Intergovernmental Oceanographic Commission

Workshop Report No. 41

First Workshop of Participants in the Joint FAO-IOC-WHO-IAEA-UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2 - Pilot Phase)

Dakar, Senegal,
28 October-1 November 1985

Unesco

IOC Workshop Reports

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No.	Title	Publishing Body	Languages
1	CCOP-IOC, 1974, Metallogenesis, Hydrocarbons and Tectonic Patterns in Eastern Asia (Report of the IDOE Workshop on); Bangkok, Thailand 24-29 September 1973 UNDP (CCOP), 138 pp.	Office of the Project Manager UNDP/CCOP c/o ESCAP Sala Santitham Bangkok 2, Thailand	English
2	CICAR Ichthyoplankton Workshop, Mexico City, 16-27 July 1974 (Unesco Technical Paper in Marine Sciences, No. 20).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish (out of stock)
3	Report of the IOC/GFCM/ICSEM International Workshop on Marine Pollution in the Mediterranean, Monte Carlo, 9-14 September 1974.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock)
4	Report of the Workshop on the Phenomenon known as "El Niño", Guayaquil, Ecuador, 4-12 December 1974.	FAO Via delle Terme di Caracalla 00100 Rome, Italy	English (out of stock) Spanish (out of stock)
5	IDOE International Workshop on Marine Geology and Geophysics of the Caribbean Region and its Resources, Kingston, Jamaica, 17-22 February 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock) Spanish
6	Report of the CCOP/SOPAC-IOC IDOE International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Suva, Fiji, 1-6 September 1975.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
7	Report of the Scientific Workshop to Initiate Planning for a Co-operative Investigation in the North and Central Western Indian Ocean, organized within the IDOE under the sponsorship of IOC/FAO (IOFC)/Unesco/EAC, Nairobi, Kenya, 25 March-2 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
8	Joint IOC/FAO (IPFC)/UNEP International Workshop on Marine Pollution in East Asian Waters, Penang, 7-13 April 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
9	IOC/CMG/SCOR Second International Workshop on Marine Geoscience, Mauritius, 9-13 August 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
10	IOC/WMO Second Workshop on Marine Pollution (Petroleum) Monitoring, Monaco, 14-18 June 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish (out of stock) Russian
11	Report of the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish (out of stock)
11 Suppl.	Collected contributions of invited lecturers and authors to the IOC/FAO/UNEP International Workshop on Marine Pollution in the Caribbean and Adjacent Regions, Port of Spain, Trinidad, 13-17 December 1976.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
12	Report of the IOCARIBE Interdisciplinary Workshop on Scientific Programmes in Support of Fisheries Projects, Fort-de-France, Martinique 28 November-2 December 1977.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
13	Report of the IOCARIBE Workshop on Environmental Geology of the Caribbean Coastal Area, Port of Spain, Trinidad, 16-18 January 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
14	IOC/FAO/WHO/UNEP International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas, Abidjan, Ivory Coast, 2-9 May 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French
15	CPPS/FAO/IOC/UNEP International Workshop on Marine Pollution in the South-East Pacific, Santiago de Chile, 6-10 November 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
16	Workshop on the Western Pacific, Tokyo, 19-20 February 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Russian
17	Joint IOC/WMO Workshop on Oceanographic Products and the IGOSS Data Processing and Services System (IDPSS), Moscow, 9-11 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
17 Suppl.	Papers submitted to the Joint IOC/WMO Seminar on Oceanographic Products and the IGOSS Data Processing and Services System, Moscow, 2-6 April 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
18	IOC/Unesco Workshop on Syllabus for Training Marine Technicians, Miami, 22-26 May 1978 (Unesco reports in marine sciences, No. 4)	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
19	IOC Workshop on Marine Science Syllabus for Secondary Schools, Llantwit Major, Wales, U.K., 5-9 June 1978 (Unesco reports in marine sciences, No. 5).	Division of Marine Sciences, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian Arabic
20	Second CCOP-IOC Workshop on IDOE Studies of East Asia Tectonics and Resources, Bandung, Indonesia, 17-21 October 1978.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
21	Second IDOE Symposium on Turbulence in the Ocean, Liège, Belgium, 7-18 May 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
22	Third IOC/WMO Workshop on Marine Pollution Monitoring, New Delhi, 11-15 February 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish Russian
23	WESTPAC Workshop on the Marine Geology and Geophysics of the North-West Pacific, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Russian
24	WESTPAC Workshop on Coastal Transport of Pollutants, Tokyo, 27-31 March 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (out of stock)
25	Workshop on the Intercalibration of Sampling Procedures of the IOC/WMO UNEP Pilot Project on Monitoring Background Levels of Selected Pollutants in Open-Ocean Waters, Bermuda, 11-26 January 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English (superseded by IOC Technical Series No. 22)
26	IOC Workshop on Coastal Area Management in the Caribbean Region, Mexico City, 24 September-5 October 1979.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English Spanish
27	CCOP/SOPAC-IOC Second International Workshop on Geology, Mineral Resources and Geophysics of the South Pacific, Nouméa, New Caledonia, 9-15 October 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
28	FAO/IOC Workshop on the effects of environmental variation on the survival of larval pelagic fishes Lima, 20 April-5 May 1980.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
29	WESTPAC Workshop on Marine biological methodology Tokyo, 9-14 February 1981.	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
30	International Workshop on Marine Pollution in the South-West Atlantic Montevideo, 10-14 November 1980.	IOC, Unesco Place de Fontenoy, 75700 Paris, France	English (out of stock) Spanish
31	Third International Workshop on Marine Geoscience Heidelberg, 19-24 July 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
32	UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the context of the New Ocean Regime Paris, 27 September - 1 October 1982	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish

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INTRODUCTION

As part of UNEP's preparatory activities for the development of an Action Plan for the Protection and Development of the Marine and Coastal Environment in the West and Central African Region, an International Workshop on Marine Pollution in the Gulf of Guinea and Adjacent Areas was convened jointly by IOC, FAO, WHO and UNEP in Abidjan, 2-9 May 1978, where thirty-one experts from seventeen countries reviewed the major marine pollution problems of the region and provided scientific guidance on activities that would promote the protection of human health, fisheries resources and coastal and marine ecosystems (IOC Workshop Report no. 14, Unesco, 1978).

After the signature of the Abidjan Convention for the Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, in March 1981, and the recommendations of the Second Meeting of the Steering Committee for the Marine Environment of West and Central Africa, April 1982, the Project Document on the joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2-Pilot Phase) was signed in April 1983.

The WACAF/2 Project co-ordinated by FAO and supervised by UNEP, combines four components which are implemented by the co-operating UN Organization, as follows :

(i) analyses of metals, chlorinated hydrocarbons and petroleum hydrocarbons in marine biota (FAO);

(ii) intercalibration of sampling and analytical techniques (IAEA/FAO);

(iii) observations on floating oil slicks and tar on beaches, sampling and analysis of floating tar balls, and basic oceanographic observations necessary for the understanding of pollutant transport in the region (IOC);

(iv) monitoring of the microbiological quality of recreational waters and seafood (WHO).

The present Workshop was convened by the Intergovernmental Oceanographic Commission, on behalf of and in collaboration with, the co-operating UN Organizations in order to review the results so far obtained by the participating scientists in the region and to consider a long-term regional collaborative programme on marine pollution research and monitoring in West and Central Africa.

The Report of the Workshop is printed in English only; however, the scientific contributions have been printed in their original languages : 10 in English and 7 in French.

(SC.86/WS/43)

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1. OPENING OF THE WORKSHOP

The First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) was opened by his Excellency Mr. Cheikh Abdoul Khadre Cissokho, the Minister for the Protection of Nature of the Republic of Senegal, at 10.00 on Monday, 28 October 1985, at the Unesco Regional Office for Education in Africa (BREDA).

The Participants in the Workshop were welcomed, on behalf of the Director of BREDA, by its Acting Director, Mr. Ogunniyi, who recalled the important role of BREDA in the development and execution of programmes in the West and Central African Region.The Technical Secretary for the Intergovernmental Oceanographic Commission (IOC), Dr. Rolf Schneider, welcomed the Participants on behalf of the Secretary IOC and on behalf of the co-operating United Nations Agencies, expressing their gratitude to the Government of Senegal and to BREDA for hosting the Workshop and explaining the aims of this Workshop and the attention expected to be paid to it by the relevant bodies of the UN Agencies, in particular of IOC

His Excellency the Minister for the Protection of Nature, in his opening address, recalling the history of WACAF/2, indicated that in particular pollution by hydrocarbons is regarded as constantly increasing in the coastal waters and on the beaches of the Gulf of Guinea and the adjacent regions, thus causing adverse effects on coastal ecosystems and fishery resources. He therefore considered it necessary for the WACAF/2 Project to contribute to the knowledge of pollution by petroleum hydrocarbons as well as by other pollutants, such as heavy metals, organochlorines and micro-organisms, in order to fight marine pollution.

2. ADMINISTRATIVE ARRANGEMENTS

2.1 DESIGNATION OF THE CHAIRMAN, VICE-CHAIRMAN AND RAPPORTEURS

Mr. D. Bâ (Senegal) was proposed and unanimously elected as Chairman for the Workshop. Mr. A.C. Ibe (Nigeria) was unanimously designated as Vice-Chairman and Mrs. Mbi (Cameroon) and Mr. D. Kouamé (Ivory Coast) as Rapporteurs.

The List of Participants is attached to this Report as Annex II.

2.2 CONSIDERATION OF THE AGENDA

After minor comments and suggestions from Participants, the Provisional Agenda was adopted as proposed by the joint Secretariat of IOC, FAO, WHO and IAEA, and is given in Annex I.

2.3 CONDUCT OF THE WORKSHOP, TIMETABLE AND DOCUMENTATION

The Technical Secretary for IOC, on behalf of the joint Secretariat informed the Bureau and the Participants about the servicing arrangements for the Workshop in BREDA and introduced the Provisional List of Documents. He also proposed a provisional timetable for the Workshop which was found acceptable.

3. GENERAL STATEMENT ON THE ACTION PLAN FOR WEST AND CENTRAL AFRICA

The Technical Secretary for FAO conveyed greetings to the participants in the Workshop from Mr. Y.J. Ahmad, the Acting Director of UNEP's Oceans and Coastal Areas Programme Activity Center, who, due to other commitments, was unable to attend the Workshop.

He then summarised the steps which led in 1981 to the signature of the Convention for the Co-operation in the Protection and Development of the Marine and Coastal Environment of the Western and Central African Region. At the same time an Action Plan for the region was approved. The first projects to be implemented were :

- Institution and Co-ordination of National Contingency Plans for Marine Pollution Emergencies (WACAF/1);
- Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2);
- Control of Coastal Erosion in West and Central Africa (WACAF/3).

In April 1985, the First Meeting of the Contracting Parties to the Abidjan Convention, noting with satisfaction the progress made in these three projects, approved additional activities for implementation under the Action Plan, e.g. on evaluation of impacts of pollution on the marine environment and on harmonisation of national environmental legislation with the Abidjan Convention. In addition, it was decided to establish, in due course, a Regional Co-ordination Unit in Abidjan as the Regional Secretariat for the Implementation of the Action Plan. Similar secretariats have been successfully set up in Athens for the Mediterranean Action Plan and in Kuwait for the Kuwait Action Plan. The Contracting Parties, however, stressed the necessity to continue projects WACAF/1 and WACAF/2 as a matter of priority and approved funding through the Regional Trust Fund for the period 1986-1987.

4. PROGRESS REPORT ON THE IMPLEMENTATION OF THE WACAF/2 PROJECT

The Technical Secretary for FAO presented a report on the progress achieved from an administrative and organisational point of view, since the initiation of the project in April 1983 (Annex III).

The Participants expressed their full satisfaction with the progress achieved. It was however stressed, that in order to obtain a better geographical coverage, additional institutions should be encouraged to join project WACAF/2.

The Technical Secretary for IAEA reported on the intercalibration exercise conducted on heavy metals and organochlorines in biota (Annex IV). He commented that the results on heavy metals of that exercise were very encouraging. Results on organochlorines were not received so far. Participants welcomed the assistance given by the IAEA International Laboratory for Marine Radioactivity and recommended that such intercalibrations should be repeated on a regular basis in order to further improve analytical precision.

5. INDIVIDUAL SCIENTIFIC REPORTS OF PARTICIPATING RESEARCH CENTRES BY RESPONSIBLE LEADING SCIENTISTS

The Participants summarised the results so far obtained in the course of the WACAF/2 Pilot Phase and outlined their planned activities in the forthcoming operational phase. The following reports were presented and are annexe V in the original language to this Report, as agreed upon under Item 9.

Heavy metals in seafood

C. Biney (Ghana)	(Annex V/1)
I.L. Mbome (Cameroon)	(Annex V/2)
D. Bâ (Senegal)	(Annex V/3)
B.S. Metongo (Ivory Coast)	(Annex V/4)

Organochlorines in seafood

D. Faulkner (Sierra Leone)	(Annex V/5)
N. N'Jie (The Gambia)	(Annex V/6)

Tar on beaches

P.K. Koffi (Ivory Coast)	(Annex V/7)
J.C. Njock (Cameroon)	(Annex V/8)
U.K. Enyenihi (Nigeria)	(Annex V/9)
E.C. Okonya (Nigeria)	(Annex V/10)
P. N'Diaye (Senegal)	(Annex V/11)

Pollution by micro-organisms

I. Sow (Senegal)	(Annex V/12)
R. Paris and D. Diallo (Senegal)	(Annex V/13)
D. Kouame (Ivory Coast)	(Annex V/14)

Each presentation was followed by in-depth discussions and suggestions for future activities which were taken up again under Agenda Item 7.

J.B. Babadounga (Gabon) announced that a laboratory in Gabon is being established and will hopefully be able to participate in the components on monitoring of petroleum hydrocarbons and micro-organisms starting at the end of this year.

The results so far obtained in the Project were then summarized under Agenda Item 6.

6. THE STATE OF CONTAMINATION OF THE MARINE ENVIRONMENT IN THE WACAF REGION

Under this item both, experts from, and outside, the WACAF Region, as well as Technical Secretaries of the co-operating UN Organizations summarised mainly on the basis of the individual scientific reports, the present knowledge on the state of contamination of the marine environment in the West and Central African Region, as compared with other areas.

6.1 GENERAL PHYSICAL OCEANOGRAPHY AND HYDROGRAPHY IN THE WACAF REGION

Mr. A.C. Ibe (Nigeria) summarised the knowledge on the physical oceanographic phenomena that affect the transport and deposition of contaminants in the marine and coastal environment. He stressed that these dynamic phenomena include both large scale events that originate for the most part outside of national boundaries as well as smaller scale processes that are triggered off in the vicinity or on national coastlines.

The large scale events are the oceanic currents. The oceanic currents directly affecting the hydrography of the WACAF Region are the Canary, Benguela, the Equatorial Counter Current, the South Equatorial Current and the Guinea Current. In the immediate vicinity of the coasts, tide and wave generated currents are the dominant processes. Tidal currents are particularly effective around river mouths but they are less effective on the continuous and straight shorelines except in areas with high ($>$4m) tidal ranges. Wave-induced currents are, however, more prevalent everywhere and attain velocities generally less than 1m/s. The recognition of the interplay between oceanographic phenomena and the spread and deposition of pollutants would stimulate the acquisition of oceanographic data as an integral part of the WACAF/2 Project. At first, such studies could be on national basis but because of the across boundary nature of the processes, a regional approach is imperative.

The Participants unanimously agreed that oceanographic observations should urgently be intensified (see item 7.1).

6.2 LEVELS OF HEAVY METALS AND ORGANOCHLORINES IN MARINE ORGANISMS

Mr E. Bacci (Italy) summarised that, from the results presented by the participating Research Centers, some first preliminary conclusions can be drawn. Concerning mercury, levels found in tuna fish muscle, 0.1. - 0.3. mg kg^{-1} wet weight (WW), are lower than those typical in similar samples from the Mediterranean area (0.5 - 2.5 mg kg^{-1} WW), where natural contributions (cynnabar or deposits, volcanic activities, degassing) as well as anthropogenic contamination are present. Figures for mercury levels of tuna fish muscle from "unpolluted" and non-anomalous areas range from 0.1 to 1.0 mg kg^{-1} WW. Results from other samples, i.e. fish, other than tuna, shrimp muscle, and bivalve mollusc soft parts ($<$ 0.1 mg.kg^{-1} WW) indicate typical natural levels and are, consequently, lower than those found in similar samples from the Mediterranean (0.1.-1.0 mg kg^{-1} WW).

Cadmium concentrations in fish and crustacean muscles are, in general, lower than the detection limit of the analytical technique used (flame AAS) which is 0.2 mg kg^{-1} WW. However, in bivalve mollusc soft parts, results range from 0.2 to 2.0 mg kg^{-1} WW. According to recent literature, 0.001 - 0.010 mg kg^{-1} WW appears to be the range of the levels of cadmium in marine fish muscle, where probably the concentration of this element is physiologically regulated. Higher levels are reported for bivalve mollusc soft parts from other areas (0.1 - 1.0 mg kg^{-1} WW).

The few figures available for lead are near to or lower than the detection limit (0.5 mg kg^{-1} WW) by hydride generation - AAS. In other regions, the Mediterranean included, levels of lead in fish and crustacean muscle are often in the range 0.05-0.50 mg kg^{-1} WW.

