although the Northern region has been endowed by nature with conditions which make it one of the largest fish reserves in the world, it also bears the responsibility of preserving these resources, through the management of their exploitation (a process which is already underway) and the scientific study of its coastal zones, which are of prime importance, since the reproduction of the great majority of the fishing of the region takes place to the South of Cap Vert and as far as the Casamance.

It is our desire that your work be instrumental, in laying the foundations of these different projects and in the drafting of Unesco's long term programme, with provision for the establishment of economic models. It is to be hoped that, beyond biological and technical considerations, your conclusions will not overlook the human dimension, a prerequisite to any form of balanced approach.

I hereby declare the Workshop on coastal ecosystems open.

Closing address at the Workshop on Ecosystems by M. Louis Sauger, Director General of I.S.R.A.

Ladies and Gentlemen,

The Workshop on the Ecosystems of the West Coast of Africa ends today and I would like to take this opportunity of thanking all those who were involved in its preparation and successful realization.

Firstly, I would like to express our gratitude to Unesco for its efforts in focusing the attention of the coastal states of Africa, on such current, controversial issues as the conservation, exploitation and management of coastal ecosystems ; the solution to these problems can only be reached through an understanding of the respective mechanisms of the issues involved.

I would also like to thank all the national representatives whose presence here has given this meeting the prominence it deserves.

The information they have provided, concerning the findings of the research carried out in their various countries, has enabled us to assess the ground already covered and to evaluate what remains to be covered. We are also grateful for all the efforts they have made, despite the limited means at their disposal.

This Workshop has provided the opportunity of reviewing national issues and of identifying regional priorities.

The few days, during which the Workshop was in progress, have enabled you to draw up the broad lines of a regional programme, to which each region would contribute and for which Unesco might provide the necessary coordination and material support, possibly in conjunction with other regional and international institutions.

Although there is an overall awareness of the scale of the problems which still have to be overcome before the implementation of any such programme is possible, it is nevertheless my fervent hope that, encouraged by this Workshop in our determination to provide concrete solutions to current and future problems, as defined in the course of our discussions, the countries of the West Coasts of Africa will pool their human resources and combine their efforts, so that this crucial objective is reached, for the welfare of all and for a more effective control of our development.

I do not doubt for a minute that, in defining the scientific priorities which have emerged from the mass of research to be undertaken, those concerned have taken account of the all-important issue of development, which is of particular interest to us, as Africans, since, where our regions are concerned, scientific research is supposedly at the service of development.

I trust that you have enjoyed your stay in Senegal, despite the hot, oppressive weather and the extreme conditions of temperature under which you worked.

With many thanks to the delegates and the organizers, not to mention the interpreters, may I wish you all a safe return to your respective places of work.

I hereby declare closed the Workshop on the Ecosystems of the West Coast of Africa.

ANNEX III : ABSTRACTS OF THE PAPERS PRESENTED AT THE WORKSHOP

The Congolese Continental Shelf and its Sediments

Mr. J. F. Makaya (Congo)

In collaboration with the ORSTOM Centre at Pointe-Noire, the Geology Laboratory of the University of Brazzaville has mapped the sedimentary cover of the continental shelves of South Gabon, the Congo, Cabinda and Zaire.

In all, 320 samples were taken during three dredging operations carried out by the research vessel Le Nizery (June 1971, March 1972 and November 1972).

Rocky formations are found more frequently from the South towards the North, in proportion to the decreasing thickness of the loose sedimentary cover.

The Congolese shelf to the North of Pointe-Noire shows both present-term and relict deposits. From the coast up to 80m offshore, a relatively regular zonation is to be found. Existing pelitic sedimentation predominates, combined with the presence of green particles, to be found in increasing quantities offshore, as well as a slight proportion of calcareous fauna. Carbonates are present at distances between 100 and 120m, forming the basic component of the sediment cover. These are holocene shelly substances. Beyond 120m, the green particles reappear in increasing numbers, as far as the outside edge where they become a mass of real green sands. The quartz fraction is slight, towards the coast, and completely absent offshore.

A method for the study and determination of the different taxonomic groups in the estuarine areas : examples given of the Saloum and Casamance *

E. S. Diop (Senegal) **

By means of "classical" methods of mapping (by photointerpretation), it is possible to determine and define the natural areas of certain estuaries. This is true in the case of the extensive morphopedological and plant groups of the Saloum and the Casamance. The automatic mapping

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* Presentation given at the conference on "The Coastal Ecosystems of West Africa". UNESCO/CRODT - Division of Marine Sciences. Held in Dakar from 11 to 15 June 1979.

** The geomorphology laboratory of Dakar - Geography Department of the University of Dakar-Fann.

of these different taxon-landscapes is obtained by remote sensing, a method which processes the numerical data recorded by satellite (Landsat). These different taxons, especially those of the Saloum estuary, have been the subject of systematic study.

The following analysis emphasizes the advantages of adopting this method of mapping, according to interdisciplinary methods, with a view to acquiring a more detailed knowledge of these natural environments.

The Coastal Zone of Gabon : A Brief Synopsis

J. B. Moussavou

(Scientific Research Authority, Gabon)

The coastal zone of Gabon is a region of special scientific interest in terms of geology, biology, physicochemistry and geography.

The coastal sedimentary basin is composed of a succession of continental, lagoon and marine facies which "are laid out in a series of convex rings towards the East", indicative of the progradation which caused them. Near the coast, sand, clayed sands and Plio-Quaternary clays occasionally cover earlier deposits.

The coastal zone is low and flat and is fringed with offshore bars, which more or less enclose a series of vast lagoons. Former lagoons have been completely closed by littoral sedimentation and have become coastal lakes, fed by coastal rivers.

The Como and Mondah rivers flow into the sea through wide estuaries (the Gabon Estuary) and a large bay (the Bay of Mondah).

This coastal zone is very rich :

- the fauna is very varied, in the lagoons, lakes and estuaries, as well as in the maritime coastal strip;
- the flora consists mainly of the mangrove;
- the coastal sands and gravel are exploited, including laterites.

To the above features should be added the continuing activity in oil exploration and exploitation carried out (on and off shore), especially in the continental shelf.

Apart from geological surveys of the subsurface, for the purposes of oil exploration, "the difficulty of access due to the extensiveness of the marshy plains and the mangroves" has meant that the coastal zone has not been widely studied.

In view of the related problems, the management and protection of the Gabonese littoral have become the concern of the authorities who introduced :

- An Anti-Pollution Centre (under the supervision of the Ministry for Scientific Research, responsible for the Environment and the Protection of Nature), set up in 1976.

- As regards legislation, laws obliging factory owners to include waste-processing units in their plants.

- A research programme (Department of Oceanology at the Science Faculty of Omar Bongo University), known as "the national oceanology research programme", as defined by an interministerial commission in November 1977, in collaboration with the CENAREST*.

The geographic position of Gabon, its ecological conditions and the existing structures of research, justify the establishment of a Regional Oceanology Centre (to concentrate on research and training).

An Example of the Mobility of the Coastal Line : The Coastal System of Togo and Benin

André Klingebiel

From Ghana to Nigeria, namely from the Volta delta to that of the Niger, the coastal line is composed of a continuous sandy beach, backed up by a complex system of almost continuous sand bars. The erosions and accretions which can be seen at various points of the coastal line, especially in the proximity of permanent or temporary river mouths or coastal lagoons, are indicative of the mobility of the sand on the littoral.

The reasons for this mobility are the following :

- a coastal drift from West to East with a solid flow rate estimated at approximately 1 to 1,5 million m3/year. This drift is caused by the oblique breaking of the surf from the South West.

- sands brought down to the coast, either from the continental shelf (little information is available on this subject), or from coastal rivers. The Volta delta represents the main contributing factor to coastal drift. It is feared that the dams built on the Volta may impede the drift of sand to the sea; the long term consequences of this have not been assessed. Similarly, no measurement has been made of the sands brought down by the Mono river, and their effect on the development of the river mouth at Grand Popo has not been determined.

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* CENAREST - Centre National de la Recherche Scientifique et la Technologie (National Centre for Scientific Research and Technology).

The construction of the artificial ports of Cotonou and Lomé caused the rapid formation of accretions (upstream) and of erosions (downstream) to these obstructions.

These problems were considered by a study workshop jointly organized from 29 January to 9 February 1979 by the United Nations and the governments of Togo and Benin.

The Problem of the Intrusion of Salt Waters into the Coastal Aquifers of the Littoral of African Sahel

Ch. B. Gaye*

Water is present virtually everywhere on the African littoral, but the proximity of the sea hampers utilization and represents a serious hazard.

It is an established fact that sea water seeps through the substrata of continents and is superimposed on fresh water already present in the coastal water-bearing beds. One of the main difficulties involves the utilization of this water without unduly disturbing the delicate balance which exists between fresh water and salt water.

After reviewing the factors determining this phenomenon, this paper, based on an example from Senegal (Malika), attempts to show, on the one hand, the possible effect utilization might have, however short, and, on the other hand, to stress the need to undertake surveys on an individual basis, so as to avoid overlooking a key factor in this balance, namely the heterogeneity of the formations under consideration.

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* Department of Geology, Faculty of Science, Dakar University.

The Study of the Hydrology and Sedimentology of the Estuaries

André Klingebiel

Hydrological mechanisms in an estuarine environment are dependent on tidal cycles, seasonal variations, river flow, the specific morphology of the estuary and the formation of a salt intrusion or "salt corner".

A detailed study of the movements of water masses and the measurement of "residual flow" help to define the line of nodal points (where the residual flow is nil) and to draw up hydrological charts which may be instrumental in forecasting changes in the location of the estuary's salt corner and of its "mud stopper". This hydrological information is an essential factor in understanding the ways in which fresh water and salt water come into contact and mix.

Estuarine sedimentation is caused by two kinds of drift :

- the drifting of sand on the bed : tidal currents have different characteristics according to whether the tide is rising or falling, on bars or shallows or in channels. Residual drifting usually occurs in the downstream direction in the upstream estuary, but plotting experiments have shown drifting in an upstream direction on some median sand banks. Residual drifting is observed at the river mouth in an upstream direction.

- the decantation of the fine suspended particles which gather near the nodal point creating a "mud stopper", the formation of which is also dependent on the salinity gradients and, especially, the speed of tidal currents.

The distribution of the various sediment facies in estuaries is closely linked with the hydrological system and with the kind of deposits brought down by the river.

Although physical and even mathematical models of estuarine systems can be constructed, the representativeness of these models must be adjusted for each example under consideration.

Evaluation of Primary Production and Energy Pathways in a Tropical Lagoon

Lionel Lemasson (ORSTOM)

The study of primary production and of its controlling factors was first undertaken in lagoon Ebrié (Ivory Coast), with the double aim of evaluating potential phytoplankton production and the net production of carbon, and also of studying the energy pathways as regards the first stages of the ecosystem. The findings of this study may eventually be applied to other tropical, coastal or brackish waters (lagoons and estuaries). First of all, it was necessary to ascertain the hydrobioclimate of the lagoon (study of the environment and its main physical, chemical and biological parameters and of their variations during the year), and to establish certain essential physical parameters, such as the mixing-rate of fresh water-salt water, water budget, etc ...

The second phase involved the evaluation of gross and net production, by carrying out surveys at eight different check points, each representative of a particular zone, during the three main seasons (dry season, rainy season, floods). The findings were then applied to the whole complex of lagoon Ebrié.

The dynamics of the system (cycles of carbon and phosphorous, by means of radio-active tracers) and the energy pathways between the first trophic levels (nutrients, phytoplankton, zooplankton) were also tackled; this involved the evaluation of regulating elements (nitrogen, and phosphorous), of primary energy pathways (water-sediment exchanges, light, external factors, etc ...), of assimilation and excretion rates, heterotrophic production and rates of remineralization, the turnover rates of the biomass and of nutrients and of zooplankton grazing rates.

General Presentation of the Benthic Ecology of Lagoon Ebrié (Ivory Coast)

G. S. Zabi

Oceanography Research Centre,
B.P.V 18, Abidjan (Ivory Coast)

A comprehensive review has been carried out of the benthic ecology of the Ivory Coast lagoon system. A brief comparative study of several Guinea Coast lagoons indicated that, as yet, their benthos was relatively unknown.

It is suggested that all West African countries interested in a better exploitation of their lagoons should set up a work group to study the benthos of their lagoons and to establish an appropriate integrated programme.

The Contribution of Soil Microbiology to the Mangrove Management Projects

Vincent A. Jacq

the Bel Air ORSTOM Centre, Dakar

The success or failure of agriculture management in mangrove areas is partially associated with the efficiency of the bacterial cycles of sulfur. The characteristics of the biotope of the mangrove can be described as follows; in chemical terms, it is rich in the presence of sulfur compounds (sulfates, sulfides, colloidal sulfur, pyrites etc ...) which can account for 3 to 5% of the mass surface area; in bacteriological terms, it has a high level of bacterial activity affecting the sulfur cycle.

When the biotope is left undisturbed, the sulfur compounds evolve very gradually and slowly. The twice daily submersion by the brackish waters of the swamp creates a relative equilibrium between oxidizing bacteria (Thiobacillus) and sulfate or elemental sulfur reducing agents.

These various forms of equilibrium have been upset by man's intervention and, from the agronomic viewpoint, two stages of management have been affected :

1) During the installation of the racks : a rapid acidification of the soil occurs (pH = 3), caused by the rapid oxidizing of the sulfides as a result of chemical and, especially, bacterial processes. In emerged soil, this process occurs more rapidly, there being no activity from the reducing bacteria, as they are all strictly anaerobic. In an environment which is alternatively emerged and immerged, an equilibrium is established between the sulfate or sulfo-reducing bacteria and the anaerobic thiobacilli (T. denitrificans). The process of sulfur oxidizing can thus be prevented; a similar process seems to occur in the "ridge" method of cultivation, a method traditionally used by Casamance peasants.

2) After installation of the rice plantation : a large-scale "damping off" of the seedlings is frequently noted, as well as a significant drop in the harvest, with or without the death of the rice seedlings. These accidents are caused by the accumulation of a blackish covering of toxic sulfides (Fe S) which has formed around the germinating seedlings and ultimately around the roots. These sulfides appear only under extremely anaerobic conditions, as a result of prolonged saturation of the soil, caused by rains or excessive watering. They are produced by sulfate reducing bacteria (from sulfates already in the soil, or in water for irrigation, or in fertilizers) or from sulfo-reducing bacteria (from elemental sulfur present in the soil, or "delayed reaction fertilizers" of the "sulfur coated-urea" variety) when the Thiobacillus denitrificans is sufficiently active.

In this paper, emphasis is laid on the importance of the water system used to rid mangrove soil of its salts; bacteria in the sulfur cycle are more active in a salt environment or a brackish environment of which they are endemic, than in a less saline environment; the sulfides thus produced are not only toxic as regards flora, but also as regards fauna, including fish, at levels approximating tens of p.p.m.

On the Variations of Sea Water Temperatures along the West Coast of Africa

Joël Picaut

Oceanography Research Centre, Abidjan

Recent research has shown that the mass of equatorial oceanic waters, which represent an important source of energy for the atmosphere, undergo considerable variations as regards their dynamic and internal structures. This variability seems to be particularly pronounced in the coastal zone and the concept of the average physical parameter is irrelevant in many cases of studies carried out on the coastal ecosystems of Africa. The study of this variability constitutes one of the main objectives of physical oceanography, as currently practised, in view of its far-reaching effects on major socio-economic issues, such as fisheries, pollution and weather forecasting.

With the help of the many authorities of the coastal countries of West Africa, the research centre in Abidjan was able to collect a large number of regular measurements of the physical parameters of the coastal zone, from Senegal to Angola. Most of these measurements involved daily readings of the surface temperature of the sea over very long periods, and weekly measuring of water levels by means of tide gauges. The very low level of background noise, due to the stable meteorological conditions of the West African coast, means that the establishment of this latter parameter is very important. In fact, the average daily level of this series of measurements integrates the horizontal and vertical variations of temperature, of salinity and current, for the entire continental shelf in the proximity of the point of measurement.