Copper and zinc concentrations in marine animal tissues are almost similar to the findings from other areas regarded as unpolluted.

First results on chlorinated pesticides and PCBs seem, at present, to indicate a "background" level, as in other regions, more than a hot spot situation.

In an informal round-table session, two additional documents on this topic were presented :

- Bacci, E. and Gaggi, C. "Present trends in environmental Pollution Studies", (Annex VI/1)
- Whitehead, N.E., "Factors influencing marine pollution surveys in West and Central Africa", (Annex VI/2).

The results of the subsequent discussions are summarised under item 7.1.

6.3 FLOATING OIL SLICKS AND TAR BALLS, TAR ON BEACHES

The Technical Secretary for IOC recalled to the Participants that during the Pilot Phase of the Project, only six research centres (in Senegal, Ivory Coast, Nigeria (2), Cameroon and Congo), had participated in the observations on beach tar and expressed his satisfaction with the dedication to this component that he had experienced during the individual reports under item 5 and the following discussions. He appreciated the fact that at least 5 additional centres in Senegal, the Gambia, Sierra Leone, Ghana and Gabon, had expressed their wish to joint in these observations. Summarizing the individual contributions he regretted that there had apparently been confusion on the methodology to be applied, rendering unsatisfactory any scientifically sound evaluation of the results so far obtained.

Reviewing the results obtained in spite of all constraints concerning intercomparability, he concluded that there appears to be a tendency of elevated levels of beach tar in the Eastern Gulf of Guinea (up to several kg m^{-2} in Nigeria, Cameroon and Congo), whereas those in the western and northern parts of the Region reached values only an order of magnitude lower (few hundreds of g m^{-2} in Ivory Coast and Senegal). This can easily be attributed to the high level of mineral oil exploitation and transportation in the first area, and perhaps also to the current distribution. In total, the range of weights of beach tar in the area compares with data obtained in the Mediterranean Sea.

He concluded that longer-term observations carried out by more participants and using the same methodology, together with observations on floating oil slicks and oceanographic parameters are necessary before any final conclusions can be drawn as to the state of contamination by oil in West and Central Africa.

The results of the subsequent discussions are summarised under Agenda Item 7.1.

6.4 CONTAMINATION BY MICRO-ORGANISMS

Mr. Mujeriego (Spain) summarised the results on surveillance of the micro-biological quality of coastal waters. The work has begun this year in Senegal and Ivory Coast. The two institutions have now gathered practical experience concerning sampling, analysis and statistical data handling.

The methods used for sampling and enumeration of three types of faecal bacteria in coastal waters have been adequate,necessitating only some refinements and standardization. The participating laboratories were commended for work done up to now and encouraged to continue according to the lines agreed. As the number of samples counted in both laboratories was still low, there was no way to reach any statistically valid conclusions.

Concern was expressed that no results from Nigeria were available so far.

The results of the subsequent discussions are listed under Agenda Item 7.1.

7. FUTURE CO-OPERATION IN MARINE POLLUTION RESEARCH AND MONITORING IN THE WACAF REGION

7.1 IDENTIFICATION OF MAJOR SCIENTIFIC PROBLEMS AND FUTURE NATIONAL AND REGIONAL CO-OPERATION, TRAINING, EDUCATION AND EQUIPMENT

The Participants discussed a detailed programme for the period 1986/1987 for the analysis of contaminants in biota. It was decided that heavy metals (mandatory : Hg, Cd) and organochlorines (mandatory : DDT and PCB), should be analysed in the following mandatory species :

Top predator fish : *Sphyraena sphyraena* (European barracuda)
(if not available : *Thunnus obesus*) (Bigeye tuna)

Predator fish : *Pseudotolithus senegalensis* (Cassava croaker)
(if not available : *Epinephelus aeneus*) (White grouper)

Bottom feeding fish : *Cynoglossus monodi* (Guinean tonguesole)
(if not available : *Pagellus belottii*) (Red pandora)

Plankton feeding fish : *Sardinella maderensis* (Madeiran sardinella)
(if not available : *Ethmalosa fimbriata* (Bonga shad)

Shrimp : *Penaeus notialis* (Pink shrimp)

Oyster (Sea-) : *Ostrea denticulata* (Denticulate rock oyster)
(or *Ostrea cucullata*) (Cucullate rock oyster)

Oyster (Mangrove) : *Crassostrea (Gryphea) gasar*

Participants were encouraged to monitor also, whenever possible, other species of local economic importance.

It was further decided that for fish, shrimps and bivalve molluscs, the soft part should be analysed.

A minimum of two sampling sites should be chosen by each laboratory, one site in a clean area, where all mandatory species should be sampled, and one site in a highly polluted area, where only bivalve mollusc species should be sampled.

Of each of the mandatory species, a minimum of 10 specimens per sampling site and per year should be analysed for metals and a minimum of 5 specimens per sampling site and per year should be analysed for organochlorines.

The Workshop stressed the importance of analysing bivalve molluscs due to their role as sentinel organisms for contamination. Results from the WACAF/2 monitoring activities would consequently be of direct relevance as a regional contribution to the joint IOC/UNEP world-wide mussel-watch programme implemented in the framework of the Marine Pollution Monitoring System of IOC's Global Investigation of Pollution in the Marine Environment (GIPME).

It was stated that as a useful voluntary research component of the project, also sampling and analyses of sediment samples for metals, organochlorines and petroleum hydrocarbons should be attempted. At a later stage of the project analyses of water samples might also be envisaged. Assistance through IOC and its experts was deemed necessary for these aims.

With regard to the project component on monitoring of marine pollution by petroleum hydrocarbons, and on oceanographic observations required for the comprehension of pollutant transport in the region, the Participants agreed on the following conclusions for future activities :

(i) A network of institutions involved in the sampling of tar on beaches is developing in West and Central Africa. Since the method applied has been different in the laboratories involved and since an adequate scientific evaluation of the observations into seasonality and dynamic processes involved will profit from long-term observations, these observations should be carried on through two more years adhering strictly to the method given in UNEP/IOC/IAEA Reference Methods no. 15 (draft) which has been copied to all participants in this component. The extension of these observations over this period will also allow for the inclusion of new participants to obtain a better coverage of the region and to strengthen the network of participating Research Centres.

(ii) In several countries, the implementation of this component still requires the provision of basic equipment, such as balances, anemometers, compasses, etc., and training, which can now be offered by some of the more experienced participants if funds are made available for the travel and subsistence expenses. IOC should now attribute highest priority to these aims. Governments, as well as the more experienced institutions, should also assist by granting fellowships in these more experienced institutions. This assistance would at the same time increase international collaboration within the region.

(iii) Concerning the desirable observations of floating oil sicks, only limited additional equipment and training would be required. Research vessels not being available in some of the countries, these observations should nevertheless be carried out by national collaborative efforts involving e.g. the navies, the merchant marines, civil aviation and air forces. Such a collaboration has already been agreed upon in one of the countries.

(iv) The participating scientific experts also recommended that whilst all former and additional participating Research Centers carry on their observations, those of them which already have the basic equipment and vessels at their disposal, be encouraged and supported to initiate in-depth studies into the chemical analysis of floating oil slicks and tar balls, as well as sediments, for petroleum hydrocarbons.

(v) One prerequisite for a successful performance of chemical analysis for petroleum hydrocarbons was seen in intercalibration exercises on sampling and analytical methodology for which the assistance through IOC was requested.

(vi) On the basis of the results of these exercises and as a matter of general need, a training workshop was recommended on all aspects of monitoring oil pollution, for which assistance through IOC was also requested.

(vii) It was further concluded that currents, waves, winds, interaction with sediments, suspended particles and biota will influence the transfer and distribution of pollutants. In order to relate the distribution and concentration levels to sources of pollutants, the influence of these dynamical factors on the environment need to be ascertained and understood. For this purpose, a series of detailed oceanographic studies, comprising further measurements and analysis of currents, waves, water levels, sediment patterns, nutrient concentrations need to be carried out from the nearshore, littoral zone to the open ocean.

(viii) Assistance through IOC was therefore requested in terms of additional equipment and training. Practical training could be provided by the more advanced institutions in the Region through participation of trainees of other countries in oceanographic research cruises, where equipment is employed, data collected, reported and analysed. In this context, it was requested that IOC assist in obtaining the permission of Governments to enter their territorial waters for research vessels from other countries carrying out such activities under WACAF/2.

(ix) Training should also be provided in the form of a more continuous type at technical and scientific levels. An inventory of suitable facilities and opportunities in the Region should be up-dated. Identified gaps should be supplemented through support from the Project.

Concerning further developments of monitoring of micro-biological contamination there are four areas to be activited :

(i) The participating laboratories should now widen the scope of their work and begin the micro-biological surveillance of sea-food, like oysters or mussels, which are of national or of local interest.

(ii) WHO will approach countries that are not yet participating in this programme, and ask them to nominate a national laboratory for participating in the micro-biological surveillance of coastal waters and sea-food in the context of WACAF/2. The inclusion of 5 more laboratories would be realistic.

(iii) As far as possible WHO will strive to arrange a training and intercalibration exercise by inviting participants from all the laboratories to one laboratory for one week workshop on sampling, enumeration and data handling in order to secure the use of identical methods in all laboratories and to improve the methodology in use.

(iv) Concerning the individual laboratories they are requested to do the minimum surveillance programme agreed but they are completely free to widen the scope of their individual work, in areas such as adaptation of the enumeration methods for the three indicator bacteria and the study of the relevancy of these three indicator organisms in tropical coastal waters. It is to be noted, that in the framework of WACAF/2, WHO and other agencies cannot assist the laboratories in these extra activities, but that support for such a work could possibly be given through other WHO programmes.

7.2 REQUIREMENTS IN SUPPORT TO THE PLANNED ACTIVITIES

Participants in the Workshop discussed ways and means to improve scientific support and co-operation between participating laboratories in the implementation of their future work programme. The following specific proposals were made :

(i) To facilitate communication and avoid bureaucratic delays, correspondence between UN Organizations and National Focal Points should be copied to research institutions concerned.

(ii) To encourage technical co-operation between developing countries (TCDC) funds should be made available for exchange or visits for scientists within the region.

(iii) Ways and means should be found to improve the access of participating laboratories to up-to-date scientific literature.

(iv) Contacts should be initiated by UN Organizations between participating institutions in the region and advanced research institutions in developed countries with the aim of establishing informal partnerships through which experienced scientists, on a voluntary basis, would give special assistance and advice to laboratories participating in WACAF/2.

8. OTHER BUSINESS

The Workshop was informed by the Secretariat that it was planned to hold the Second Scientific Workshop on WACAF/2 late in 1987. Participants suggested that it be held in a country not having hosted a WACAF/2 Meeting so far and the Secretariat was requested to investigate with Governments in that direction.

9. ADOPTION OF THE REPORT

The Report in its English version was thoroughly discussed by the Participants, and was approved with some amendments; editorial matters were left to the Secretariat. It was agreed that the progress report prepared by UN Organizations, the individual scientific reports, after editorial changes as to uniformity in format, and discussion papers, be annexed to the report.

10. CLOSING OF THE WORKSHOP

The Chairman thanked all Participants for their valuable contributions to the Workshop.

Mr. F.E. Ikomè (Cameroon), on behalf of the Participants, extended their thanks to the Government of Senegal, to the Unesco Regional Office for Education in Africa for hosting this Workshop, to the Chairman, Mr. D. Bâ,and the Secretariat for the efficient conduct of the Workshop.

The Chairman closed the Session at 15.20 hours on Friday 1 November 1985.

ANNEX I

AGENDA

1. OPENING
2. ADMINISTRATIVE ARRANGEMENTS
    - 2.1 DESIGNATION OF THE CHAIRMAN, VICE-CHAIRMAN AND RAPPORTEURS
    - 2.2 CONSIDERATION OF THE AGENDA
    - 2.3 CONDUCT OF THE WORKSHOP, TIMETABLE AND DOCUMENTATION
3. GENERAL STATEMENT ON THE ACTION PLAN FOR WEST AND CENTRAL AFRICA
4. PROGRESS REPORT ON THE IMPLEMENTATION OF THE WACAF/2 PROJECT
5. INDIVIDUAL SCIENTIFIC REPORTS OF PARTICIPATING RESEARCH CENTERS BY RESPONSIBLE LEADING SCIENTISTS
6. THE STATE OF CONTAMINATION OF THE MARINE ENVIRONMENT IN THE WACAF REGION
    - 6.1 GENERAL PHYSICAL OCEANOGRAPHY IN THE WACAF REGION
    - 6.2 LEVELS OF HEAVY METALS AND ORGANOCHLORINES IN COMMERCIAL SPECIES
    - 6.3 FLOATING OIL SLICKS AND TAR BALLS, TAR ON BEACH
    - 6.4 CONTAMINATION BY MICRO-ORGANISMS
7. FUTURE CO-OPERATION IN MARINE POLLUTION RESEARCH AND MONITORING IN THE WACAF REGION
    - 7.1 IDENTIFICATION OF MAJOR SCIENTIFIC PROBLEMS AND FUTURE NATIONAL AND REGIONAL CO-OPERATION, TRAINING, EDUCATION AND EQUIPMENT
    - 7.2 REQUIREMENTS IN SUPPORT OF THE PLANNED ACTIVITIES
8. OTHER BUSINESS
9. ADOPTION OF THE REPORT AND RECOMMENDATIONS
10. CLOSURE OF THE WORKSHOP

ANNEX II

LIST OF PARTICIPANTS

I. EXPERTS FROM THE REGION

Bâ, D.	Laboratoire de chimie analytique et toxicologie Faculté de médecine et de pharmacie Université de Dakar Dakar Sénégal
Babadounga, J.B.	Centre National anti-pollution Ministère de l'Environnement et de la Protection de la Nature BP 3241 Libreville Gabon
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Cooper, J.F.	Laboratoire de chimie analytique et toxicologie Faculté de médecine et de pharmacie Université de Dakar Dakar Sénégal
Diaw, P.A.	Ecole Inter-Etats des Sciences de Médecine Vétérinaire 8, rue Woro Sicap Fann Karack Dakar Sénégal
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Enyenihi, U.K.	Institute of Oceanography University of Calabar PMB 115 Calabar Nigeria

Faulkner, D.F.	Institute of Marine Biology and Oceanography University of Sierra Leone Private Mail Bag Freetown Sierra Leone
Ibé, A.C.	Nigerian Institute for Oceanography and Marine Research PMB. 12729 Victoria Island Lagos Nigeria
Ikomé, F.	Station de recherches halieutiques de Limbé PMB. 77 Limbé Cameroun
Koffi, P.K.	Centre de recherches océanographiques 29, rue des Pêcheurs BP V18 Abidjan Côte d'Ivoire
Kouadio, B.C.	Laboratoire de microbiologie du Centre médical des gens de mer c/o Ministère de la marine Abidjan Côte d'Ivoire
Kouamé, D.	Laboratoire de microbiologie du Centre médical des gens de mer c/o Ministère de la marine Abidjan Côte d'Ivoire
Mbi, C.	Institut de recherches médicales et d'études des plantes médicinales BP 6163 Yaoundé Cameroun
Mbome, I.L.	Institut de recherches médicales et d'études des plantes médicinales BP 6163 Yaoundé Cameroun
Métongo, B.S.	Centre de recherches océanographiques (CRO) BP V18 29, rue des Pêcheurs Abidjan Côte d'Ivoire

N'Diaye, P.	Département de biologie marine (IFAN) Université de Dakar Dakar Sénégal
N'Jie, M.	Fisheries Department 6, Marina Parade Banjul Gambia
Njock, J.C.	Station de recherches halieutiques de Limbé P.M.B. 77 Limbé Cameroun
Okonya, E.C.	Nigerian Institute for Oceanography and Marine Research PMB. 12729 Victoria Island Lagos Nigeria
Paris, R.	Ecole Nationale Supérieure Universitaire de Technologie (ENSUT) BP 5085 Dakar Sénégal
Sow, I.	Division de Prévention et Contrôle de Pollution et Nuisance Direction de l'Environnement 104, rue Carnot Dakar Sénégal

2. INVITED EXPERTS

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3. OBSERVER

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4. SECRETARIAT

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World Health Organization
Regional Office for Africa
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International Atomic Energy Agency
International Laboratory of
Marine Radioactivity
Musée Océanographique
Monaco

ANNEX III

PROGRESS REPORT ON WACAF/2

1. Introduction

After the signature in March 1981 of the Abidjan Convention for the Co-operation in the Protection and Development of the Marine and Coastal Environment of the West and Central African Region, the primary scope of the WACAF 2 project is to support the development and implementation of the Action Plan conceived on the basis of the Convention through the preliminary assessment of the levels of selected pollutants in marine biota, through a survey of tar balls on beaches and the establishment of the degree to which recreational waters and seafood represent a health hazard. The present report is largely based on the one prepared for the Fourth Meeting of the WACAF Steering Committee and the First Meeting of Contracting Parties to the Abidjan Convention, convened in Abidjan from 15 to 17 and from 18 to 20 April respectively. It aims at giving a comprehensive picture of the progress made up to September 1985 from an administrative and organizational point of view.