From the first detailed study of all the data available, there emerged 3 scales of time and space in the significant variability recorded :

- Twelve hourly variations :

Generated by the tide on the rim of the continental shelf, they occur in the form of internal tides moving towards the coast with a wave length of 10 to 30 km. This periodic phenomenon affects the thermal structure from the surface to the sea-bed, giving, for example, temperature variations on the sea-bed of 2 to 6°C within a few hours.

- Variations extending from several days to several months :

Although the scale of variations of approximately one week, in zones such as the coasts of Mauritania and Angola, is closely linked with the direct effect of the wind (Ekman drift), the same cannot be said of the Gulf of Guinea where this direct effect of the wind seems to be relatively slight. A large number of the variations in this time range seem to be caused by the presence of oscillations concentrated in equatorial zones.

The deflection of purely equatorial waves by the North-South coast, free-running waves generated by external causes, their continuing formation made possible by favourable topographic conditions, waves caused by oscillating external factors (tide-wind); most of these waves move, leaving shallow waters on the right (on the left) in the Northern (Southern) hemisphere at a speed of approximately one metre per second, giving a distance

scale of 500 to 2000km. On the Northern coast of the Gulf of Guinea, where many measuring points are located, the following readings were recorded : waves of a duration of 45 days created by atmospheric conditions, of 14,7 days of astronomic origin, of 9 days due to atmospheric conditions, of 4-6 days linked with the earth's rotation.

- Annual and multi-annual variations :

Seasonal phenomena including multi-annual fluctuations which seem to have a great effect on the climatology of Africa as a whole (drought in the Sahel), and on fisheries. In fact, occurrences, similar to those of the famous "El Niño" off the Peruvian coast, have been recorded in the Gulf of Guinea.

This first study was only made possible by the presence of coastal stations at different points along the West African coast. Currently, as far as can be ascertained, this simple, inexpensive method of measurement is utilized only in the Congo, Benin, Togo, Ghana, Ivory Coast, Senegal and Mauritania. The distances between these various measuring points prevent the establishment of any accurate knowledge of these phenomena on a large scale, facts which should ultimately lead to the possibility of forecasting this variability. Because of the extensive cloud cover over a large proportion of the countries concerned, there is little chance of acquiring such information by satellite.

The setting up of coastal stations, located at regular intervals, from Angola to Mauritania, to carry out simple measurements, such as the daily temperature and hourly height of the sea surface, should result in a better understanding of the basic problem of the variability of the coastal waters of West Africa.

Moreover, an observation system of this kind would provide a constant source of valuable information for the oceanographic biologists and meteorologists of the countries concerned.

Some Observations on the Living Organisms to be found in Lake Nokoué

Christian Dossou

The lagoon of Nokoué is now rightly known as lake Nokoué, since the Cotonou channel was closed in April 1978. A still brackish environment, a new balance is evolving in terms of hydrology, which requires a new series of adaptation on the part of the organisms present. A review of the present distribution of salinity (Texier et al, 1979), suggests a different distribution of these organisms, on the basis of other factors, such as the nature of the bed (mud, sandy mud or sand).

Characteristics of the Organisms present in Lake Nokoué

Firstly, there is evidence of polymorphism, especially on Mollusca of the genus Pachymelania and Tympanotonus, which enabled Mozeran-Pasquier (1976) to create different varieties within the main species Tympanotonus fuscatus and Pachymelia fusca.

The second characteristic of these organisms is their euryhaline capacity, allowing them to endure variations of salinity, perhaps linked with other physico-chemical factors such as temperature, oxygenation, ionic ratios. Some marine organisms have thus been able to move some distance up the Ouémé and Sô rivers, both of which flow into the lake. In this respect, mention should be made of the Lamellibranchia Aredo petiti and Bankia which have destroyed the acadjas of our fishermen, and also of Poeneus duorarum, the exploitation of which is interesting from the economic viewpoint, and especially of the fish reviewed below.

Some Observations on the Fish present in Lake Nokoué

It would seem that the distribution of the various species of fish caught by fishermen in different parts of the lake is related to variations of certain physicochemical factors (the number of species and the quantity caught) from April to December 1979 (see table below). With a view to studying the immediate feeding requirements of fishfarming output, an initial review is being carried out of the different components of the plankton which seem to be present in different parts of the lake (acadjas areas, and various protected areas and free zones which the review hopes to establish by studying the stomach content of the fish present in the lake).

Other organisms which are currently exploited according to artisanal methods, include : the Lamibranchia Anadora (Arca) Senilis and Crassostrea Gasar and the Crustacea Callinectes latimanus.

A study of the above species is pending, especially that of the Lamellibranchia : Anacarda (Arca) Senilis and Crassostrea gasar, as well as a study of the Crustacea; especially Callinectes latinamus.

A Survey of the Different Species of Fish used in Fish Breeding in Lake Nokoué

	A	B
Ethmalosa fimbriata	+++	++
Tilapia melanopleura	+++	+++
Tilapia zilii	++	++
Hemichromis fasciatus	++	++
Cynoglossus senegalensis	++	+
Psettus sebae	+	+
Gerres melanopterus	+	+
Sardinella eba	+++	0

	A	B
Pristipoma jubelini	++	0
Liza falcipinnis	+	0
Caranx carangus	+	0
Elops lacerta	+	0
Hepsetus odoe	+	0
Hydrocynus forskalii	+	0
Distichodus rostratus	+	0
Acanthurus monroviae	+	0
Labeo senegalensis	+	0
Pellonula afzeliusi	+	0
Dasyatis margarita	+	0
Chloroscrombus	+	0
Alestes macrolepidotus	0	+
Chrysichtys nigroditatus	0	+

A = Before closure of the Cotonou Channel (April 1978) - Salinity = 16 - 20°/oo

B = Seven months after the closure of the Cotonou Channel - Salinity = 3 - 6°/oo

+++ = in very large quantities

++ = in large quantities

+ = present

0 = absent

The Biological Cycle of Ethmalose in Lagoon Ebrié

F. Gerlotto (CRODT, Dakar)

The ethmalose (Ethmabsa fimbriata) is the most commonly found clupeidae on the African coast in estuarine zones and lagoons. This presentation shows the correlation established between its biological cycles and the degree of salinity, adopted as a dominant parameter in the brackish environment.

1) Reproduction

- Breeding ground : It is strictly limited to areas of the lagoon where the salinity exceeds 5°/oo. Ethmalose eggs are found in the area of Abidjan and as far as the river Agnéby which marks the limit between areas subject to marine influence and those areas unaffected by this influence.

- Laying periods : According to the calculations of the R.G.S. and based on eggs collected, it has been shown that the eggs are laid during the dry seasons (December/May and August/September), namely when there is maximum salinity in the breeding grounds. Moreover, outside these areas, the fish are always immature.

2) Migrations

The shoal movement in the lake has been recorded, on the basis of the recurring frequencies of the size of the fish caught in the seine nets, inside and outside the breeding grounds. The ethmalose are born at Vridi where they remain for several months and then move off to different areas of the lagoon. In fact, at Vridi, ethmalose have been found from 3cm upwards, and from 6cm upwards at Tiebissou (fresh water zone), with maximum dispersal at 12cm. They then regroup in the areas near the breeding grounds and are found measuring 13/14cm at Tieboussou and 14/17cm at Vridi, where the eggs are laid, after which the fish move out to sea (20cm).

3) Conclusion

The ethmalose display euryhaline characteristics during their early stages and, until reaching a length of 12cm, can tolerate a range of salinity from 35 to 2°/oo. During reproduction, however, they require a salinity level above 5°/oo. Salinity can therefore be regarded as a factor which does not affect the somatic life of the ethmalose but which does dominate the germinal phase of its biology.

Fisheries in the Lagoons of the Ivory Coast : Sociological Aspects and Ways and Means of Exploiting the Natural Environment

François Verdeaux

Oceanography Research Centre, ORSTOM, Abidjan

The lagoon network of the Ivory Coast consists of three different lagoon complexes, stretching along the coast for nearly 300km. Fishing methods vary in all three lagoon complexes. In lagoon Aby (East), the seine net (beach seine or ring net) is the most commonly used fishing method; lagoon Ebrié (centre) is fished partly individually, and partly by seine nets; in lagoon Grand-Lahou (West), seine nets are forbidden and only individual fishing is allowed.

1. Current methods of exploiting the lagoon environment and the social conditions of production (lagoon Ebrié)

Apart from shrimp fishing which this paper does not cover, there are two main categories of fisheries operated in this lagoon, in direct contrast to each other:

- individual fishing : (passive, selective methods) a traditional specialty practised by native fishermen, for whom this activity is often their only source of income and a necessary basis, ahead of another kind of activity (shrubbery plantations);

- seine net fishing : (active, non-selective methods) these collectively handled nets can measure up to between 1,500 and 2,000m and are expensive (2,5 million for a beach seine net). Privately-owned by immigrant entrepreneurs or absentee businessmen (from the cities), these nets are operated by a salaried workforce, 99% of which are immigrants and 90% foreign.

The contrast between these two forms of fisheries is seen in the partitioning of the fishing areas, resulting in an unequal distribution of the common means of production, the stocks of fish. With a seine net catching 4 to 5 times more fish per fisherman than an individual net, the 700 to 800 seine net operations catch the same quantity of fish as 3,000 individual fishermen. The use of the seine net has brought about the lagoon equivalent of a property monopoly.

2. The historical development of fishing techniques

This situation came about of recent date, as a result of a series of historic changes marked by the important part played by social factors. These changes fall into 3 distinct periods :

- Precolonial : collective fisheries as part of traditional fishing rights, and individual fisheries in the more limited context of the "court" existed in conjunction with each other;

- Colonial : the disappearance of collective techniques and the growth of individual operations, under the joint influence of the new possibilities of currency circulation and the dismantling of the former system of distribution. It was only at the end of this period (the opening of the lagoon to the sea in 1950), that changes to the natural environment occurred;

- Rapid economic growth : (from 1958-60 to the present day) The introduction of new methods which, although collective, were capitalist in character (private ownership, salaried work force). Between 1964 and 1975, these operations increased by 360%; a smaller mesh and longer nets were introduced. This increase in fisheries coincided with the development of shrubbery plantations all around the lake side, resulting in a generalized property boom.

3. Trends and prospects

The current trend towards intensifying the exploitation of existing stocks, which is more reminiscent of plunder than of a desire to improve management of the environment, is reinforced by the importance of fisheries and the lagoon in the regional system of production.

The now urgent rush to acquire land and to build up holdings of private property has meant that fishing has become a necessary prerequisite to any long term investment (plantations, real estate ...).

Agricultural experiments currently underway will perhaps lead to a reversal of this trend. As its name suggests, this technique ressembles more a method of farming than a simple picking activity. If it were introduced into the existing systems of production, as the lagoon equivalent of a plantation, it would be possible to convince the local lakeside population of the importance of this economic area, momentarily the object of acquisitiveness, and to gradually install a more efficient management of the reputedly very rich environment.

Fishery Statistics in Lagoon Ebrié (Ivory Coast) 1976 - 1977

J. B. Amon Kothias, J. M. Ecoutin, F. Gerlotto,
J. P. Hie Dare, R. Lae and J. R. Durand

In lagoon Ebrié (Ivory Coast), fishing is mainly carried out by means of six different kinds of tackle : small and large mesh gillnets (1,5 to 2 and 6,5 to 8 inch stretch mesh respectively), cast nets and multi-hooked lines for individual fishing, beach seine nets and ring nets for collective fishing. Statistics compiled for the year 1977, suggest an initial estimate of approximately 6,700 tons for the total catch; the results obtained by two different methods - based on market distribution and fishery surveys - are very similar.

Beach seine nets and ring nets are responsible for the bulk of the catch - 4,800 tons - contributing similar amounts. Individual fisheries - small gill nets being the most frequently used in this category - account for 25-30% of the total catch, namely approximately 1,900 tons in 1977.

More than 85% of the catch is made up of six species - or groups of species :

- Ethmalosa fimbriata (61,3%)
- Tilapia guineensis and T. Heudelotii (6,1%)
- Elops lacerta (5,5%)
- Chrysichthys nigrodigitatus and C. walkeri (5,0%)
- Tylochromis jentinki (4,3%)
- Sardinella maderensis (4,2%)

Although the use of ring nets, in the area under marine influence, has increased considerably since 1975, the findings from fresh water areas seem to indicate a stagnation in the total catch and a serious reduction in fish length (dominance of juveniles), both of which are probably caused by the small mesh of the beach seines (13mm stretched) and/or overfishing.

Research Carried Out by the Lagoons of the Ivory Coast

J. R. Durand

Oceanography Research Centre, ORSTOM, Abidjan

The Ivory Coast is particularly well endowed with a network of brackish lagoons, covering a distance of nearly 300km along its off-shore bars, and representing a total surface area of approximately 1,200km^2. These lagoons are complex in pattern, since they are subject to the combined influence of both continental and marine waters; this occurs in different ways, depending on the rate of flow of the rivers concerned and the scale and source, either natural or artificial, of communications with the marine environment.

It is only since 1970 that these tropical environments have begun to be studied systematically on a large scale, despite their great importance in many respects, for a wide range of activities undertaken by man : communications, trade, fisheries, tourist industry. These activities involve the concentration of the population along the coast, leading gradually to urbanization and its inevitable effects on the environment. This process is entirely typical and particularly spectacular in the case of lagoon Ebrié, with the Vridi canal and the rapid development of the port and city area of Abidjan.

There are three main areas of intervention :

1) Research into the physico-chemical environment

This research aims to supply a preliminary description of the environment both in static (bathymetry) and dynamic terms (the extent and rate of the rise in level, variations in space and time of physico-chemical factors, such as salinity, temperature ...).

This section also includes the study of the effects of pollution on the ecology of lagoon Ebrié, especially in the urban area of Abidjan.

2) Energy transfers in the ecosystem of the lagoon

This field covers all aspects of production, be it primary, secondary or terminal. A review of the transfers made to the first levels of the trophic chain should be instrumental in analysing the mechanisms and in identifying the main factors involved in the productivity of tropical lagoons.

3) The exploitation of stocks

Any information liable to contribute towards a more comprehensive grasp of lagoon fisheries - traditionally highly productive - must be considered : the development of methods for investigating artisanal techniques, the collection of statistics, the biology and ecology of the most prevalent species (fish and crustacea), population shifts, socio-economic aspects.

Aquacultural research deserves special mention : this research involves the bio-ecology of the species under consideration and the quality of the environment (risk of dystrophic crises).

Until now, this research has been carried out in lagoon Ebrié, but it will be extended to cover lagoon Aby, an environment which is almost as vast but less changed and polluted, with a view to comparing findings on two expanses of brackish water in close proximity to each other.

The originality of an integrated, global research project involving several complementary disciplines and providing information in fields of basic research as well as in fields with more immediate or short-term implications (environmental protection, management of stocks, aquaculture), has proved to be very positive, in two respects; it supplies the necessary information and makes it possible to train researchers in the study of brackish waters, whereas, on a regional basis, the results of such a research project can be applied to many different angles, and the team set up in the Ivory Coast could act as a training and information centre for scientists involved in the study of brackish, tropical environments.

The Main Fisheries in the Coastal Zone (0 - 30m) and the Estuaries of Senegal

A. Samba and P. Freon (C.R.O.D.T.)

The coastal zone of Senegal (up to 6 miles) and beyond is an area exclusively reserved for traditional (or artisanal) canoe fishing, engaged in the exploitation of mainly pelagic as well as benthic species.

The fishing of small pelagic fish is particularly prevalent on the south coast (between 12°20 and 14°40 N) where there are three important off-loading centres (Mbour-Joal-Djiffer). The ring net and the gill net are the most commonly used methods : small industrial sardine boats operate on the south coast beyond the 6 mile limit, but at depths less than 30 metres.