2. History and Organization of the Pilot Project

The project document between FAO, IOC (of Unesco), WHO, IAEA and UNEP was signed on 19 April 1983 for a duration from November 1982 to October 1984. Total cost of the project: U.S.$632 700 (U.S.$509 500 from the Environment Fund of UNEP, U.S.$47 000 contributed by FAO, U.S.$33 600 contributed by IOC, U.S.$18 600 contributed by WHO and U.S.$24 000 contributed by IAEA).

WACAF 2 combines 4 components technically coordinated by UN organizations, with FAO serving as the lead agency. The components are:

A. Analysis of metals, chlorinated hydrocarbons and petroleum components in marine biota (coordinated by FAO)

B. Intercalibration exercise for sampling and analytical techniques (coordinated by IAEA in cooperation with FAO)

C. Observation of oil slicks and tar on beaches, sampling and analysis of floating tar balls and basic oceanographic observations (coordinated by IOC)

D. Monitoring of the microbiological quality of recreational waters 'and seafood (coordinated by WHO)

UNEP is responsible for the coordination of this project with the other ones carried out under the WACAF Action Plan umbrella. The UN bodies have informed the WACAF National Authorities and Focal Points on the initiation and workplan of the project and have invited them to designate their national institutions which should participate in a project implementation. FAO has circulated a letter on this subject on 29 March 1983, and IOC on 9 May 1983 (see Annexes IV and V in UNEP/G.50/3). WHO has initiated, through its regional office in Brazzaville, contacts with several countries to serve as first sites for bacteriological studies and water quality control.

A broad array of institutions replied, although at times with many months delay, to the initial call for participation. Many research agreements were finalized only in the second half of 1984 and the first few months of 1985. As a result, the project duration was extended by 1 year to October 1985, although, in line with available funding, research agreements were signed initially for a duration through 1984 in the hope that new funds would become available upon reaching the operational state of the Regional Trust Fund to beef up project activities begun in 1984. By September 1985, a total of 17 research or university institutes and laboratories from 10 countries, some of which are participating in more than one component, had joined the WACAF 2 project (Appendix 1) This total excludes one institute phasing out its participation in favour of another, upon request by the National Focal Point for WACAF. The First Meeting of Contracting Parties to the Abidjan Convention, convened from 18 to 20 April in Abidjan, has now approved extension of the project through 1987 and urged National Focal Points to provide additional support to participating institutions. It was further decided that, upon the Regional Trust Fund becoming operational, funds should be made available to WACAF 2 as a matter of priority. This is now the case, and financial support for the first year of the new project phase is thus secured. With this in mind, amendments to the previously stipulated research contracts have been forwarded to all participants in components A and B so as to guarantee smooth transition from the pilot phase to the long-term monitoring phase. Project amendments cover primarily running costs, while training, eventual expenses for repairs and spare parts will be dealt with on a case-by-case basis.

3. Provision of Equipment, Accessories, Glassware, Chemicals, etc.

The major equipment delivered to participating institutes were 3 gas-liquid chromatographs, 3 atomic absorption spectrophotometers, one freeze-dryer, 6 'teflon bombs' for the decomposition of the organic sample matrix, 5 soxhlet extraction units in the project component on analyses of heavy metals and chlorinated hydrocarbons, as well as 3 complete membrane filtration sets in the microbiological monitoring component. Of the latter, only one was delivered to a research institute while the other two remained with WACAF National Focal Points, pending the designation of participating institutes.

Other equipment supplied comprised complete sets of glassware indispensable for the execution of work and voltage stabilizers to back-up sensitive electronic equipment for those countries known to suffer from strong variations in voltage.

Furthermore, chemicals and standards for analyses of pesticides, heavy metals and petroleum hydrocarbons were delivered to participating institutes according to their commitments. In three cases, nitrogen carrier gas had to be bought because locally available grades were insufficient for GLC analyses. In the microbiological project component, chemicals, reagents and culture media were brought for three participants.

A number of spare parts were purchased to repair or upgrade already existing equipment in participating laboratories, as well as an AAS in IAEA's Monaco laboratory, involved in the intercalibration. Upgrading of one GC with an electron capture detector for pesticide analysis of a centre already involved in heavy metal analysis is still under way.

Delays were encountered in the installation of the GLCs and AASs bought through the project, partially due to late availability of material essential for the installation, but also, to some extent, to manpower shortage of the manufacturer. In two cases, difficulties in the installation resulted from faulty components which were adjusted or replaced as part of the warranty. All six instruments are now operational.

A total of US-$220 000 was spent on equipment and materials, and institutes adhering to the component on heavy metal and hydrocarbon analyses have been informed in an end-of-year statement on the expenditures incurred for them against their allocation in their research agreement. The total allotment for 1984 has, in all cases but one been paid and in some cases exceeded, while no substantial expenditures for equipment were effected in 1985.

4. Training

Training has, since the formulation of the project document, been considered one of the most important activities of the project. In 1984 it consisted primarily of an external training component and to a lesser extent of other local training. Fourteen participants from 11 institutes in eight countries in the project components on heavy metal and hydrocarbon analyses and on microbiological monitoring of water quality had participated in training courses or scientific visits abroad lasting between 1 and 5 weeks and in another 4 cases project funds had been made available for local training. Training focussed on sampling, sample preparation, analytical methods and calculation and interpretation of results. In 1985, more emphasis has been laid on on-the-job training; a national seminar on work within the component on microbiological safety, held in two countries by a WHO consultant, covered the following programme: (a) monitoring programmes, (b) analytical procedures, (c) quality control, (d) interpretation of chronological results, and (e) evaluation of results. A training course is being planned for 1986 on microbiological methodology for laboratory personnel of participating and interested institutes. All institutes but one participating in the component on pollutant analyses in marine organisms have been visited by FAO consultants in preparation for the project's scientific workshop.

5. Visiting Experts

In 1983 and 1984, a number of missions were staged by all UN agencies involved with the scope of identifying, in close collaboration with the respective National WACAF Authorities and Focal Points, potential participants for the individual project components while, at the same time, assessing their needs for equipment and training as well as to sort out obstacles on the way to a successful participation in the project. A total of 28 institutes, in addition to National Focal Points, in ten countries were visited by the various missions. The countries were: Benin, Cameroon, Congo, The Gambia, Ghana, Ivory Coast, Nigeria, Senegal, Sierra Leone and Zaire (Appendix 2). Project implementation being well under way, the major objective of consultant missions in 1985 was on-the-job training, development of work programmes and preparation of the project's first scientific workshop.

6. Data Collection, Handling and Reporting

According to the respective research agreements, participants were expected to submit six-monthly progress reports and a final report at the end of the pilot phase of the project.

To facilitate this job, data reporting forms and method manuals developed originally for similar projects in other Regional Seas projects and elsewhere were distributed to participants in the beach tar component (Appendix 3) and in the component on contaminants in organisms. If larger amounts of data become available during subsequent project phases, standardized reporting should allow for computer processing.

Because of the initial delays in the signature process of research agreements and the relatively great quantities of equipment and expendables to be supplied essentially from outside the region, analytical work had not yet started in the project component on heavy metal and hydrocarbon analyses by the end of 1984. Therefore, the travel reports from the trainees were considered sufficient reporting for the previous period. First tentative results on contaminant levels were nevertheless obtained during the training courses through analyses on a few samples of marine biota bought in the Dakar and Douala fish markets respectively. As might have been expected, metal levels (cadmium, zinc, selenium with the exception of total mercury) were much higher in sessile filter-feeding oysters than in migratory pelagic mackerel. The latter compared well with those of the international standard MA-A2.

All institutes but one in that project component have initiated analytical work and started reporting results on the intercalibration exercise (see below) and of analyses carried out on locally-sampled material (Appendix 4) Results are being presented individually by participants at the workshop.

Following consultant missions (see Section 5), six laboratories reported beach-tar observations (Appendix 5) Sampling routine involved between 1 and 3 stations visited in half-monthly to approximately two-monthly intervals. Since data are somewhat scanty and may range over 4 orders of magnitude in an individual station (most data reported vary between 10 and 200 g per sampling station of a 2-m broad stretch from sea level up the beach) they do not lend themselves easily for interpretation at this stage.

7. Intercalibration

Parallel with analyses of heavy metals and chlorinated hydrocarbons, all institutes agreed to participate in a regional intercalibration exercise. IAEA's International Laboratory of Marine Radioactivity in Monaco has distributed sets of well-homogenized shrimp and mussel samples for analysis of trace metals and chlorinated hydrocarbons, together with detailed descriptions and instructions. The material has been analysed by standard methods with the scope of enforcing quality control from the very beginning of the analyses. Six institutes have so far reported results to IAEA (Appendix 4).

8. Project Publications

The IAEA Laboratory in Monaco has been involved, as part of the Regional Seas Programme's efforts and thus also within the framework of WACAF, in standardizing methodology and developing easy-to-follow instructions for all aspects of the monitoring programme. A series of Reference Methods for Marine Pollution Studies has been and is still being issued (Appendix 6). They cover

- sanitary quality of coastal, recreational and shellfish-growing waters, and
- chemical contaminants in marine organisms.

Those already available have been distributed among participants.

As of June 1984, a quarterly bilingual project newsletter has been issued to serve as a vehicle for information exchange and a forum to present and discuss environmental and methodological issues of relevance to WACAF 2. Six issues have been published so far.

9. Summary, Conclusions and Recommendations

- Although it took considerably more time than evisaged, the pilot project reached its operational phase in the course of 1984. By September 1985, a total of 17 institutes from ten countries, some collaborating in more than one project component, had joined the WACAF 2 project.
- Five institutes committed themselves for analyses of organochlorines in marine biota, seven for heavy metal analyses, including participation in a regional intercalibration exercise, two for microbiological monitoring and water quality control, and six for beach-tar surveys.
- As agreed in the respective research agreements, equipment and material indispensable for analyses have been made available to participants. Follow-up amendments are awaiting approval of the respective National Focal Points.
- External training was arranged for most participants in 1984, while some on-the-job training was provided during consultant travels in 1985.
- Serious information gaps were identified with many participants and concerted action will have to be taken to beef up regional research capabilities, e.g. through:
    - further training, external and on-the-job;
    - improvement of library facilities in participating institutes through subscription to key journals and acquisition of books;
    - increase of exchange of relevant scientific papers and reprints;
    - enhancement of communication among participants;
    - setting up of a system of tutorship by which more experienced scientists extend, on a voluntary basis, special assistance and advice to WACAF participants;

- encouragement of presentation and outside publication of research findings.

- On the equipment side, it will be necessary to earmark, in the forthcoming budgets of research institutes, funds for petrol, particularly in those cases where gas shortages for displacements occur and where frequent powercuts render operation of a stand-by generator indispensable.

- On the whole, it would be desirable to reach a more equal geographical coverage through involvement of new institutes and countries in WACAF 2 and improve performance of already-participating ones. It seems quite clear that the performance of all institutes should be improved in the next project phase in order to build up the capabilities (manpower, institutional and equipment) to meet the ambitious objectives of the project born out of the need of national governments to obtain the baseline and monitoring data required for their management and policy decision.

- The Workplan and Timetable of the pilot phase of Project WACAF 2 is attached as Appendix 7.

APPENDIX 1

Institutes and Laboratories Participating in the Various WACAF 2 Modules as at September 1985

Component A.	Analysis of metals, chlorinated hydrocarbons and petroleum components in marine biota (coordinated by FAO)
Component B.	Intercalibration exercise for sampling and analytical techniques (coordinated by IAEA in cooperation with FAO)
Component C.	Observation of oil slicks and tar on beaches, sampling and analysis of floating tar balls and basic oceanographic observations (coordinated by IOC)
Component D.	Monitoring of the microbiological quality of recreational waters and seafood (coordinated by WHO)

Cameroon

- Institut de recherche médicale et d'études des plantes médécinales, Centre de nutrition et Centre d'études des plantes médécinales, B.P. 6130, Yaoundé

  participating in components A (heavy metal and pesticide analyses) and B

- Station de recherches halieutiques de Limbé, PMB 77, Limbé

  participating in sampling programme in component A for above and in component C

Congo

- Centre O.R.S.T.O.M. de Pointe Noire, B.P. 1286, Pointe-Noire

  participating in component C

Gabon

- Centre national anti-pollution, Ministère de l'environnement et de la protection de la nature, Libreville

  participation in component C agreed in principle

The Gambia

- Fisheries Department, 6 Marina Parade, Banjul

  participating in components A (pesticide analyses) and B and participation in component C agreed in principle

Ghana

- The Institute of Aquatic Biology, P.O. Box 38, Achimota

  participating in components A (heavy metal and pesticide analyses), B and C

Ivory Coast

- Centre de recherches océanographiques, 29 rue des Pêcheurs, B.P. V18, Abidjan

  participating in components A (heavy metal analysis), B and C

- Laboratoire central de nutrition animale, 06 B.P. 353, Abidjan 06

  participating in components A (heavy metal analysis) and B

- Laboratoire de microbiologie, Centre médical des gens de mer, Ministère de la marine, Abidjan

  participating in component D

Mauritania

- Centre national de recherches océanographiques et des pêches, Nouadhibou

  participation in component C agreed in principle

Nigeria

- Chemistry Department, University of Ibadan, Ibadan

  participating in components A (pesticide and petroleum hydrocarbon analyses), B and C

- Institute of Oceanography, University of Calabar, PMB 1115, Calabar

  participating in component C

- Chemical and Physical Oceanography Department, Nigerian Institute for Oceanography and Marine Research, PMB 12729, Lagos, Victoria Island

  participating in component C

Senegal

- Laboratoire de chimie analytique et toxicologie, Faculté de médecine et de pharmacie, Université de Dakar, Dakar

  participating in components A (heavy metal analysis) and B

- Institut des sciences de l'environnement de l'Université de Dakar, in collaboration with CRODT, Dakar

  participating in component C until mid-1984

- Institut fondamental d'Afrique Noire, Département de biologie marine, Université de Dakar, Dakar

  designated for participation in component C in substitution for Institut de sciences de l'environnement

- Laboratoire de microbiologie de l'Ecole nationale supérieure universitaire de technologie (ENSUT), Direction de l'environnement, Ministère de la protection de la nature, Dakar

  designated for participation in component D

Sierra Leone	- Institute of Marine Biology and Oceanography, Fourah Bay College, Private Mail Bag, Freetown participating in components A (heavy metal and pesticide analyses), B and C

APPENDIX 2

Institutes Visited other than the National Focal Points

Benin	- Département de chimie, Université nationale du Bénin, Cotonou (FAO, IOC)
Cameroon	- Station de recherches halieutiques, Limbé (FAO, IOC) - Institut de recherche médicale et d'études des plantes médécinales, Yaoundé (FAO)
Congo	- Département de géologie, Faculté des sciences, Brazzaville (IOC) - ORSTOM, Pointe-Noire (IOC)
The Gambia	- Fisheries Department, Banjul (FAO)
Ghana	- Institute of Aquatic Biology, Achimota (FAO)
Ivory Coast	- Centre de recherches océanographiques (CRO), Abidjan (WHO, FAO, IOC) - Laboratoire de chimie-physique, Université nationale de Côte-d'Ivoire, Abidjan (IOC) - Départment de biologie et de physiologie animale, Université nationale de Côte-d'Ivoire, Abidjan (FAO) - Laboratoire de la Société d'exploitation des mines (SODEMI), Abidjan (WHO) - Laboratoire du Centre médical des gens de mer, Abidjan (WHO)
Nigeria	- Chemistry Department, University of Ibadan, Ibadan (FAO) - Institute of Oceanography, University of Calabar, Calabar (FAO, IOC) - Nigerian Institute for Oceanography and Marine Research (NIOMR), Victoria Island, Lagos (IOC, WHO) - Laboratory of Microbiology, Department of Biological Sciences, Lagos University (WHO) - Laboratories of the Petroleum Inspectorate, Nigerian National Petroleum Corporation (WHO)
Senegal	- Laboratoire de chimie analytique et toxicologie, Faculté de médecine et de pharmacie, Université de Dakar, Dakar (FAO)

- Institut des sciences de l'environnement, Faculté des sciences, Université de Dakar, Dakar (IOC)
- Centre de recherche océanographique de Dakar-Thiaroye (CRODT) (WHO, FAO, IOC)
- ORSTOM, Dakar (IOC)
- Laboratoire de la Société nationale d'exploitation des eaux du Sénégal (SONNES), Dakar (WHO)
- Institut technologique de l'alimentation (ITA), Dakar (WHO)
- Institut Pasteur de Dakar (WHO)

Sierra Leone

- Institute of Marine Biology and Oceanography, Fourah Bay College, Freetown (FAO)
- Faculty of Pure and Applied Science, Fourah Bay College, Freetown (FAO)
- Faculty of Engineering, Fourah Bay College, Freetown (FAO)

Zaire

- Département de l'environnement, Kinshasa (IOC)

APPENDIX 3

Method Manuals Distributed to Participants in the Beach Tar Component (IOC)

IOC/WHO Manuals and Guides No. 7, Guide to operational procedures for the IGOSS Pilot Project on Marine Pollution (Petroleum) Monitoring, Unesco, 1976

IOC/WMO/UNEP Manuals and Guides No. 7 (Supplement), Manual for monitoring of oil and petroleum hydrocarbons in marine waters and on beaches (for use in the IOC/WMO/UNEP Pilot Project on Baseline Studies and Monitoring of Oil and Petroleum Hydrocarbons in Marine Waters (MED I) as part of the Coordinated Mediterranean Pollution .Monitoring and Research Programme), Unesco, 1977

IOC Manuals and Guides No. 11, The determination of petroleum hydrocarbons in sediments, Unesco, 1982

IOC Manuals and Guides No. 13, Manual for monitoring oil and dissolved/dispersed petroleum hydrocarbons in marine waters and on beaches (Procedures for the petroleum component of the IOC Marine Pollution Monitoring System (MARPOLMON-P), Unesco 1984

IOC Technical Series No. 12, Oceanographic products and methods of analysis and prediction, Unesco, 1977

APPENDIX 4

Institutes Reporting Results on their Participation in the Component on Analyses of Pollutants in Biota

These were, by September 1985

Cameroon

- Institut de recherches médicales et d'études des plantes médécinales, Yaoundé

  Intercalibration results have been reported. Field sampling of fish has been carried out in February 1985 with the assistance of the Fisheries Research Station at Limbé. Sixteen species of fish and marine invertebrates were collected and results on Hg and Cd levels reported.

The Gambia

- Fisheries Department, Banjul

  Is completing setting up of its laboratory and will start reporting results soon.

Ghana

- Institute of Aquatic Biology, Achimota

  Reported intercalibration results for Hg, Cd and 3 other trace metals in mussel and shrimp samples.

Ivory Coast

- Laboratoire central de nutrition animale, Abidjan

  Reported intercalibration results for Hg and Cd in the mussel and shrimp samples, as well as for 7 other trace metals

- Centre de recherches océanographiques, Abidjan

  Is completing its laboratory set up and will start reporting results soon.

Nigeria

- Chemistry Department, Ibadan University

  Reported intercalibration results for Cd and 6 other trace metals in mussel and shrimp samples.

Senegal

- Laboratoire de chimie analytique et toxicologie, Université de Dakar

  Reported intercalibration results for Hg, Cd and 3 other trace metals in mussel and shrimp samples.

Sierra Leone - Institute of Marine Biology and Oceanography, Fourah Bay College, Freetown

Reported results on analysis of PCB, DDT and its derivatives and lindane in 4 fish species caught in the estuary of Sierra Leone River.

APPENDIX 5

Institutes Reporting on their Participation in the Beach Tar Component

These were, by September 1985:

Cameroon

- Fisheries Research Station, Limbé

  Started on 3 stations on a 25-km coastline in February 1984. Results were received from sampling on 13 occasions between February and November 1984. No results were received since December 1984.

Congo

- Centre ORSTOM de Pointe-Noire

  Started on two stations on one beach in December 1983. Results received for one sampling per month during December 1983 - December 1984. No results were received since then.

Ivory Coast

- Centre de recherches océanographiques (ORSTOM), Abidjan

  Started in October 1984 on two stations.

Nigeria

- Institute of Oceanography, University of Calabar

  Between July 1984 and April 1985, 7 to 8 transections of one beach were sampled on 10 occasions. No reporting since May 1985.

- Nigerian Institute for Oceanography and Marine Research (NIOMR), Lagos

  Observations were made on 11 occasions on one beach between May 1984 and August 1985.

Senegal

- Institut de sciences de l'environnement, Université de Dakar

  Started in January 1984 on one station. Results of 2-3 subsequent samplings during one low-tide period on one day per month received for January to June 1984. After that time the Senegalese National Focal Point for WACAF designated the Département de biologie marine of IFAN as the Senegalese participant. Sampling has not yet been resumed.

Four other countries are at present evaluating their possibilities for participating in this component by nominating suitable research centres.

APPENDIX 6

Reference Methods for Marine Pollution Studies

A. Sanitary Quality of Coastal Recreational and Shellfish-growing Waters

draft(E) 09.05.84	No. 1	UNEP/WHO: Guidelines for monitoring the quality of coastal recreational and shellfish-growing waters
Rev.1(E) 31.08.84 Rev.1(F) 31.10.84	No.2	UNEP/WHO: Determination of total coliforms in sea-water by the membrane filtration culture method
Rev.1(E) 31.08.84 Rev.1(F) 31.10.84	No.3	UNEP/WHO: Determination of faecal coliforms in sea-water by the membrane filtration culture method
Rev.1(E) 31.08.84 Rev.1(F) 31.10.84	No. 4	UNEP/WHO: Determination of faecal streptococci in sea-water by the membrane filtration culture method
Rev.1(E) 31.08.84 Rev.1(F) 31.10.84	No. 5	UNEP/WHO: Determination of faecal coliforms in bivalves by multiple test tube method
in preparation	No. 21	UNEP/WHO: Determination of total coliforms in sea-water by multiple test tube method
in preparation	No. 22	UNEP/WHO: Determination of faecal coliforms in sea-water by multiple test tube method
in preparation	No. 23	UNEP/WHO: Determination of faecal streptococci in sea-water by multiple test tube method
in preparation	D	UNEP/WHO: Determination of faecal coliforms in in estuarine waters, suspended matters and sediments
in preparation	M	UNEP/WHO: Statistical methods for the evaluation of results from monitoring the quality of coastal recreational and shellfish-growing waters

B. Chemical Contaminants in Marine Organisms

in preparation	No. 6	UNEP/FAO/IAEA: Guidelines for monitoring chemical contaminants in marine organisms
Rev.2(E) 12.11.84	No. 7	UNEP/FAO/IAEA/IOC: Sampling of selected marine organisms and sample preparation for trace metal analysis
Rev.1(D) 12.11.84	No. 8	UNEP/FAO/IAEA/IOC: Determination of total mercury in selected marine organisms by cold vapour atomic absorption spectrophotometry

draft(E) 30.08.84	No. 9	UNEP/FAO/IAEA: Determination of total arsenic in selected marine organisms by flameless atomic absorption spectrophotometry
(E) 12.11.84	No. 10	UNEP/FAO/IAEA: Determination of total selenium in selected marine organisms by hydride generation atomic absorption spectrophotometry
Rev.1(E) 12.11.84	No. 11	UNEP/FAO/IAEA/IOC: Determination of total cadmium, zinc, lead and copper in selected marine organisms by flameless atomic absorption spectrophotometry
Rev.1(E) 12.11.84	No. 12	UNEP/FAO/IAEA: Sampling of selected marine organisms and sample preparation for the analysis of chlorinated hydrocarbons
(E) 12.11.84	No. 13	UNEP/FAO/IAEA: Determination of methylmercury in selected marine organisms by gas chromatography
(E) 17.09.82	No. 14	UNEP/FAO/IAEA: Determination of DDTs and PCBs in selected marine organisms by gas-liquid chromatography

APPENDIX 7

Workplan and Timetable for WACAF 2 Pilot Phase

	Activities	Timetable	Responsibility
(a)	Selection and purchase of equipment	January '83 - June '85	Agencies in consultation with UNEP
(b)	Compilation and review of existing data relevant to the project	May - December '83	Agencies in cooperation with authorities and institutions
(c)	Identification of institutions and development of institutional network and work programme	May '83 - June '85	Agencies in cooperation with relevant national authorities
(d)	Interagency review meeting	October '83 (Rome)	UNEP with cooperating agencies
(e)	Identification of instrumentation and training needs and techniques to be used	November '83 - March '85	Agencies in consultation with relevant national authorities
(f)	Identification of key areas and organisms to be sampled and development of sampling strategy	November '83 - March '85	Agencies in cooperation with relevant national authorities and institutions
(g)	Training of personnel for initiation of programme	November '83 - June '85	Agencies with assistance of national institutions
(h)	Installation of instruments	December '83 - June '85	National institutions with assistance of agencies
(i)	Collection of environmental samples for pollutant analysis	December '83 - December '85	National institutions with the assistance of agencies
(j)	Interagency Review Meeting	November '84 (Geneva)	UNEP with cooperating agencies

Workplan and Timetable (cont'd)

Activities		Timetable	Responsibility
(k)	Detailed progress report on preliminary results of project	January '85	Agencies in cooperation with national institutions
(l)	Intercalibration exercises	January - December '85	Agencies in cooperation with national institutions
(m)	Analysis of pollutants in biota and the environment	January - December '85	National institutions with the assistance of agencies
(n)	Workshop of participating laboratories to review the results obtained and to consider a long-term collaborative programme	October '85	IOC/FAO/IAEA/WHO/UNEP and relevant national authorities and institutions

ANNEX IV

RESULTS OF WACAF INTERCALIBRATION EXERCISE FOR TRACE METALS

by

International Laboratory of Marine Radioactivity (Monaco)

Introduction

This document reports results of the first intercalibration exercise carried out within the framework of WACAF/2. It records results only for trace elements since no results were supplied for chlorinated hydrocarbons by the date of the Dakar Workshop.

The exercise was organized and evaluated by the International Laboratory of Marine Radioactivity, part of the International Atomic Energy Agency, and situated at Monaco. We have organized many such exercises over the years.

The samples distributed were Mussel powder (MA-M-2/TM) and Shrimp powder (MA-A-A3/TM). The latter was prepared specially for the WACAF group, but will be used for other intercomparisons as well.

Participants were asked to analyse the samples according to the reference methods originated by and supplied by UNEP.

The participating laboratories were given code numbers 1-6 in a random fashion. This follows the convention of the IAEA to not reveal the identity of participants unless it is commonly agreed amongst them that this be done.

The participants are listed alphabetically by country in the appendix.

Results

The results were submitted in many cases after the deadlines set, but arrived early enough for this document to be produced. The promptness is actually slightly better than for usual worldwide intercalibrations carried out by the Monaco Laboratory.

In the tables which follow, the results are given, in ascending order, together with the standard deviation of the supplied results. All results are in mg kg^{-1}. In one case a laboratory did not supply the figures for the multiple analyses requested, nor their standard deviation.

The results were supposed to be supplied in terms of dry weight. One laboratory did not do so, nor did they supply the moisture content of their samples. This makes it impossible to estimate the dry weight figures from the data they supply, but when the overall scatter of results in seen, this really makes little difference. Their results are therefore included unchanged along with the others.

For another participant it is not stated whether his results are fresh weight or dry weight basis. It is assumed they are dry weight basis.

Also included are the certified values for the mussel powder, and the 95% confidence limits. That is, the median value of results submitted in an intercomparison exercise worldwide, after statistical tests to reject ~~results~~ obvious outliers. Following that, limits are established statistically, such that one can be 95% confident the real median lies within them. The limits are known as "confidence limits". These are not yet available for the shrimp powder.

Some results from the Monaco laboratory are included where available, for comparison, although the laboratory was not a formal participant in the intercomparison exercise.

VANADIUM

Only laboratory 6 contributed values for this element. They report values of less than 0.3 mg kg^{-1} for both samples. Analysis at Monaco gave 0.745±0.016 mg kg^{-1} for the shrimp samples only. No certified values are available.

CHROMIUM

Only laboratory 1 reported values, for mussel and shrimp of 6.38 and 4.64 respectively.

Certified value : (mussel) 1.25 : confidence limits 0.95-1.62.

MANGANESE

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	56.4±2.2
Monaco	70.7±1.1
1	72.40

Certified value: 67.1 Confidence interval 60.7-75.3

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
1	3.63
6	3.67±0.26

IRON

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	185.8±4.2
1	362.98

Certified value: 256.2: confidence limits 229.2-268.2

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	41.4±2.7
1	78.73

NICKEL

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	2.52±0.27
1	12.09

Certified value: not given.

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	0.255±0.044
1	12.05

COPPER

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
4	5.80±0.50
5	7.04±0.37
6	7.70±0.56
1	8.77
2	10.4±1.5

Certified value: 7.96: confidence limits 7.53-8.44

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
Monaco	18.65±0.41
1	27.00
4	21.2±1.7
5	21.57±0.83
2	22.1±2.2
6	23.3±1.4

ZINC

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
5	68.1±3.3
4	161±12
Monaco	172.3±2.2
1	238.18
2	296±22
6	297.9±5.5

Certified value: 156.5 Confidence limits: 152.8-166.7

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
5	38.5±1.6
Monaco	69.4±1.2
4	78.7±1.5
2	143.2±6.5
1	149.32
6	157±12

CADMIUM

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
5	1.31±0.10
6	1.48±0.26
Monaco	1.584±0.021
1	1.80
3	2.01±0.12
4	2.72±0.45
2	3.05±0.15

Certified value: 1.32 Confidence limits: 1.16-1.54

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	less than 0.1
5	0.368±0.051
Monaco	0.533±0.031
4	0.72±0.12
3	1.113±0.034
2	2.09±0.31
1	2.39

MERCURY

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
4	0.67±0.13
5	1.23±0.19
3	1.237±0.083
1	1.43
2	1.58±0.29

Certified value: 0.95 Confidence limits: 0.85-1.06

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
4	1.77±0.21
1	1.88
2	2.17±0.56
3	2.188±0.043
5	2.63±0.28

LEAD

Mussel powder:

Laboratory	Value (mg kg^{-1}) and S.D.
2	1.52±0.17
Monaco	1.650±0.035
1	2.24
4	5.4±1.3
5	6.5±1.0
6	11.5±1.5

Certified value: 1.92 Confidence limits: 1.53-2.50

Shrimp powder:

Laboratory	Value (mg kg^{-1}) and S.D.
6	0.255±0.044*
2	2.27±0.31
5	2.45±0.12
1	2.84
4	3.10±0.80

* This result is an outlier.

Discussion

It is difficult to comment in detail on the shrimp results. As mentioned there are no medians or confidence limits available yet. However, it is possible to do some statistical tests on the results from the WACAF Group, and the results are that with one exception they form a coherent group and are likely to be acceptable. More comparison will be available later when results come from the worldwide intercomparison.

An interesting exercise is to take the submitted results and determine their overall mean and standard deviation. This is a measure of how good the WACAF analysts are as a group.

If another group had a greater spread, they would be worse analysts as a whole but if their spread was less, they would be better analysts. There is available another interesting group within the Regional Seas Programme to compare WACAF with. The other group is MEDPOL, the Regional Seas group for the Mediterranean.

Last year a similar exercise was organised for them, and they also analysed the mussel sample. It is therefore possible to compare WACAF and MEDPOL analyses directly. However, it should be pointed out that the laboratories in the MEDPOL Group were chosen specially because they had some experience.

In the following table we give the means and standard deviations for all the analyses submitted by both groups and in brackets the standard deviation expressed as a percentage of the mean.

Sample : Mussel powder

Element	Cu	Zn	Cd	Hg	Pb
WACAF	7.9±1.7(22%)	212±98(46%)	2.06±0.69(34%)	1.23±0.40(32%)	5.4±3.9(73%)
MEDPOL	9.7±3.1(32%)	158±44(28%)	1.52±0.64(42%)	0.86±0.25(29%)	5.7±4.8(84%)

The important figures to examine are the ones in brackets. They are comparable between the two groups and show that in general the analytical performance of the two groups is equally scattered.

Another general conclusion, only obvious from a comparison with worldwide intercalibrations, is that there is a tendency for values to be higher that the certified ones. This is due to inadequate blank corrections, and inadequate checking for matrix effects.

In addition, though not obvious in the table, analysts in both groups need to check their analysis for zinc. The standard deviations for this element for their groups are significantly larger than for the worldwide intercalibration group.

How good are individual laboratories? How should one compare them with the median and confidence limits? How does an analyst know if this result is acceptable or not ?

We must return to an examination of how results are treated statistically. They are tested for the presence of outliers. If an outlier is found, it is not further considered. For the present results, only one value from one laboratory can be classified as "outliers". That is for an analysis on the lead in the shrimp sample. All the other results from both samples form a consistent distribution and none can be rejected. In statistical terms they are "accepted". That does not mean necessarily that the analyst should be satisfied. His results should be as near the median as possible. One useful test could be that his results should be within a standard deviations of the accepted results. Those analysts whose figures fall outside those limits can probably improve their analysis.

You will note in the figure that the confidence limits are much closer than the lines for the standard deviation. The greater the number of laboratories, the closer those lines become. Obviously it is very difficult to be close th those limits each time even for an experienced analyst.

How good are these results for an international monitoring network ? We would have to say that values are likely to be accurate only to ± 30% on average and some values may be much more inaccurate than that. Obviously a lot of work is necessary to improve the accuracy (which seems generally much worse than the precision in this case). However it should also be noted that imppovement will be rather slow. Since the apparently experienced MEDPOL laboratories did not do significantly better than the WACAF ones, it is clear that a lot of effort is needed, even beyond what they have already put in.

It should also be noted that the values obtained here are for samples with essentially background concentrations, and therefore the results of the intercalibration exercise are relatively pessimistic. A pollution accident will produce levels which are an order of magnitude higher, and those levels should be easier to measure. In such a case one would hope that values would be able to be compared to better than the ±30% mentioned above.

Conclusions

This exercise has proven relatively successful for a first-time one. Mostly WACAF analysts are capable of producing results for trace elements (for some of which the analysis is not easy) which are certainly of the correct order of magnitude.

In addition to that their performance compares well with that of a group which is supposed to have had much more experience.

However, it is clear that in both cases many of the results submitted do not fall within a standard deviation of the median where this is known. That means there is plenty of room for improvement. Such improvement is not simple and demands very careful attention to follow precisely the reference methods and to continue to monitor closely analytical performance by taking part in as many intercalibration exercises as possible.

Appendix

Participants (who were able to supply results)

Centre de Nutrition, Institut de recherches médicales et d'études des plantes médicinales, Yaoundé, Cameroon.

Institute of Aquatic Biology, P.O. Box 38, Achimota, Ghana.