Ring nets (measuring 200 to 300m) are mainly used for fishing the Sardinella aurita but also the Sardinella maderensis, Ethmalosa fimbriata, Caranx rhonchus, Pomadasys spp. The mean catch is 3,3 tons per operation : the catch is always at its highest during the hot season. In 1977, ring nets were responsible for landing 14,000 tons approximately.

The gill net is used mostly for Sardinella maderensis (with a mesh of 30mm^2) and Ethmalosa fimbriata (with a mesh of 40mm^2). The catch is high from June to October; in 1977, gill net fishing landed 4,700 tons. The average catch is 950kg per operation.

Other traditional forms of fishing exist : the pelagic catch of all these "artisanal" methods is approximately double that of the catch made by industrial sardine boats. Artisanal sea fishing also involves demersal species - they are fished by means of baited hand rods, often in rocky areas. The catch is less than that of pelagic fish, but is of a greater market value, the most commonly fished species being the Sarranidae, the Sparidae

and a pelagic species : Pomatomus saltatrix. In the estuaries, fishermen use fixed nets to catch shrimps (in Casamance, in the Saloum). Standing gill nets are used to catch fish such as Pseudotolthus, Tilapia, etc ...

Note on the Coastal Ecosystem of South Senegal

the Importance and Interest of Studying the Marine Coastal Zone

P. Freon [x]

The coastal ecosystem of South Senegal is of great importance to the region, since it acts as the nursery for most of the species to be found on the continental shelf between Guinea Bissau and the North of Mauritania. There is another nursery in Mauritania in the area of the banc d'Arguin to the South of cape Timiris, but it seems to be less extensive than the former. These two nurseries produce stocks of both pelagic and demersal species, with a total biomass in excess of 10 million tons and a yield of marketable species amounting to approximately 1.5 million tons per year for the whole of the coastal zone concerned.

The coastal zone is extremely affected by natural bydroclimactic variations, subject as it is to the influences of both the oceanic environment and those of the land mass, and large scale variations are recorded in the renewal of certain species.

The exploitation of commercially viable stocks is, in most cases, at an optimal level, and there are occasionally signs of overexploitation. Under these conditions, the stocks in question are affected even more by environmental variations, whether natural or caused by pollution, and stochastic simulation models have indicated that several successive years of a poor renewal level can result in the collapse of the stock concerned, especially in the case of pelagic fish.

The setting up of an integrated pluridisciplinary research programme seems, therefore, to be of great importance. Without attempting to model the entire ecosystem, the ideal procedure would consist of drafting a plan of the system and of underlining the necessary means for a more efficient management and protection of the environment, on which most of the fishery resources of Mauritania, Senegal, Gambia and Guinea Bissau depend.

[x] Oceanographical biologist at ORSTOM, CRODT, BP 2241 DAKAR-SENEGAL

Presentation of the F.A.O. Representative

M. Charbonnier

Within the context of this workshop and at this point in discussions, a brief presentation of F.A.O. activities concerning the evaluation and management of marine resources and in the field of fisheries operated in brackish waters, would not appear inappropriate.

I would like to make this presentation, not by way of mere information, but as an attempt to initiate complementary activities, in fields where the responsibilities of UNESCO and FAO may coincide.

The FAO participates in the evaluation and management of marine resources through its **Fishery Committee for the Eastern Central Atlantic or CECAF, which groups together those** countries, the coastline of which borders on the geographic area from the Straits of Gibraltar to the mouth of the river Congo, and other countries which fish or have fished to any great extent in the area (U.S.S.R., Poland, Greece, France, Korea, Japan, etc.).

In view of the importance of fisheries for the region, I would like to point out that the United Nations Development Programme decided to finance a fisheries development project for **Eastern Central Africa ; FAO was given responsibility for the** technical execution of this programme, and, as most of you are aware, its headquarters is located in Dakar.

As I have already mentioned, FAO activities concerning the evaluation and management of stocks, have expanded considerably in recent years, a fact which is indicative not only of the advantages to be gained from a more comprehensive knowledge of marine resources, but also of the phenomenon which prompted the recent evaluation of the law of the sea; although the extension of exclusive economic zones to 200 nautical miles off-shore offers coastal countries important opportunities for economic development, it also gives rise to a series of very real problems involving the development and management of the fisheries for which they are responsible.

The **CECAF and** its complementary project have endeavoured to be of assistance to the African countries in the accomplishment of this task; in the course of the last two years, therefore, nine special working groups were organized, to review and analyze the data which had accumulated in regional laboratories and elsewhere. This survey, which dealt with stocks considered as the most important, in economic terms, shrimps, demersal fish, sardines, other species of pelagic fish and hake, mobilized researchers, working on the stocks present in the region, or those who had previously been involved in similar research. This review, a synopsis of which was actually presented here several weeks ago, supplied the basis for a more comprehensive understanding of the productivity of these vast geographic areas and the main types of resources available.

Several delegates at this meeting, especially M. Garcia, who was very involved in the work of these different groups, could doubtless provide further details on the findings of this review, should you require them, in as far as they are complementary to UNESCO's own concerns. Without wishing to anticipate any possible comments from M. Garcia, I should like to say that some of the working groups were convinced of the need to study the productivity of the mangroves in Liberia, Sierra Leone and Nigeria and South Gabon.

Moreover, and by way of a mere suggestion, as part of your discussions on the establishment of a research programme, another possible complementary theme - which emerged in the presentation made this morning by Messrs. Zabi and Mensah - involves the sampling of coastal marine resources (benthos, the young of oceanic species, shrimps, species suitable for aquacultural purposes), so that the value of these biological resources could be accounted for in the planning of the utilization of the land/sea interface.

Finally, with your permission, I should like to give a brief description of the FAO programme on the Ecology of fisheries carried out in brackish waters. The general aim of this programme is to promote the development and management of fisheries in brackish waters, thanks to the participation of the individual countries concerned, and also of the regional fishery authorities. As regards this part of the African coast more specifically the programme has sought to collect information on the productivity of brackish waters, on the problems affecting the yield of brackish water fisheries and on zones which can be used for the purposes of this industry. The particularly important aspects of this programme, some of which coincide with the concerns of this workshop, include the interdependence which exists between certain kinds of sea fisheries and the more effective management of the resources of brackish waters; the forecasting of the potential yield from brackish water fisheries, the dependence of the development of brackish water aquaculture on the availability of alevin, which, in turn, depends on an efficient management of the alevin-producing stocks; finally, an essential part of this programme is concerned with the evaluation of environmental changes, with a view to assessing their probable effects on catches and breeding possibilities.

It is therefore possible to identify a certain number of fields in which UNESCO and the FAO can cooperate and which may provide you with some ideas for your discussions of preliminary plans for regional cooperation.

The Ecology of Mangroves in Senegal

C. Marius
Pedologist at the ORSTOM Centre (Dakar)

The mangrove has already been defined. This type of biotope is concentrated in three main areas of Senegal, each typified by a particular river, the Casamance, the Gambia and the Saloum.

There are three types of plants, known under the global term of mangrove. The main hydrological factor remains the salinity of the waters of the mangrove which can sometimes be 2 to 3 times greater than that found in neighbouring seawater, during the dry season, especially in the "tannes". The PH varies between 7 and 8.

The sediments are sand or mud with their intermediaries. Recorded fauna includes molluscs and crustacea (crabs). Mangroves are basically suited for rice-growing, which is carried out by the Diolas.

Discussions then dealt with various points, which can be resumed as follows :

1) As regards salinity, it was shown that the process of reversibility does not occur in a clay environment, i.e. freshening does not take place in this kind of sediment.

2) It was observed that the river Gambia behaves differently to the other rivers because it has a much larger catchment basin than that of the Casamance, for example.

3) Fresh water resources were not evaluated.

4) Finally, emphasis was laid on the ecological and economic importance of the Senegalese mangrove.

Shrimp fishery in Casamance

L. G. Lerest, CRODT - Dakar

Shrimp fishery in Casamance is artisanal and is carried out upstream as far as Ziguinchor and downstream 40 km. to Tambakounda, which marks the official limit for this kind of artisanal fishery. The catch is made by means of nets and takes place by night during ebb-tide.