Centre de recherches océanographiques, B.P. V 18, Abidjan, Ivory Coast.

Laboratoire Central de Nutrition Animale (Lacena), 06 B.P. 353, Abidjan 06, Ivory Coast.

Department of Chemistry, University of Ibadan, Ibadan, Nigeria.

Laboratoire de chimie analytique et toxicologie, Faculté de Médecine et Pharmacie, Université de Dakar, Dakar, Sénégal.

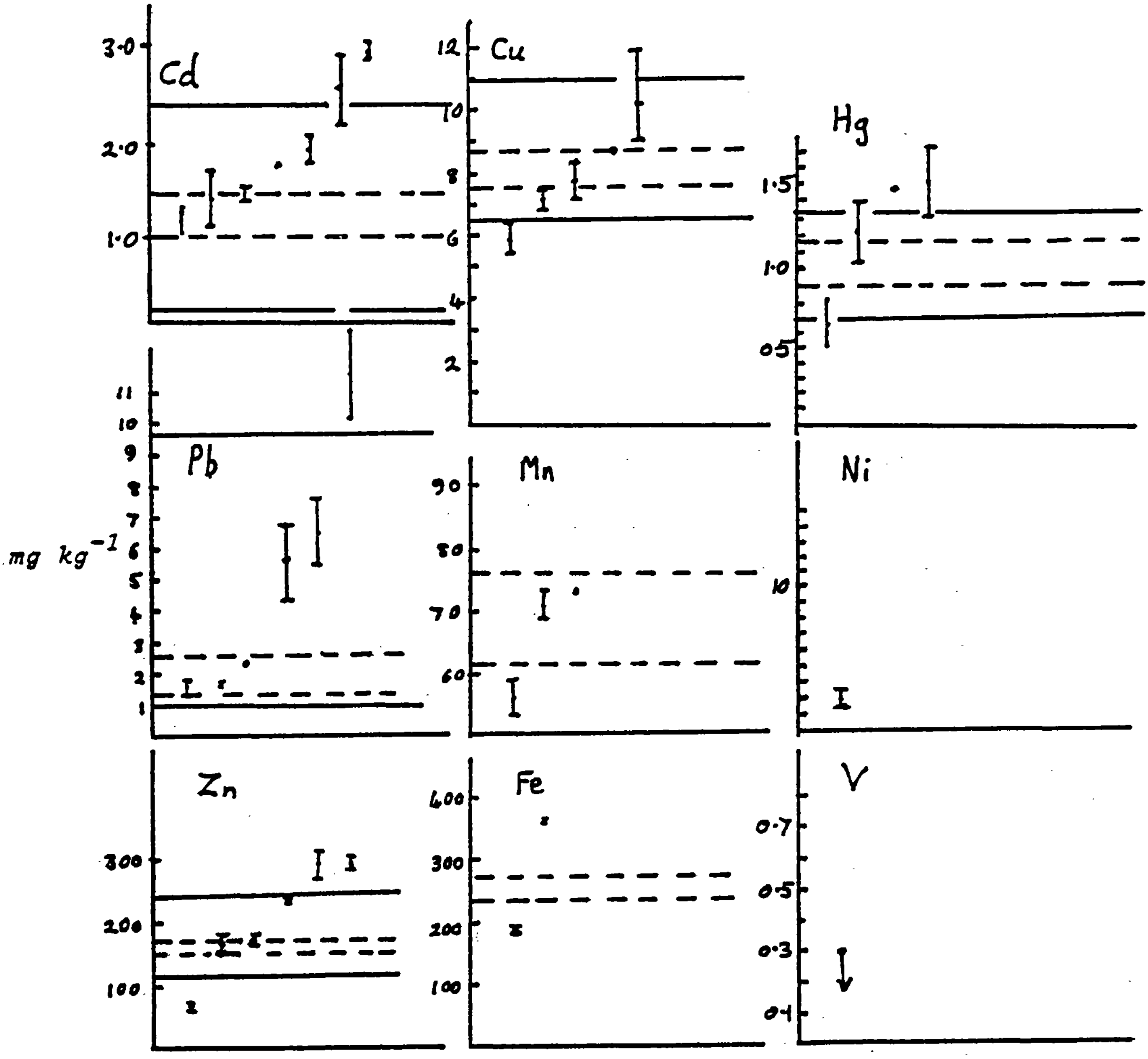


Figure 1. Comparison of reported results for trace elements in Mussel powder. Dotted lines are 95% confidence limits. Bold lines are one standard deviation each side of the mean.

ANNEX V

INDIVIDUAL SCIENTIFIC REPORTS OF PARTICIPATING RESEARCH CENTRES

by Responsible Leading Scientists

TRACE METAL ANALYSIS IN FISH
GHANA : INSTITUTE OF AQUATIC BIOLOGY, ACHIMOTA

by C.A. Biney

1. INTERCALIBRATION EXERCISE

The period between May and the end of July was used for this exercise. Trace metal analyses were conducted on lyophilised shrimp and mussel tissues supplied by IAEA, Monaco, the results of which have already been submitted.

2. TRACE METAL ANALYSIS OF FISH

This has been carried on since September 1985 on ten fish species namely :

- Apex predators
  - Sphyraena sphyraena
  - Epinephelus aenus
  - Thunnus obsesus

- Demersal stationary tinfish
  - Pseudolithus senegalensis
  - Mugil cephalus
  - Cynoglossus senegalensis
  - Cynoglossus monodi
  - Balistes capriseus
  - Balistes punctatus

- Pelagic filter feeder
  - Ethmalosa fimbriata
  - Pseudopeneus prayensis

3. METHODS

Analytical procedures were basically according to the recommended methodology 1.2.3. 1.00g of fish tissue was decomposed in a pressure container (Groteklaes teflon bomb) in the presence of 2.5 ml nitric acid at 120°C for 8 hours. Copper, lead, zinc and cadmium were determined by flame atomisation while mercury was determined by cold vapour atomic absorption spectrophotometry using a Varian 1275 AAS. This preliminary digestion was normally followed by a second digestion of the same fish tissue but involving the addition of aqueous standard solutions to the samples. The amounts added were based on the results of the preliminary digestion.

Some modifications from the recommended methodology were made during the course of analyses

(i) When using the flame atomisation technique lead was determined at 217.0 nm instead of the recommended 283.3 nm and zinc was measured at 213.9 nm instead of 307.6 nm.

(ii) With the cold vapour method the stannous chloride/hydroxylamine hydrochloride solution was prepared as follows :

Solution 1 - 6% sodium chloride + 6% hydroxylamine hydrochoride in distilled water.

Solution 2 - 10% stannous chloride in in H_2SO_4

1 ml each of solutions 1 and 2 were added to 1 ml of the digested fish sample in a boiling tube. Metallic mercury was volatilised by aeration using a small pump. A schematic drawing of the apparatus used is shown in Fig. 1.

4. RESULTS AND DISCUSSION

The results of trace metal analyses for the ten fish species are outlined in Tables 1 and 2. Some of the data have also been interpreted graphically in Figs 2-4.

Data obtained so far do not allow the reaching of definite conclusions because not enough fish species have been analysed from any given area. The general pattern which has emerged is that the apex predators in the food chain eg Sphyraena sphyraena and Thunnus obsesus show higher concentrations of especially Hg and Zn. The highest levels of mercury and zinc recorded so far occured in the dark muscle of Thunnus obsesus (Fig. 2). However wide variations occured with fishes from all levels of the food chain. For instance, three individuals of Pseudolithus senegalensis which is a demersal stationary species had Zn levels close to or higher than the apex predators (Table 1).

Variation also occurred with fishes of the same species. An exemple is given in Fig. 3 which shows the levels of Hg, Zn and Cu for two individuals each of Sphyraena sphyraena and Cynoglossus senegalensis. This could be due to sexual and age differences.

Not much can be deduced with respect to the evaluation of metal accumulation at this stage since an ample range of sizes of the same species from a given area have yet to be analysed. Data obtained for Balistes capriscus (Fig. 4) seem to indicate an accumulation of mercury but not zinc. Mercury accumulation in fish has already been demonstrated.

Lead and cadmium levels were not determined in several instances mainly because of the unreliability of the flame atomisation technique at such low concentrations. It is hoped that in the future we shall be able to obtain the necessary equipment to improve upon these determinations. We also hope that it will be possible subsequently to correlate our data with the actual use and sources of polluting containing substances in Ghana.

5. REFERENCES

(i) UNEP/FAO/IAEA/IOC. Sampling of selected marine organisms and sample preparation for trace metal analysis. Reference methods for marine pollution studies No. 7 Rev. 2, UNEP 1984 a;

(ii) UNEP/FAO/IAEA/IOC. Determination of total cadmium, zinc, lead and copper in selected marine organisms by flame atomic absorption spectrophotometry. Reference methods for marine pollution studies No. 11 Rev. 1, UNEP 1984 b;

(iii) Renzoni, A., Bacci, E and Falciai, (1973). Mercury concentration in the water sediments and fauna of an area of the Tyrrhenian coast. Rev. Intern. Oceanogr. Med. Tomes XXXI-XXXII, 17-45.

Table 1 : Trace metal analysis of fish

Species (sex)	Station	FL(cm)	Wt(g)	Hg	Zn	Cu	Pb	Cd
Sphyraena sphyraena(M)	5°22'0°30'W	43	384	240	2730			
" (M)	"	30	92	90	5680			
Pinephelus aenus	"	40	824	110	3240	300	260	
"	5°45'0°10'E	36	570	75	2890	220		
Hunnus obsesus(M)	"	40	1300	125	6800	480	200	160
"				280	15540	3720	300	300
Eudolithus senegalensis(M)	5°22'0°30'W	35	425	200	4320	600	650	
" (F)	5°45'0°10'E	25	134	20	4700	200		
" (F)	"	26	172	40	4780	400		
Ynoglossus monodi	"	31	170	25	1930	200		
"	"	32	150	45	1750	280		
Ynoglossus senegalensis	"	19	60	20	4380	390		
"	"	20	70	80	1600	280		
Lagil cephalus(M)	5°37'0°2'W	13	26	20	640	200		
" (F)	"	12	20	20	570	200		
Ethmalosa fimbriata(M)	"	10	15	20	810			
" (F)	"	10	15	20	775			

1 - light muscle

2 - dark muscle

Table 2 : Trace metal analysis of fish

Species (sex)	Station	FL(cm)	Ult(g)	Hg	Zn	Cu
Balistes capriscus	5°22'0°30'W	33	795	250	4000	
"	"	21	210	50	3640	
"	"	25	330	245	5455	650
Balistes punctatus	"	25	374	85	5580	350
"	"	20	195	105	11188	470
Pseudopeneus prayenis	5°45'0°10'E	19	105	57	3100	350
"	"	18	113	50	2680	470
"	"	17	93	60	4120	590
"	"	16	67	60	2780	650

FIGURE 1

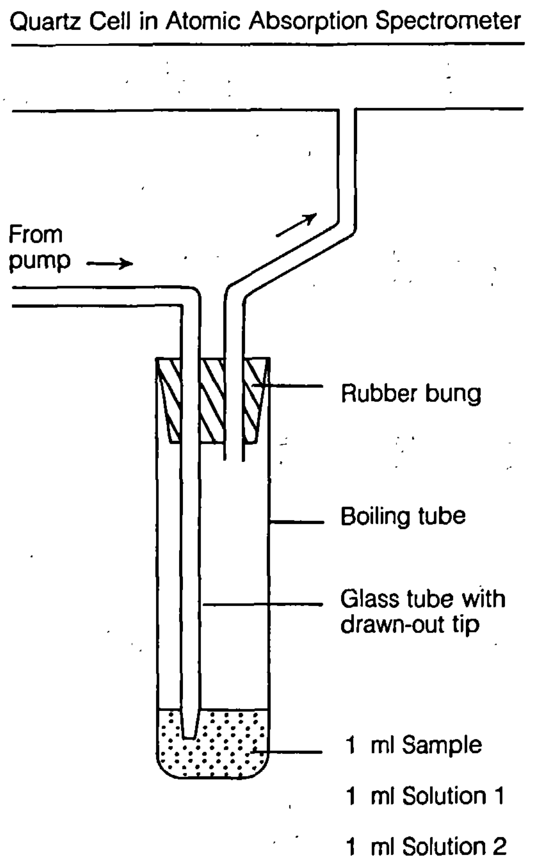


Fig. 1. Arrangement for mercury determination by the cold-vapour method.

FIGURE 2

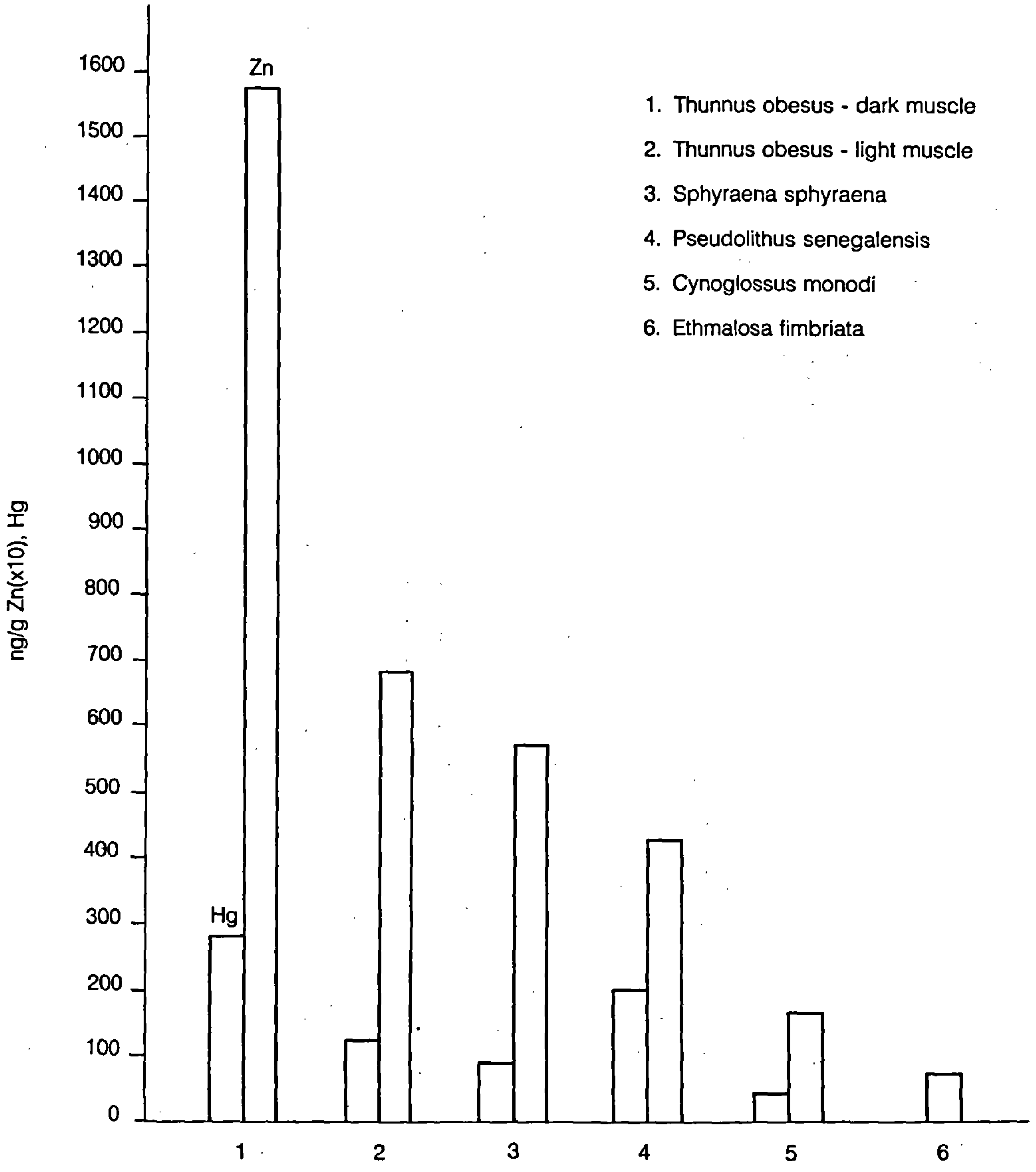


Fig. 2. Comparison of Mercury (Hg) and Zinc (Zn) contents from fish at different trophic levels.

FIGURE 3

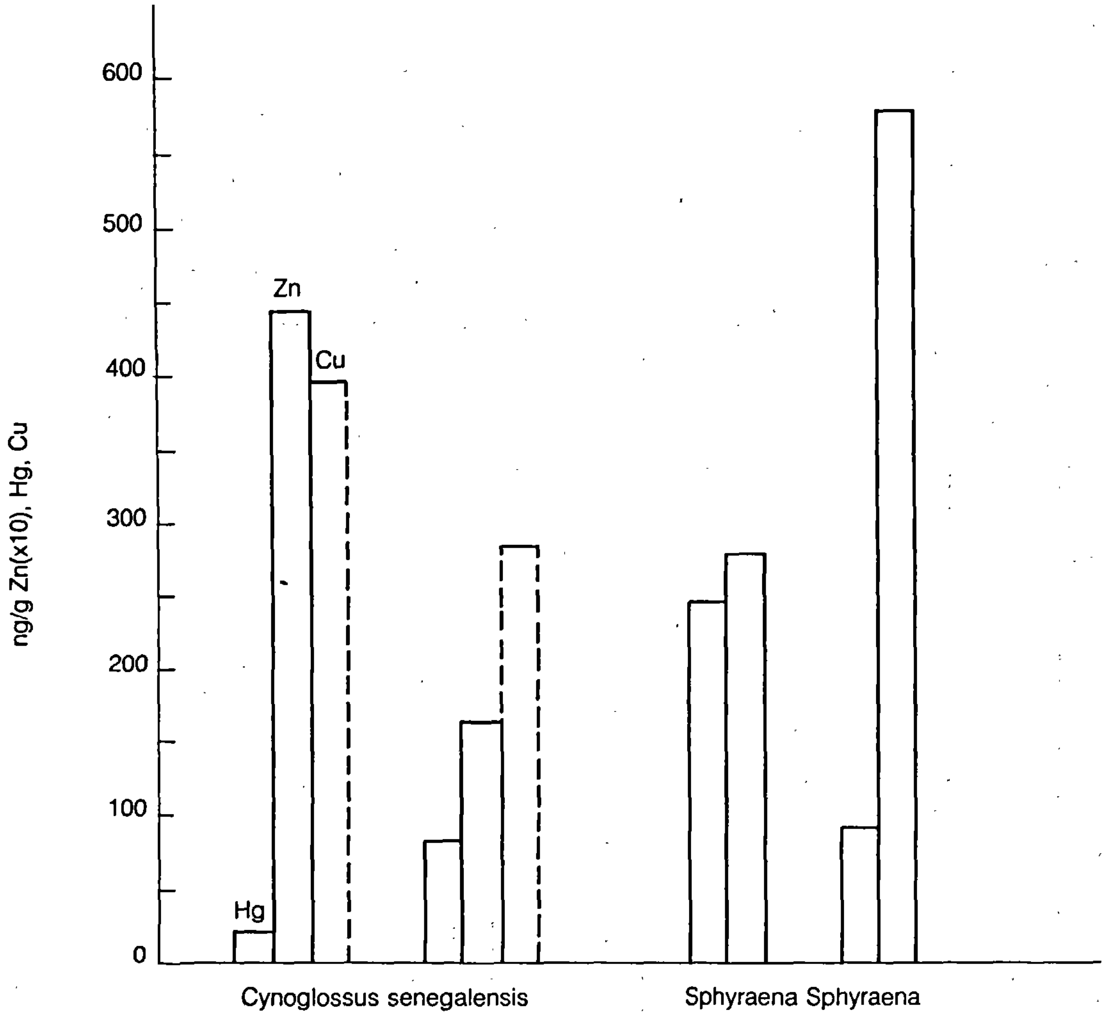


Fig. 3. Comparison of Mercury (Hg), Zinc (Zn) and Copper (Cu) levels in individuals of the same species.

FIGURE 4

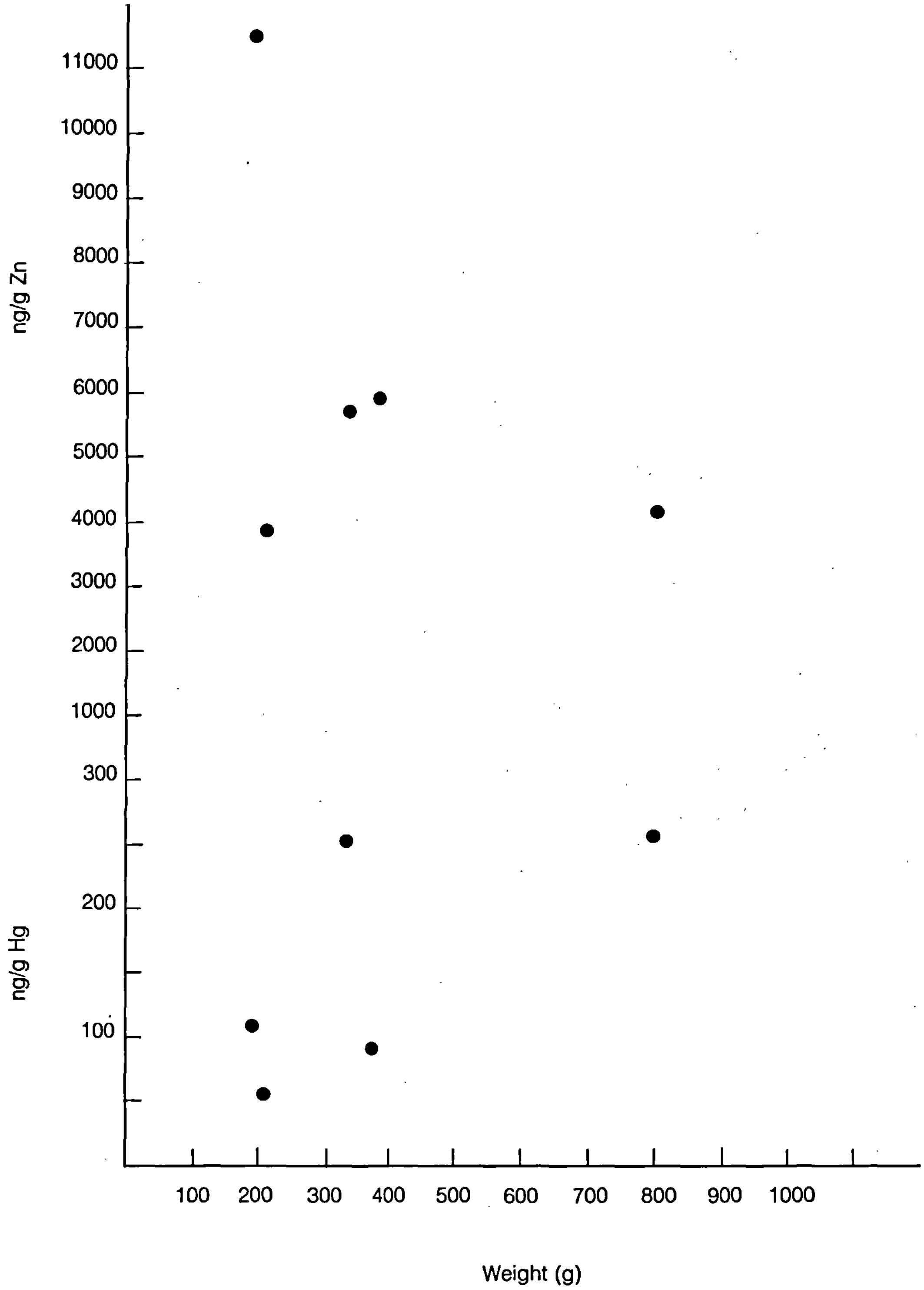
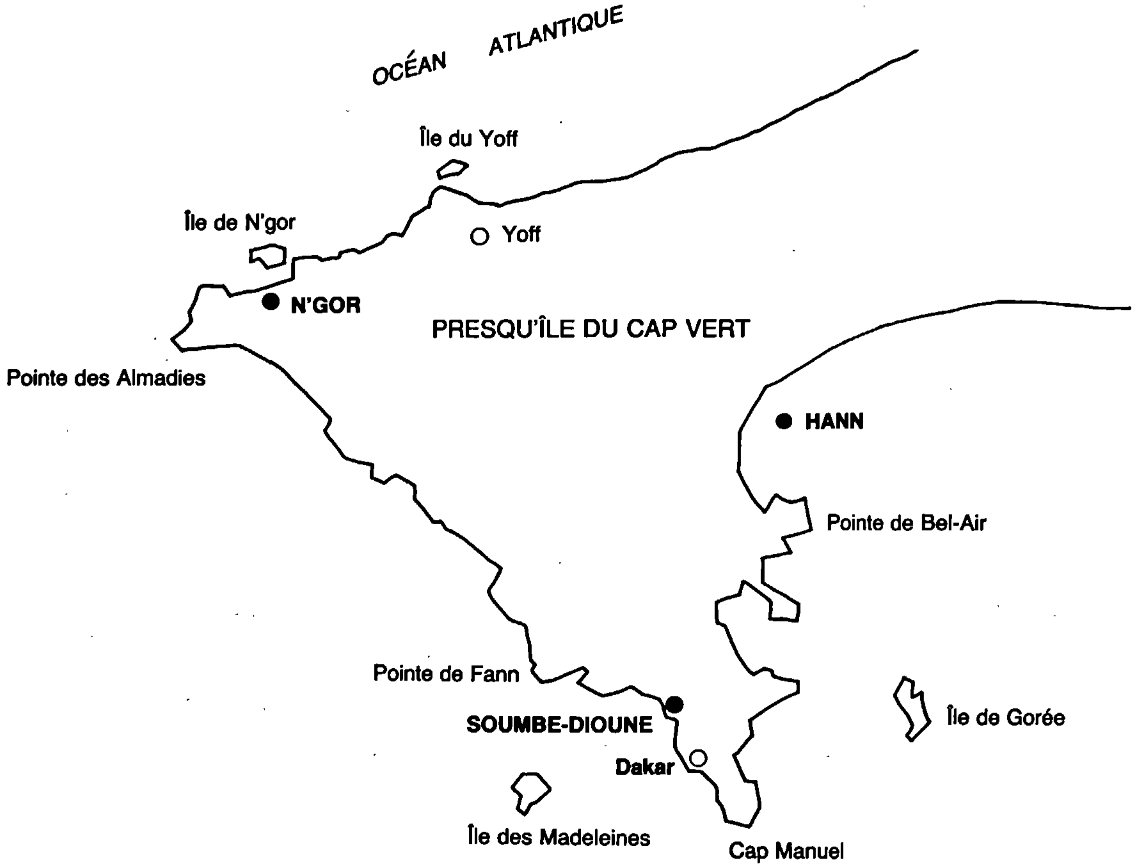


Fig. 4. Mercury (Hg) and Zinc (Zn) concentrations in relation to body weight of Balistes sp.

FIGURE 5



● Stations de prélèvements

PRELIMINARY SURVEY ON MERCURY AND CADMIUM LEVELS IN SOME MARINE FISHERY PRODUCTS

CAMEROON : INSTITUT DE RECHERCHES MEDICALES ET D'ETUDES DES PLANTES MEDICINALES, YAOUNDE
STATION DE RECHERCHES HALIEUTIQUES DE LIMBE
by I. Mbome Lape, T. Agbor Egbe, G.E. Martin, C. Njock, F. Ikome and C. Mbi

ABSTRACT

Mercury and Cadmium levels were determined in the tissue samples of about sixteen marine organisms from Cameroon. The results obtained indicate that marine pollution by these two heavy metals is not yet a problem in Cameroon.

INTRODUCTION

Heavy metals, particularly mercury and cadmium, have received much attention from researchers because of their high toxic, transport, bioaccumulutation and bioconcentration potentials (1). Their input to marine environment can originate both from natural and anthropogenic sources.

Concerning the Cameroonian coastal waters, Hg natural input should be low compared to other areas, such as the Mediterranean, where cinnabar deposits are located. Similarly, Cd inputs from natural sources should be low.

However, the growing industrialisation along the coast, especially in the cape Limbo and the Douala - Bonaberi areas may raise the input of Hg and Cd to the marine coastal environment. There, sedimentation of contaminated suspended matter, biological transformation (i.e. mercury methylation), bioaccumulation and bioconcentration phenomena can result in the pollution of local fishery products.

Within the framework of the FAO/UNEP WACAF 2 pilot project work was therefore initiated to evaluate the state of pollution in marine organisms along the coastal areas of Cameroon. However, for our preliminary studies fishery products were obtained from the coastal area indicated in Figure 1 (map).

1. MATERIALS AND METHOD

1.1 SPECIES

The species collected are listed in Table 1. Most of them are of commercial importance and inhabit the coastal waters of West and Central

Africa, from Senegal to Angola. Their feeding habits as well as their usual maximum lengths are indicated.

1.2 SAMPLE PRETREATMENT

Fish and crustacean muscles and molluscs soft parts were analysed, pretreatment was carried out as follows : after identification at the Limbé Fishery station, specimens were deep-frozen and transported to the Centre for Nutrition laboratory in Yaoundé. Tissue samples were prepared, freeze-dried, ground into fine powder and passed through a 150 um sieve. Aliquots of 0,25 g of lyophilised material were used for pressure decomposition with nitric acid according to Stoeppler and Backhaus (2) and homogenous subsamples were used to determine the residual water content.

1.3 ANALYSES

An atomic absorption spectrophotometer, Varian series 175 was used with hallow cathode lamps. Total mercury was determined by the cold vapour method and cadmium by air - acetylene flame.

The method of standard addition (3) was used to check interference due to the biological and acid matrices. Precision was tested on 6 homogenous replicates and results were around 10% and 15% (coefficient of variation) for Hg and Cd respectively, at the 1000 microgram per kilogram level.

The accuracy of the analytical methods was tested by participating in the IAEA intercalibration exercise.

2. RESULTS

The results for the preliminary survey on mercury and cadmium levels in fishery products from Cameroon are presented in table II.

Mercury levels found can be considered as typical natural background representatives (4). Mean mercury concentrations of 200 ug/kg wet weight have been reported for Pomadasis jubelini from Senegal by Gras et al. (5).

As for Cd, levels in fish muscles are generally lower than the detection limits of the analytical method used. Our results are in agreement with the low cadmium levels found in other surveys (4) (6). It is likely that Cd levels in fish muscles could be regulated (7) and do not reflect the water level. The Cd concentration found in the shrimp and oyster soft-part samples are almost similar to typical background levels which are generally higher than those in fish muscles.

3. CONCLUSION

For this preliminary survey the idea was to determine mercury and cadmium levels in as many species of marine organisms as possible. The organisms studied were collected during a six-day period in early march 1985.

The results obtained indicate that marine pollution by mercury and cadmium is not yet a problem in Cameroon. However, investigations should be extended to other coastal areas and larger sampling made throughout the year.

Since pollution in general is not limited to the marine environment only, it is necessary in the future, using other indicators in the hinterland, to evaluate the true background and "hotspot" levels of Hg and Cd, and other heavy metals in Cameroon.

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FIGURE 1 - Map of Cameroon indicating sampling area, S.

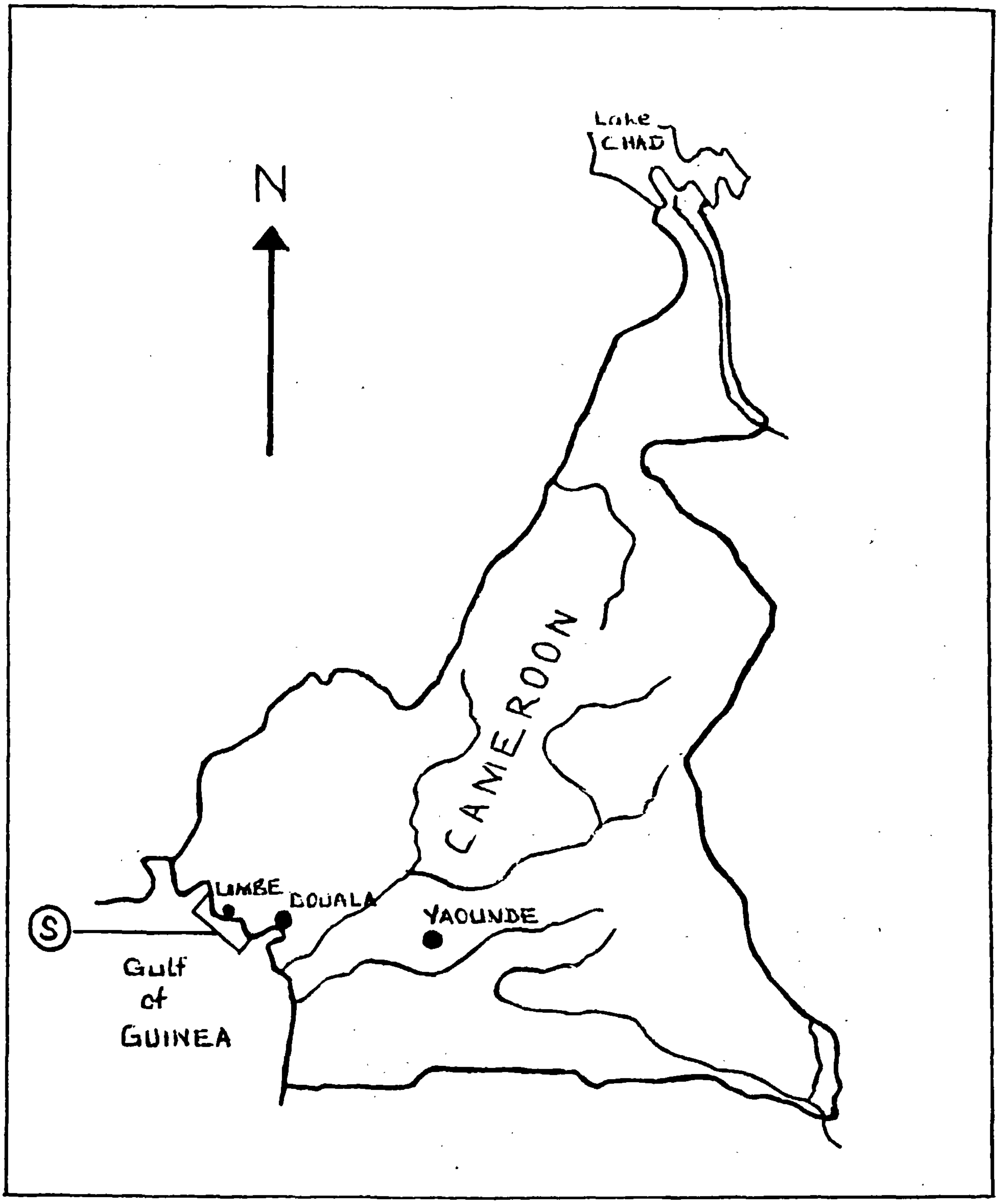

**TABLE I - Names of species, their sizes and eating habits.
The figures in brackets are the common sizes.**

COMMON NAME	Scientific Name	Max. Size (cm)	Eating Habits
West African Spanish Mackerel	Scomberomus tritor	98 (50)	Small fishes
Flat needle fish	Ablennes hians	95	Small fishes
Goreen snapper	Lutjanus goreensis	80 (60)	Fish & invertebrates
African moony	Psettias sebae	20 (15)	Small vertebrates
West African ilisha	Ilisha Africana	22 (18)	Small fishes and crustaceans
Bobo croaker	Pseudotolitus elongatus	45 (30)	Shrimes and crustaceans
Sompat grunt	Pamadasys jubelini	60 (45)	Crustaceans and molluscs
Bonga shad	Ethmalosa fimbriata	30 (25)	Phytoplankton
Madeiran sardinella	Saedinella maderensis	30 (25)	Phytoplankton
Sicklefin mullet	Liza falcipinnis	33 (25)	-
Fourwing flying fish	Hirundichthys affinis	25	-
-	Caranx spp	-	-
Pink Shrimp	Penaeus notialis	23 male 17 female	-
Estuarine prawn	Palaemon hastatus	7.5	-
Mangrove Oyster	Grifea gasar	-	-
Sea Oyster	-	-	-

TABLE II - Mercury and cadmium concentrations in marine organisms in ug/kg of tissue wet weight, letter I stands for individual sample and C for composite sample from about 8 to 20 individual organisms. The sign < indicates values below detection limits which are 20 and 100 ug/kg ww for Hg and Cd respectively, under our conditions.