Shrimp fishery has been marked by two important phases;

1) 1960 - 68 - Estimated on the basis of the number of canoes utilized, fishery activities increase, as does the catch.

2) After 1974, there is a drop in production which can only be explained by overfishing (a provisional hypothesis). An alternative hypothesis is based on the ecology of the shrimp, Penaeus duararum, an amphibiotic species : salinity variations are therefore taken into account. As this factor varies greatly from one year to another, it is difficult to establish any average figure.

Example: At Ziguinchor, the following salinity variations were recorded :

3 to 36‰ in 1966 and 1967

25 to 50‰ in 1978

Two phases of research were adopted :

1) to establish whether the shrimp is larger during periods of higher salinity.

2) to establish the catch-salinity correlation. However, as very little information was available for the years between 1968 and 1978, the pluviometry for this period was consulted, given its marked influence on salinity.

Several kinds of correlations were attempted, and it was noted that there was a definite correlation between the catch of one year and the pluviometry of the two years in question, since the soil of the mangrove can act as a reservoir which is capable of restoring the salt content during the rainy season. On the basis of this correlation, therefore, the catch should be forecast for the coming year, and this has prompted the authorities to estimate production at 1500 tons/per year. It may therefore be assumed that average production is less than that of 10 years previously, in the long term.

During the ensuing discussions, it was observed that no correlation had been established between the salinity level and other environmental factors, which had not been discounted, as a result of taking the pluviometric influence into consideration.

The problems involving population dynamics were not covered, but it can be said that level of fishery activities, the extent of post-larval renewal etc. can be considered as stable in the case of this specific correlation, which is only valid for the Casamance, being itself affected by size at migration. The above factors must be considered in any fisheries control in the Casamence.

Research Programme on the Consequences of Pollution on the Ecology of Lagoon Ebrie

by Ph. Dufour, Oceanographic Research Centre ORSTOM

Abidjan

The large West African lagoons number amongst the most productive natural environments in the world. This productivity, as well as their esthetic qualities and salubrity, are threatened by human interference : the industrialization of the coast, the development and modernization of agriculture, extensive public works, and often anarchic methods of fishing.

As a result, the effluent from 1.2 million inhabitants of Abidjan removes 15% of the oxygen content from lagoon Ebrié, in urban areas. At the present rate of growth of the capital, the waste discharge is likely to double every seven years. This explains the growing concern of the Ivory Coast authorities, which was aroused as early as 1966, and finally led to the establishment of a global research programme on the ecosystem of lagoon Ebrié, including the consequences of pollution.

This research programme began in 1974 and is currently in progress.

Before describing the programme, three comments should be made :

1- West African lagoons are greatly affected by the incoming waters, due to their high degree of enclosure which hinders water flow, and to the high temperatures which accelerate chemical and biological processes.

2- The aim of the research carried out by the CRO is not to draw up a list of pollutants, but to compare ecologies of the parts of the lagoon subject to various forms of pollution to varying degrees.

3- This programme is an integral part of the programme concerned with "the consequence of pollution" which analyzes the ecosystem as it was, prior to human interference. .

Research on the impact of pollution has been divided into four different operations;

1) the study of disturbances of certain characteristic physico-chemical parameters : oxygen; nutrient salts; organic matter; the part played by water circulation in the dilution and diffusion of pollution.

2) The identification of the role of pollution as regards phytoplankton production, particularly the eutrophic effect of different forms of industrial and domestic pollution (from oil mills, soap works slaughterhouses, dye plants, domestic sewage). This research is carried out simultaneously "in situ" and "in vitro".

3) The evaluation of faecal bacterial contamination of the water, of which the possible repercussions on public health are undesirable.

4) The study of the self-purifying capacity of the environment as regards organic material. This capacity is considerable and fast acting, due to the high temperatures of the host waters. The findings of this study may lead to the possibility of "natural lagooning", an alternative solution to the costly and complex purifying plant.

One of the objectives of the programme is to supply the national authorities of the Ivory Coast with the technical criteria necessary for an effective management of the environment. Another objective is to extend the analysis of the findings from lagoon Ebrié, to allow this information to be utilized in other ecologically similar tropical lagoons and estuaries.

Biological and Economic Consequences of Land Extraction in the Bay of Adiopodoume

J. B. Amon Kothias and S.G. Zabi, Oceanographic Research Centre
Abidjan

Lagoon Ebrié suffers from a high level of man-made pollution especially in the urban area of Abidjan. One of the most recent and increasingly recurrent effect of human activities involves the removal of sand from the main bays : the Bay of Bingerville, the Bay of Biétri, the Bay of Koumassi and the Bay of Adiopodoumé.

Situated as it is in the part of the lagoon which is subject to marine influence, the bay of Adiopodoumé has a level of salinity which varies greatly according to the seasons : a predominantly marine influence during the dry season (20‰) and a predominantly continental influence during the rainy season (2‰). Although the temperature differences are low, (annual range :5°C), its waters are warmer during the dry season than during the rainy season. It is a deep bay, 3000 m long and 600 to 800 m wide, covering approximately 240 hectares.

The available biological data was supplied as a result of the trawling operations carried out in this bay by GALOIS and DIA in 1972 and 1973 (crustacea and fish) and sampling surveys of the lagoon benthos undertaken by ZABI in 1978. As regards fish and shrimps, the most prevalent species caught in the lagoon, are also present in this bay, particularly during their post larval and/or young phase, making the bay of Adiopodoumé into something of a nursery. As regards the benthos, molluscs are present, both as bivalves and as gasteropods. Several polychaetous worms are also present.

The study of the distribution of the young (shrimps) in lagoon Ebrié showed that they prefer areas penetrated by fresh water. Salinity, in itself, does not appear to be a determining factor in their distribution. The fine sediment, deposited by the rivers and streams as they enter the lagoon, are much appreciated by the shrimps, which find it ideal for burrowing in. However, it is mainly the accumulation of organic plant material which would appear to be the most important factor. This detritus forms the basis of the diet of young Penaeidae, either directly or by the intermediary of the meiofauna which they carry.

The following favourable conditions, resumed below,

- granulometry
- plant coverage at the edge of the bay
- richness of the benthic nutrient cycle

and considered by GILES and ZAMORA (1973), then by GARCIA (1977) as being the most determining in the distribution of young shrimps, are all present in the bay of Adiopodoumé.

The bay acts as a nursery for various species of fish, especially :

- Chrisichthys walkeri and Pellonula afzeliusi

Other species are less prevalent, but most fish caught are at an early stage of their development.

The Consequences of any Future Removal of Sand from the Bay of Andiopodoume

It is not known what sand extracting methods (suction or dredging) will be used, but, whatever technique is adopted, the result will be identical, namely the removal of sediment (sand) from the bed of the bay, i.e. destruction of the substratum, which,

supports plant coverage,

contains the benthic flora and fauna

which plays an important part in the nutrient cycle, essential to the growth of the young.

Unfortunately, the consequences of this disturbance to the ecological environment are all too clear. In biological terms, they will be immediate and catastrophic, since the young of the various species present, being very demanding as to their nutritional requirements, will be decimated, and the benthic fauna destroyed.

Sand could be safely extracted from other, already highly polluted, areas of the lagoon, and its removal might even be of help in purification projects.

An Example of Non Coordinated Coastal Management The Closure of the Channel of the Lagoon of Cotonou (Benin).

A. Klingebiel

In South Benin, the network of lagoons, including Lake Nokoué and the lagoon of Porto Novo, has two outlets: a permanent outlet, through the Nigerian lagoon, and an intermittent outlet through the channel of the lagoon of Cotonou.

Until 1959, this channel, which is 4.5 km. long, 250 m. wide and 4 to 6 m. deep, was frequently blocked at its mouth by a sandy spit formed by the coastal drift from the beaches, moving from West to East. This drift, estimated at 1.5 million tons per year, was interruped by the construction of the port of Cotonou, 2 km. West of the mouth of this channel.

The channel remained open between 1959 and 1977. The tidal currents, which moved through it, deepened and widened it slightly, as the banks were eroded. A greater penetration of salt waters into the lake and its affluents (as far as 40 km. from the mouth), resulted in a high level of salinity of the lagoon environment; it was considered necessary to limit this occurrence, by constructing a submersible barrier at the entrance to the channel. A system of sluices was to be used, to control the entry of marine waters into the channel.

Unfortunately, the construction of this barrier coincided with the re-establishment of the coastal drift of sands from the West, by-passing the Port of Cotonou, of which the obstructive effect was removed by saturation.

The lack of tidal currents in the channel and the re-establishment of the coastal drift had the joint effect of forming a sandy off-shore spit which has permanently closed the channel since April 1978.

None of the research carried out independently by the Port authorities, on the one hand, and the organizations studying the lagoon system, on the other, had envisaged this unfortunate combination of effects, which could have been foreseen if systematic procedures of consultation had been organized. This example emphasizes the urgent need to set up pluridisciplinary and polyvalent groups to study the management of coastal ecosystems.

The protection of the coastal ecosystems; a concrete example; The National Parks of Senegal

A. R. Dupuy and J. Maigret

Although it is undoubtedly true that the coastal strip, which is still barely or ineffectively exploited by those countries bordering it, represents an important source of food, income and profit, it must not be forgotten that these ecosystems are composed of a series of different communities and that the species, subject

to exploitation, should be considered in this context. The stable balance of these species requires the protection of all plant and animal populations of invertebrates and vertebrates present in these ecosystems.

Especially precarious and threatened are the coastal environments, since they can be directly affected by man's intervention, either by changes imposed by him (pollution) or by his insistence on removing for his own use, the necessary proportion of the populations of these environments, or even his mindless destruction of these environments. To demonstrate this point, 4 examples have been taken from different groups of animals among the fauna found on the coast of Senegal: in all four cases, human intervention has resulted in a drop in population.

Amongst the Invertebrates, the example of the Cyprea sanguinolenta, a species endemic to the Cap Vert region, the relative rarity of which makes it a favourite with shell collectors, is particularly significant.

Amongst the Vertebrates, three examples are given: a) The Sea Turtle: 5 species are present on the West African Coast, and 3 or 4 of them lay their eggs on the coasts of Senegal.
b) Amongst the Cetaceans, the Sousa teuzsii species of Dolphin, endemic to the West African Coast, is found in the shallow regions of the coastal environment, lagoons and estuaries.
c) Amongst the Birds, many species have suffered from the break-down of the coastal environments: a reduction in the number of mudholes and water-covered areas, the break-down of mangrove zones, a drop in food supplies, pollution, the urbanization of the coast; examples given include the tropical bird, Phaeton atherurus, an inhabitant of the archipelago of the Madeleine Islands, the only nesting place for this species in West Africa. Disturbed by fishermen and visitors to the island, this species no longer nests there. The setting up of the National Park in 1975 helped to reestablish nestling colonies and in 1979, several tropical birds nested on the small islands in the Park.

Finally, it is our desire, that, following the example of Senegal, several other coastal countries will come to understand that the harmonious development of their economies must be accompanied by a respect for the protection of their environment, especially the marine environment. The relevant Senegalese authorities, responsible for these conservationist issues, are more than willing to share the fruits of their experience in this field.

The Organization of the National Parks of Senegal

Ch. Sagna, Head Warden of the National Park
of the Madeleine Islands.

There are, at the present time, six national parks in the Republic of Senegal, four of which can be classified as marine parks :

- The Barbary Spit National Park : 2.000 ha; created in 1976
- The Madeleine Islands National Park : 450 ha; created in 1976

- The Saloum Delta National Park : 54.000 ha; created in 1976
- The Lower Casamance National Park : 5.000 ha; created in 1970.

These parks were created to afford comprehensive protection for the wide complementary range of ecosystems present in the country.

In 1954 the Niokolo-Koba National Park was created, run by the Forestry Commission until 1967. Following the Alger Convention, in September 1968, and the creation of the Lower Casamance National Park, the Board of the Niokolo Koba National Park became the National Parks Commission, with its headquarters in Tambacounda. 1971 saw the creation of Djoudj National Park, and in 1973, the National Parks Commission was moved to Dakar, under the supervision of the Secretary for Nature Preservation.

With nature preservation established as an official issue in Senegal, it became necessary to train qualified staff. With the help of international organizations such as F.A.O., F.A.C., F.E.D., etc. a certain number of young Senegalese attended the International Training Centre for Fauna Specialists in Garoua (United Republic of Cameroun).

Today, each park is run by a Warden; in addition to the Parks Department, the National Parks Commission is composed of an administrative and financial department, a personnel department, a logistics office, a mobile Teaching Unit and an Information Office.

The Parks and Commission have a total staff of 316, with responsibility for management and supervision.

A Preliminary Hydrological Study of Lake Nokoué (Benin)

C. Dossou, H. Texier, and B. Colleuil

In South Benin, Lake Nokoué, with a surface area of approximately 160 km2 is fed with fresh water by the rivers Ouémé ans Sô, and with sea water by the channel of Cotonou Lagoon, (4.5 km. long and 250 m wide); it also communicates with the lagoon of Porto Novo, through the Totché canal (5km. long and 150 m. wide).

This lagoon system is subject to an equatorial climate, but, because of the rivers already mentioned, it is also affected by a Sudanese-like tropical climate. After the rainy season, the lake is filled with flood water, causing an almost total desalinization of the waters. During periods of low water and of high tides, sea water enters the lake through the Cotonou Channel and goes as far as 40 km upriver. Following the construction of a barrier at the channel entrance, this means of communication between the Lake and sea was completely shut off by the formation of a sand spit in April 1978.

The Evolution of Salinity in the Waters of Lake Nokoue

A series of systematic measurements show that the polypoikilohaline character of the Lake has undergone profound changes. The waters have become monotypal mesomixohaline, except for the Eastern tip of the Lake where they are mixed (meso/oligo-mixohaline) and at the Western extremity where they have become meso/poly-mixohaline. The difference in salinity between the surface and the bed is very slight.

The other parameters reviewed in this study remain invariable (temperatures, transparency and cloudiness, alkalinity, wind and exposure to the sun) or seasonal (rains and river flow rate).

The drop in salinity recorded between 1978 (16 to 20‰) and 1979 3 to 6‰) enables a rough estimate to be made of the average coefficients " of effect", account being taken of rates of evaporation and meteorological data of 1978 resulting in the following percentages: rise in the level of the Ouémé 20%; rains 40 to 50%; closure of the channel 30 to 40%.

Socio-Economic Consequences: The disappearance of shrimps and big sea fish is the most striking consequence, but a further consequence is the extension of the area open to fish breeding by means of akadjas, with the ensuing social problems. There is a tendency towards a drop in the exploitation of molluscs, such as Arca senilis and Crassostrea gazar.

The future of the Lake's aquatic life is dependent on the annual variations in salinity which should be regulated by the opening of the lagoon channel.

A Summary of the Development of Marine Sciences in Angola

Herivelto J. M. Olavo GAMBOA (Angola)

Artisanal fishery is wide-spread and is closely supervised by the State. Fishermen usually receive assistance from a central trade union.

The most commonly found fish along our coasts include the sardine, sword fish, the "caxucho", the "garopa", the rock lobster and the "corvina".

Several authorities, such as the Meteorological Office, the National Board of Maritime Transport and the Fisheries Ministry, are developing their activities in the fields of hydrology and oceanography, by means of specialized departments.

A comprehensive research programme is underway on our rivers, with a view to exploiting their potentialities to a greater extent, in terms of communications, energy, biology, geology and other fields.

The construction of new dams, the development of artisanal and mechanized fisheries, and mineralogical exploration, are all concrete examples of work carried out by the Republic of Angola.

A national training programme is required for specialists in these fields, to be carried out both at home and abroad, backed up, henceforth, by international experts to whom we are most grateful. Considerable progress has also been made in the field of navigational safety, involving the practical application of research projects on the dredging and sounding of our ports and bars, the updating of the systems of bouyage and of lighting signals, and the review of our nautical mapping, all of which guarantee a greater degree of safety for visiting, foreign ships.