Species	Number of samples analysed	Av. length	Hg conc. ug/kg w.W.		Cd conc. ug/kg w.w.	
Scientific name		(cm)	Av.	Range	Av.	Range
Scomberomus tritor	3I	32	42	23-58	<	
Ablennes hians	3I	57	51	31-65	<	
Lutjanus goreensis	1C	20	52	50-55	<	
Psettias Sebae	1C	14	118	96-140	190	170-210
Ilisha Africana	1C	16	46	40-52	<	
Pseudotalitus elongatus	3I	30	96	78-132	<	
Pomadasys jubelini	1C	21	320	280-360	345	295-395
Ethmalosa fimbriata	1C	18	<			
Sardinella maderensis	1C	15	50	45-55	<	
Liza falcipinnis	1C	21	<			
Hirondichthys affinis	3I	25	45	20-65	<	
Caranx Spp	1C	13	34	20-48	<	
Penaeus notialis	1C	9	57	52-63	<	
Palaemon hastatus	1C	-	52	50-55	205	190-225
Grifea gasar	1C	-	61	58-65	565	545-590
*Sea oyster	1C	-	72	70-75	205	180-230

RECHERCHE ET DOSAGE DES TRACES DE METAUX LOURDS DANS DES ORGANISMES MARINS AU SENEGAL

SENEGAL : LABORATOIRE DE CHIMIE ANALYTIQUE ET TOXICOLOGIE, DAKAR

par D. Ba*, M. Ciss, J.F. Cooper et B. Niane

INTRODUCTION

En collaboration étroite avec la FAO, les pays atlantiques de l'Afrique de l'Ouest et du Centre ont entrepris un large programme de surveillance continue de la pollution de leur environnement aquatique.

Au titre de notre participation au projet WACAF 2, nous avons assuré la recherche des traces de métaux lourds (Cadmium, Cuivre, Mercure, Plomb et Zinc) dans des échantillons de poissons, crustacés et coquillages, prélevés près des côtes sénégalaises.

Six espèces marines ont été retenues pour ce travail :

NOM LATIN	FRANCAIS	WOLOF(**)	FAMILLE
EPINEPHELUS AENEUS	Mérou blanc	COOF (Thiof)	SERRANIDAE
MUGIL Sp.	Mulet	GUISS	MUGILIDAE
PAGELLUS BELOTTII	Pageot(dorade rose)	YOUFOUF	SPARIDAE
SARDINELLA MADERENSIS	Grande allache	YABOY	CLUPEIDAE
PENAEUS NOTIALIS	Crevette Rodchée	SIPPAX	PENAEIDAE
ANADARA SENEGALENSIS	Arche du Sénégal	BOUTH	AREIDAE

Tableau 1 : Noms ,latins, français, Wolof et famille des espèces analysées.

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*Laboratoire de Chimie Analytique et Toxicologie - Faculté de Pharmacie - Dakar/Sénégal

**Langue vernaculaire du Sénégal

Après avoir participé à l'exercice d'intercalibration contrôlé par le Laboratoire International de la Radioactivité Marine LIRM) de l'Agence Internationale de l'Energie Atomique à Monaco, nous avons procédé à l'analyse de 56 échantillons entre le 14 mars et le 10 septembre 1985. Ce programme doit se poursuivre sur le rythme d'un contrôle mensuel de chacune des six espèces.

L'approvisionnement en poissons a été réalisé par les services du Centre de Recherche Océanographique de Dakar/Thiaroye (CRODT), directement à l'arrivée des pêcheurs de Yoff (10 km au nord de Dakar) et de Hann (quartier Sud-Est de la ville).

Nous avons pu distinguer trois zones de pêche :

(i) zone de Dakar/Yoff, au nord de Dakar, entre 14°47' et 14°52' nord et 17°16' et 17°34'W correspondant aux lieux de pêche N'Gor, Yoff, Cambarene et Malika.

(ii) zone de Dakar/Baie de Hann entre 14°37' et 14°43' et 17°20' et 17°32'W des îles de la Madeleine jusqu'à M'Bao.

(iii) zone de M'Bour et Joal-Fadiouth à une centaine de km au sud de Dakar : 14°09' - 14°24'N et 16°52' - 17°03'W.

De par sa situation, la baie de Hann (port et zone industrielle de Dakar) pouvait sembler la zone la plus exposée aux phénomènes de pollution.

La profondeur des captures a pu être évaluée dans la majeure partie des prélèvements et a pu atteindre 50 à 60 mètres notamment dans le cas des Thiofs.

1. METHODOLOGIE

Les méthodes d'échantillonnage et de traitement des échantillons avant analyse, proposées par la FAO(1) ont été scrupuleusement respectées tout au long de ce travail.

La détermination des concentrations a été toujours effectuée par la méthode des ajouts dosés.

Pour l'analyse du Cadmium, Cuivre et Zinc, nous avons appliqué les méthodes PNUE-FAO(2), utilisant la spectrophotométrie d'absorption atomique avec aspiration directe dans la flamme air-acétylène.

En ce qui concerne le Mercure et le Plomb, des aménagements ont été apportés, conformément aux méthodes proposées par les Etablissements Varian(3).

Dans le cas du Mercure, nous avons, par rapport à la technique préconisée(4), apporté des modifications au niveau du réactif 4.6* de la même revue et utilisé le générateur de vapeur "Model 65" fourni par la FAO.

Cet aménagement confère à la méthode la même sensibilité et la même fiabilité que la méthode de référence citée précédemment, tout en étant de pratique plus simple.

Dans le cas du Plomb, la méthode par entraînement de la vapeur de PbH_4 après réduction du Plomb dans le générateur de vapeur "Model 65", bien que plus longue que celle de la flamme directe, montre une sensibilité bien meilleure.

Le contrôle des résultats positifs a pu être réalisé par la mesure de l'absorption aspécifique aux longueurs d'onde 213,8 et 220,4 nm, nettement différentes de la longueur d'onde de travail initialement choisie (217 nm).

Cette absorption aspécifique n'a jamais excédé 0,006 unités d'absorbance tandis que les valeurs lues pour les échantillons positifs étaient égales ou supérieures à 0,020.

L'intégralité de la méthodologie particulière figure en annexe de ce rapport.

2. RESULTATS

Tous nos résultats ont été consignés dans les tableaux III à VIII. Les concentrations sont exprimées en milligrammes par kilogramme de poids frais (mg/kg).

La mention "ND" signifie que la teneur est inférieure à la limite de détection de la méthode. Cette limite de détection a pu être évaluée pour chaque élément (Tableau II).

ELEMENT	LIMITE DE DETECTION POUR UNE PRISE D'ESSAI DE 1g DE POISSON FRAIS
Cd	0,1 mg/kg
Cu	0,4 mg/kg
Hg	0,04 mg/kg
Pb	0,5 mg/kg
Zn	0,4 mg/kg

Tableau II : Evaluation des limites de détection de notre méthode.

Nous précisons cependant que l'erreur peut être très importante au voisinage de cette limite de détection.

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* réactif utilisé : HCl à 10%
$SnCl_2$, $2H_2O$ à 20% dans HCl très pur.

		Cd	Cu	Hg	Pb	Zn
Zone Dakar/Yoff						
Y_6	3/5/85	ND	ND	ND	0,5	6,5
Y_7	10/5/85	ND	0,5	ND	0,5	8,5
Y_{12}	6/6/85	ND	0,5	0,05	0,5	5,8
Zone Dakar/Baie de Hann						
S_4	4/3/85	ND	0,4	0,05	ND	6
H_2	12/4/85	ND	ND	0,05	0,5	6,3
H_6	22/4/85	ND	0,8	0,05	0,5	7,4
H_{11}	10/5/85	ND	ND	ND	0,7	8,7
H_{15}	30/5/85	ND	ND	0,05	1,3	6,5
H_{20}	17/6/85	ND	ND	ND	ND	6
H_{25}	10/7/85	ND	ND	0,04	0,5	6
H_{31}	8/8/85	ND	ND	ND	0,5	7,4
H_{36}	10/9/85	ND	ND	0,07	0,8	6,3

Tableau III : Concentration en métaux lourds (mg/kg) relevées dans les tissus de Sardinella Maderensis (Yaboye)

		Cd	Cu	Hg	Pb	Zn
Zone Dakar/Yoff						
Y_1	10/4/85	ND	ND	0,12	ND	3,4
Y_4	3/5/85	ND	ND	ND	1	4,2
Y_{10}	20/5/85	ND	ND	0,1	0,5	2,8
Y_{14}	6/6/85	ND	ND	ND	0,5	3,8
Zone Dakar/Baie de Hann						
H_5	22/4/85	ND	ND	ND	ND	3
H_{10}	10/5/85	ND	ND	ND	ND	3,5
Zone M'Bour/Joal						
H_{16}	30/5/85	ND	ND	0,08	ND	3,2
H_{19}	17/6/85	ND	ND	ND	ND	4,5
H_{26}	10/7/85	ND	ND	0,16	ND	2,5
H_{32}	8/8/85	ND	ND	ND	ND	1,8
H_{33}	10/9/85	ND	ND	0,04	ND	2,5

Tableau IV : Concentrations en métaux lourds (mg/kg) relevées dans les tissus de *Epinephelus aeneus* (Tiof)

Zone Dakar/Yoff		Cd	Cu	Hg	Pb	Zn
N_3	14/3/85	ND	ND	ND	ND	2,8
Y_2	10/4/85	ND	ND	0,1	ND	2,5
Y_3	3/5/85	ND	ND	ND	ND	2,7
Y_9	20/5/85	ND	ND	0,08	ND	2,5
Y_{11}	6/5/85	ND	ND	0,1	ND	3,2
Zone Dakar/Baie de Hann						
H_7	22/4/85	ND	ND	0,05	ND	2,8
H_9	10/5/85	ND	ND	ND	ND	2,5
H_{21}	17/6/85	ND	ND	ND	ND	3,2
H_{23}	10/7/85	ND	ND	0,12	ND	2,8
Zone M'Bour/Joal						
H_{30}	8/8/85	ND	ND	ND	ND	1,3
H_{35}	10/9/85	ND	ND	0,04	0,5	2,5

Tableau V : Concentrations en métaux lourds (mg/kg) relevées dans les filets de *Pagelus bellottii* (Dorade)

Zone Dakar/Yoff		Cd	Cu	Hg	Pb	Zn
Y_5	3/5/85	ND	ND	ND	ND	5,5
Zone Dakar/Baie de Hann						
H_1	12/4/85	ND	ND	ND	0,5	4,7
H_4	22/4/85	ND	ND	ND	ND	2,8
H_{12}	10/5/85	ND	ND	ND	0,5	3,5
H_{14}	30/5/85	ND	ND	0,04	ND	2,6
Y_{13}	06/6/85	ND	ND	ND	ND	3,4
H_{22}	17/6/85	ND	ND	ND	ND	3,6
H_{24}	10/7/85	ND	0,5	ND	ND	2,6
H_{29}	8/8/85	ND	0,7	ND	ND	3
H_{37}	10/9/85	ND	0,6	0,04	1,5	5

Tableau VI : Concentrations en métaux lourds (mg/kg) relevées dans les tissus de Mugil sp. (Guiss)

		Cd	Cu	Hg	Pb	Zn
Zone de Dakar/Baie de Hann						
H_3	12/4/85	0,1	2	ND	0,5	14
H_8	22/4/85	0,1	2	0,06	ND	10,5
Y_8	20/5/85	ND	3	0,05	ND	15
H_{13}	30/5/85	ND	2,3	ND	0,5	13
H_{17}	17/6/85	ND	3,1	0,04	ND	15
H_{18}	17/6/85	0,1	3,5	ND	ND	15
H_{27}	10/7/85	ND	1	0,05	ND	13
H_{28}	10/7/85	ND	1,5	0,11	0,5	14
H_{34}	10/9/85	ND	1	0,04	0,5	12

Tableau VII : Concentrations en métaux lourds (mg/kg) relevées dans les tissus abdominaux de Penaeus notialis (crevette)

Zone Dakar/Baie de Hann		Cd	Cu	Hg	Pb	Zn
S_5	4/3/85	1,8	0,5	0,05	ND	9
S_6	17/6/85	1,5	0,6	ND	0,4	14
S_7	17/6/85	0,9	0,7	0,04	ND	14

Tableau VIII : Concentrations en métaux lourds (mg/kg) relevées dans les tissus de *Anadara Senegalensis* (Arche du Sénégal)

Espèces	Nombre d'échantillons	Nombre de résultats positifs	Valeurs (mg/kg)		
			Min.	Moyenne(SD)	Max.
Poissons toutes espèces	44	0	0,1		
Penaeus notialis	9	3	0,1		
Anadara senegalensis	3	3	0,9		1,8

Tableau IX : Récapitulatif des teneurs en Cadmium dans les organismes marins au Sénégal.

La pollution locale par le Cadmium apparaît donc très limitée. Les teneurs retrouvées dans les invertébrés marins au Sénégal ont été comparées à d'autres données (tableau X).

Moules	2 mg/kg
Huîtres	3 mg/kg
Crabes	13 mg/kg
Homards	17 mg/kg
Coquilles St Jacques jusqu'à	120 mg/kg

Tableau X : Concentration en Cadmium des invertébrés marins (Source : Conseil National de Recherches au Canada, 1979)[5]

Espèces	Nombre d'échantillons	Nombre de résultats positifs	Valeurs (mg/kg)		
			Min.	Moyenne (SD)	Max.
Sardinella maderensis	12	4	0,4		0,8
Epinephelus aeneus	11	0	<0,4		
Pagellus belottii	11	0	<0,4		
Mugil sp.	10	3	0,5		0,7
Penaeus notialis	9	9	1	2,1 (0,9)	3,5
Anadara enegalensis	3	3	0,5		0,7

Tableau XI : Récapitulatif des teneurs en Cuivre dans les organismes marins au Sénégal.

A l'exception de quelques résultats positifs sporadiques dans les poissons, le cuivre n'a été retrouvé régulièrement que dans les crevettes (valeur moyenne 2,1 mg/kg) et à un niveau moindre (0,5 mg/kg) dans les arches du Sénégal.

Espèces	Nombre d'échantillons	Nombre de résultats positifs	Valeurs (mg/kg)		
			Min.	Moyenne	Max.
Sardinella maderensis	12	7	0,04	0,07	0,07
Epinephelus aeneus	11	4	0,08	0,11	0,16
Pagellus belottii	11	6	0,04	0,08	0,12
Mugil sp.	10	2	0,04		0,04
Penaeus notialis	9	6	0,04	0,06	0,11
Anadara senegalensis	3	2	0,04		0,05

Tableau XII : Récapitulatif des teneurs en Mercure dans les organismes marins du Sénégal.

Les teneurs positives rencontrées dans 48% des échantillons apparaissent faibles, sensiblement inférieures aux 0,36 et 0,21 mg/kg décelés précédemment au Sénégal (6) dans les thiofs et les dorades.

Elles ont été dans tous les cas nettement inférieures à la concentration maximale admissible dans les poissons (CMA) fixée dans la plupart des pays à 0,5 ppm (6).

Espèces	Nombre d'échantillons	Nombre de résultats positifs	Valeurs (mg/kg)		
			Min.	Moyenne	Max.
Sardinella maderensis	12	10	0,5	0,6 (0,1)	1,3
Epinephelus aeneus	11	3	0,5		1
Pagellus belittii	11	1	0,5		1,5
Mugil sp.	10	3	0,5		
Penaeus notialis	9	4	0,5		
Anadara senegalensis	3	1	0,4		

Tableau XIII : Récapitulatif des teneurs en Plomb dans les organismes marins au Sénégal.