There are no large lagoons in Angola, as there are for example on the Ivory Coast; in the area of Lobito, however, there is a series of very small lagoons, which, for reasons already mentioned have not yet been surveyed to any great extent, with a view to allowing local populations to live there normally.

This part of the country does, of course, pose problems for our colleagues in Civil Engineering: at the moment, I can give no detailed information on the ways in which the problems posed by the lagoons are being tackled.

Studies on the lagoons of Angola will be carried out in the near future. With regard to the study of marine currents or the degree of movement of the sea, and other parameters concerning Water Sciences, a research programme is envisaged, which has already been initiated by the Republic of Angola.

Rational Principles of Management and Utilization of the Coastal Zones

André Klingebiel

Man is motivated towards the sea and the management of the coastal zones by the exploitation of their many, varied natural resources: fisheries in lagoons, estuaries and in the sea; the agricultural development of irrigated plains; building materials; salt works; new forms of energy; tourism and leisure activities, etc.

The simultaneous development of these various activities inevitably gives rise to situations of conflicting interests between the economic and ethnic groups which pursue them, and can cause sometimes irreversible changes to the natural environment, and the destruction of certain basic elements of the coastal ecosystems, the precarious balance of which is often underestimated.

The evaluation of the impact of various management schemes, whether already completed or underway, in a coastal zone, implies a thorough knowledge of the ecosystem and a careful choice in the developments undertaken, mindful of the local and regional aptitudes of the natural environments.

The preparation of a series of atlases of the littoral and coastal zones, comprising thematic maps of physical, biological, geological, hydrological, socio-economic and ecological data etc., provides the opportunity for reviewing the available information, or lack of it, as regards these zones, and is also a source of information for the specialized and non-specialized "decision makers" of the coastal systems, who, thus informed, can then select the appropriate management schemes and the back-up studies which are necessary to evaluate the impact of these management projects on the environment.

Actual and quaternary molluse fauna distribution in the lower Senegal river

J. Monteillet & J. C. Rosso

Lower Senegal river was found to be an estuarine environment where lived animal species (specially Molluscs) which are known in other west african estuaries and lagoons. The distribution of the malacological fauna depends mainly on salinity range. During the dry season river flow becomes negligible and marine water moves upstream. During this low water period, salinity decrease as we move up the river. A succession of Molluscs occurs from the river mouth to the freshwater boundary.

Three groups can be identified :

1 - Estuarine or epimarine species which are six in number, live in the higher salinity portion of the estuary (36 to 5 ‰). but extend father upstream, each species having its own range.

2 - Mixohaline (brackish) species which are two in number, occur in the lower salinity portion of the estuary (5 to 0.5 ‰).

3 - Fresh water species which are about ten in number and which may tolerate a slight seasonal increase of salinity (1 to 0 ‰).

Actual malacological fauna of the lower Senegal river is scarce when compared with quaternary molluscs fauna of the same area and with those of other similar west african environments.

This scarcity is shown by the disappearence of epimarine species as well as the reduction of the number of brackish species living in more euryhaline conditions.

This evolution of the malacological fauna during the holocene could be due to changes in the river course or to anthropomorphic actions but also due to fluctuations of the sea level and river flow variations as a consequence of climatic changes in the river basin.

The Continental Shelf off the Saloum Estuary and the Islands of Gandoul and Betanti (Senegal) Sedimentological Study and Evolution at late Quaternary

E.S. Diop*

The study of the evolution at late Quaternary of the continental shelf and the Saloum Estuary may be viewed by the sedimentology (of the surface and the deep samples), the radiochronology and the determination of fauna fossils.

The C.R.O.D.T. - I.S.R.A has made various surface samplings in order to establish the mapping of the senegambian continental shelf in its whole structure.

The I.G.B.A and B.R.G.M. have carried out many deep sampling missions in the Northern part of the Continental shelf off the Saloum Estuary during the Rosilda campaign. Many diagrammatic geological sections have also been established in the Saloum Islands according to the drillings of the Sasif, H.A.

This study will therefore deal with the sedimentology of the sandy fraction in the surface samples, with the observation of the deep sections and will try as much as possible to take account in the evolution at late Quaternary of these two environments.

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Modeling in estuaries and coastal lagoons

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There are three major types of models that are of most use to studying the ecology of estuaries and lagoons. The first of these is the standard statistical model, such as the multivariate regression models used in much of fisheries work. While these models are often quite useful and require a relatively small data input, they are not very applicable to ecosystems analysis. For systems analysis we need to use a more mechanistic sort of model in which a mathematical synthesis of a great deal of reductionist data can be obtained. Such models may have stochastic as well as deterministic formulations and provide a holistic point of view for exploring the consequences of a great deal of "autecologic..." or physiological research on individual species. When used wisely, the model provides a sensitivity analysis to guide research efforts and provides a rigorous quantitative framework for assessing the adequacy of our knowledge of the ecosystem under study.

For experimental problems concerning the probable response of natural ecosystems to perturbations (e.g. pollution inputs, salinity changes, etc..), living models or microcosms should be developed as small scale analogues of larger nature. Recent work (MERL, CPEX) has shown that it is possible to maintain complex marine systems in replicate containers for long periods (months - year) to study the biological effects of various pollutents as well as biomagnification, inter and intra species interactions, and biogeochemical cycling of the pollutant. Microcosms should represent an import future research approach.

The hydrology and fisheries of the lagoons and estuaries of Ghana

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1. Two types of lagoons - open and closed - occur in Ghana.

2. An account has been given of the hydrology of a few of the lagoons - Sakumo 1 and 2 and Mukwe Lagoons and the fisheries (prevalent methods and species of fish) in all the lagoons and estuaries.

3. The rainfall, evaporation and the tides have a combined effect on the variations in the temperature and the salinity of the lagoons.

4. The levels of dissolved oxygen concentration in the open lagoon (Sakumo 2) are higher than those in the closed lagoon (Mukwe)..

5. The main organic productivity in the open lagoon is higher than that in the closed lagoon.

6. In view of the gentle fluctuations in salinity and temperature coupled with higher organic productivity in the open lagoon, fish and crustacean biomass is likely to be greater than in the closed lagoon.

7. The ecosystem of Sakumo 2 Lagoon has been found characterised by an energy storage in the form of fine mud, detritus and associated microrganisms which are brought in during the rainy season by the drainage and these are constantly enriched by sedimenting seston.

8. Prevalent types of fishing in the lagoon and estuaries include hand cast-nets, gill-nets and various types of traps.

9. Fish resources include both marine and freshwater species, shrimps and oyster also occur.

10. Traditionally, closed fishing season in the lagoons and estuaries has been adopted as a fisheries management technique.

11. Traditional aquaculture is practised in the big lagoons but industrial brackish-water aquaculture is non-existent.

12. Socio-economic impact of fisheries in the lagoons and estuaries, and brackish-water aquaculture has been discussed and found to be very important.

13. Recommendations for research and solutions to constraints in the implementation of the research programmes have been discussed.

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Some problems of lagoon research in Nigeria

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Lagoon research commenced in Nigeria in 1954 and since that time important aspects relating to physico-chemical properties of the water, phyto-plankton, zooplankton, benthic organisms, and fisheries have been tackled. More recently, microbiological and pollution studies have been initiated. Results of these investigations have been published in scientific journals, among which the following :

- Nigeria Journal of Science
- Journal of West African Science Association
- Bulletin de l'IFAN
- Journal of Ecology
- Journal of Fisheries

The next stage in these investigations will be a concentration on studies relating to primary productivity, energy transfers and nutrient cycling.

A number of problems facing scientific investigations in developing countries are considered. These include :

1. A need to achieve a balance between basic research and research related to development of natural resources.

2. The quest of Policy Makers for quick and not necessarily suitable solutions to problems.

3. Lack of scientific manpower and the lack of dedication by scientific workers.

4. Lack of financial support

5. Role of economic development vis-a-vis ecological balance.

These are discussed and the need to find solutions to them is emphasised.