Les valeurs positives retrouvées se sont situées le plus souvent au voisinage de la limite de détection.

Parmi les six espèces étudiées, seule Sardinella maderensis a fourni régulièrement des résultats positifs.

Espèces	Nombre d'échantillons	Nombre de résultats positifs	Valeurs (mg/kg)		
			Min.	Moyenne (SD)	Max.
Sardinella maderensis	12	12	6	6,8(1)	8,7
Epinephelus aeneus	11	11	1,8	3,2 (0,8)	4,5
Pagellus belottii	11	11	1,3	2,6 (0,5)	3,2
Mugil sp.	10	10	2,6	3,4(1)	5,5
Penaeus notialis	9	9	10,5	13,5(1,5)	15
Anadara senegalensis	3	3	9	12,3(2,8)	14

Tableau XIV : Récapitulatif des teneurs en Zinc dans les organismes marins au Sénégal.

Le zinc a donc été retrouvé dans la totalité des échantillons. Les concentrations, plus élevées pour Penaeus notialis et Anadara senegalensis apparaissent homogènes à l'intérieur de chacune des six espèces considérées.

CONCLUSION

L'aide efficace de la FAO nous a permis d'entreprendre l'étude de la pollution par les métaux des organismes issus de la pêche au Sénégal, en particulier dans les régions du Cap-Vert et de Thiès.

56 analyses de Cadmium, Cuivre, Mercure, Plomb et Zinc ont été effectuées sur six espèces différentes entre Mars et Septembre 1985.

Le nombre de données ainsi collectées reste cependant insuffisant, notamment pour espérer établir d'éventuelles corrélations entre les teneurs en métaux et certains paramètres comme l'âge, la taille, le poids, le sexe des poissons, la date et le lieu de prélévement.

A ce stade du programme, notre travail, que nous pouvons qualifier de simple sondage, nous permet cependant de dégager quelques observations :

- aucune différence significative n'a pu être mise en évidence entre les trois zones de pêche. L'hypothèse d'une pollution localement plus importante dans la Baie de Hann ne semble pas devoir être retenue dans le cas des métaux.

- la comparaison des résultats relevés dans les quatre espèces de poissons étudiés ne fait pas apparaître de différences significatives entre Epinephelus æneus, Pagellus belottii et Mugil sp. Par contre, Sardinella maderensis a montré des teneurs de cuivre, plomb et zinc légèrement supérieures.

- les invertébrés marins retenus pour cette étude (Penaeus notialis et Anadara senegalensis) renferment des teneurs en cadmium, cuivre et zinc sensiblement plus élevées, en relation probable avec leur localisation dans les vases.

- l'examen des teneurs en mercure ne fait pas apparaître de différences importantes entre les six espèces étudiées. Ces valeurs sont dans tous les cas comparables à celles relevées dans des milieux marins considérés comme peu pollués.

Les résultats obtenus à ce jour ne permettent pas de conclure à l'atteinte de la cote d'alerte en ce qui concerne les métaux recherchés.

Cependant, ce travail ne pourra trouver sa pleine justification que dans un suivi à long terme.

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FICHE TECHNIQUE

DESCRIPTION DES TECHNIQUES ANALYTIQUES UTILISEES POUR LE DOSAGE DE 5 METAUX LOURDS (Cd, Cu, Hg, Pb, Zn) DANS DES ECHANTILLONS DE POISSONS

Par D. Ba, J.F. Cooper, M. Ciss et B. Niane

Après minéralisation nitrique, les échantillons sont analysés par spectrophotométrie d'absorption atomique, soit par aspiration directe dans la flamme, soit à l'aide d'un générateur de vapeur (vapeur froide pour le mercure, formation d'hydrure volatil dans le cas du plomb).

Les résultats sont déduits de la courbe obtenue par la méthode des ajouts dosés.

MATERIEL UTILISE

- Support en acier inoxydable BaCr V/9 avec 18 creusets en téflon adaptables ;
- Spectrophotomètre d'absorption atomique Varian "AA 1275", équipé de lampes à cathode creuse pour le dosage du Cu, Pb, Zn, Cd et Hg ;
- Générateur de vapeur Varian "Model 65" ;
- Balance de précision type Metler ;
- Etuve thermostatée type Memmert 01.

REACTIFS

- HNO_3 "suprapur" (65%)
- Eau bidistillée
- Solutions standards :
  - solutions "mères" dosées pour chaque élément à 1 g/litre, préparée à partir de solutions "Titrisol" et d'eau bidistillée ;
  - solutions "filles" dont les concentrations apparaissent au Tableau 1.

	A	B	C	D
Cd	0,2	0,4	0,8	2
Cu	0,5	1	2	5
Hg	0,2	0,4	0,8	2
Pb	1	2	4	10
Zn	2	4	8	20

Tableau 1 : Concentration des solutions A, B, C, D (en microgrammes/millilitre)

- Solution d'acide chlorhydrique (HCl pour analyse 37%) à 1% dans l'eau bidistillée.
- Solution de dichromate de potassium ($K_2Cr_2O_7$ pa) à 3% dans l'eau bidistillée.
- Solution d'acide tartrique ($C_4H_6O_6$ pa) à 7,5% dans l'eau bidistillée.
- Solution de borohydrure de sodium ($NaBH_4$ pa) à 2,5% dans une solution de soude (NaOH pure à 0,1%)
- Solution d'acide chlorhydrique (HCl pa) à 10% dans l'eau bidistillée.
- Solution de chlorure stanneux ($SnCl_2$ pa) à 20% dans l'acide chlorhydrique concentré.

MODE OPERATOIRE

1) Détermination du pourcentage d'humidité

Placer une prise d'essai voisine de 1 g, exactement pesée dans une étuve à 110° jusqu'à poids constant (pendant une nuit).

2) Préparation des échantillons

Pour chacun des deux échantillons (p.X, p.Y), répartir 4 prises d'essai de 1 g exactement pesées dans les creusets en téflon adaptables sur le support BaCr V/9.

Procéder à des ajouts selon le tableau suivant :

Creuset No	Poisson	Eau distillée	Solution A	Solution B	Solution C
1	-	2 ml	-	-	-
2	1g p.X	2 ml	-	-	-
3	1g p.X	1 ml	1 ml	-	-
4	1g p.X	1 ml	-	1 ml	-
5	1g p.X	1 ml	-	-	1 ml
6	1g p.Y	2 ml	-	-	-
7	1g p.Y	1 ml	1 ml	-	-
8	1g p.Y	1 ml	-	1 ml	-
9	1g p.Y	1 ml	-	-	1 ml

Tableau II : Préparation de l'analyse de deux poissons.

3) Minéralisation

Introduire dans chaque creuset 2,5 ml HNO_3 "suprapur".
Fixer ces creusets dans les emplacements numérotés sur le support BaCr V/9.
Effectuer une prédigestion à l'étuve à 80-90° pendant 1 heure.
Amener la température à 135-140° et maintenir l'ensemble à cette température pendant 5 heures.
Laisser refroidir à la température ambiante.

4) Détermination analytique

Effectuer les mesures à l'aide du spectrophotomètre d'absorption atomique dans les conditions suivantes :

- Cadmium : dosage par aspiration directe dans la flamme air-acétylène : 228,8 nm   slit : 0,5 nm   lamp current : 4 mA
- Cuivre : dosage par aspiration directe dans la flamme air-acétylène : 324,8 nm   slit : 0,5 nm   lamp current : 4 mA
- Mercure : dosage par absorption atomique sans flamme.

Principe : le mercure ionique est réduit en mercure métallique volatil qui est entraîné dans une cellule de mesure par un courant d'azote.

Mode opératoire :dans le réacteur du "model 65" introduire :

18 ml HCl 10%
2 ml de minéralisat
Refermer. Agiter pour homogénéiser. Injecter à travers le septum 1 ml de chlorure stanneux à 20%. Agiter pendant 90 secondes. Introduire l'azote sous un débit de 4l/mn. Effectuer la mesure de l'absorbance par l'option "peak height" ou "peak area" programmée pour une lecture de 15 secondes.
253,7 nm slit : 0,5 nm lamp current : 4 mA

- Plomb : dosage par génération d'un hydrure de Pb (PbH_4 ou plumbane), entraînable par un courant d'azote.

Mode opératoire : dans le réacteur du "Model 65" introduire :

8 ml HCl 1%
2 ml de minéralisat
6 ml d'acide tartrique à 7,5%
3 ml $K_2Cr_2O_7$ à 3%.
Refermer. Faire arriver un courant d'azote de 2 litres par minute. Injecter à travers le septum 5 ml de solution de $NaBH_4$ à 2,5%. Faire les mesures de l'absorbance par la méthode "peak height" ou "peak area".
= 217 nm slit : 1 nm lamp current : 5 mA

- Zinc : dosage par aspiration directe dans la flamme air-acétylène
= 213,9 nm slit : 1 nm lamp current : 5 mA

Tous les résultats sont évalués par la méthode des ajouts dosés. Les limites de détection de cette méthode ont été évaluées :

Element	Limite de détection pour une prise d'essai de 1 g de poisson frais
Cd	100 ug/kg
Cu	400 ug/kg
Hg	40-50 ug/kg
Pb	500 ug/kg
Zn	400 ug/kg

Tableau III : Evaluation des limites de détection de notre méthode.

TENEURS EN METAUX LOURDS DANS LES PRODUITS DE PECHE EN COTE D'IVOIRE

par Bernard Soro Metongo

RESUME

Les concentrations de cadmium, cobalt, cuivre, fer, mercure, manganèse, nickel et de zinc ont été déterminées dans les muscles de poissons (Ethmalosa fimbriata, Chrysichthys filamentosus, Elops lacerta, Tilapia guineensis, Pseudotolithus senegalensis, Pagellus bellottii, Dentex angolensis et canariensis, Sardinella aurita et eba, Sparus pagrus africanus, Thunnus albacares) et dans les parties molles de mollusques (Arca senilis) collectés dans les lagunes et dans les zones côtières de Cote d'Ivoire de juillet à octobre 1985.

Ces résultats préliminaires ne montrent pas de différence entre les différents milieux d'origine. Le cobalt, le cuivre, le nickel et le manganèse ont des teneurs inférieures à la limite de détection de même que le cadmium sauf pour les Arca senilis. Le mercure et le zinc présentent des valeurs considérées comme normales. Le fer a des valeurs plus élevées dans les Arca senilis que dans les poissons.

INTRODUCTION

C'est dans le cadre du projet WACAF 2 relatif à la surveillance de la pollution marine dans les zones côtières de l'Afrique de l'Ouest et du Centre que nous avons entrepris des mesures de métaux lourds. En particulier le mercure et la cadmium qui par leur toxicité ont retenu l'attention de plusieurs chercheurs dans les autres parties du monde. Le choix des espèces fut dicté par leur niveau de consommation dans le pays. Les espèces étudiées ont été les suivantes :

1. POISSONS

1.1 PREDATEURS

- Thunnus albacares (thon albacore)

1.2 PETITS PREDATEURS ET PELAGIQUES

- Pseudotolithus senegalensis (Otolithe senegalais); station 1,2 et 3
- Pagellus bellottii (Pagest à tâche rouge) ; station 1
- Dentex angolensis (Denté angolais) ; station 2
- Dentex canariensis (Denté à tâche rouge) ; station 1

- Sparus pagrus africanus (Pagre des Tropiques) ; station 3

1.3 PELAGIQUES

- Sardinella aurita (Allache) ; station 1, 2 et 3
- Sardinella eba (Grande allache) ; station 1 et 2
- Ethmalosa fimbriata (Ethmalose d'Afrique) ; station 4
- Gerres nigri (Friture rayée) ; station 4
- Elops lacerta (Guinée du Sénégal) ; station 4

1.4 BENTHIQUES

- Chrysichthys nigrodigitatus (Mâchoiron) ; station 4
- Chrysichthys filamentosus (Mâchoiron) ; station 4

1.5 SEMI-BENTHIQUES

- Tilapia guineensis (Carpe) ; station 4

1.6 MOLLUSQUES

- Arca senilis (mactre) ; station 5

Les échantillons ont été pêchés au cours de la période de juillet à octobre 1985 dans les stations indiquées sur la Figure 1. Ces divers sites d'échantillonnage ont été choisis pour leur degré de pollution potentielle. Celui-ci est fonction de l'éloignement à la source de pollution maximale située dans la zone urbaine et portuaire d'Abidjian. Les diverses valeurs seront interprétées comparativement aux résultats obtenus pour un milieu de référence non ou peu pollué (lagune Aby).

2. MATERIEL ET METHODES

Les espèces ont été capturées par des piroguiers et des chalutiers. Après identification et détermination de la taille, du poids et du sexe les échantillons ont été conservés par congélation au laboratoire. Des filets de poissons et de parties molles de mollusques ont été prélevés pour l'analyse selon les techniques de préparation préconisées par le programme des Nations-Unies pour l'Environnement et l'Organisation des Nations-Unies pour l'Alimentation et l'Agriculture (1).

La décomposition de la matière organique a été réalisée par l'acide nitrique dans le système sous pression mis au point par Stoeppler et Backhaus (5). La détermination des éléments : C_d, C_o, C_u, F_e, M_n,

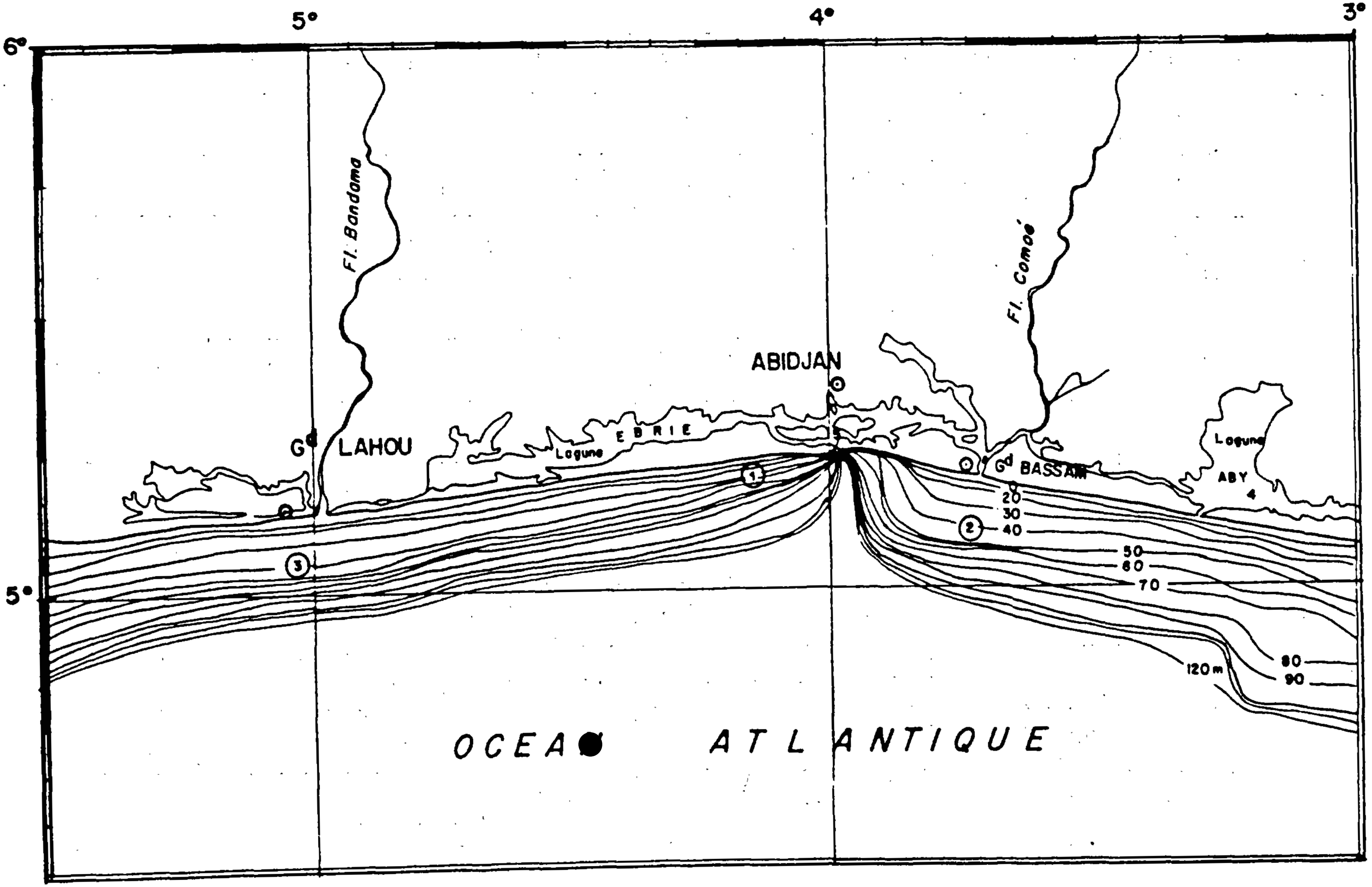

Figure 1 - Stations de pêche

TABLEAU I : - TENEURS EN METAUX LOURDS (PPM EN POIDS FRAIS) DANS LES MUSCLES DE POISSONS CAPTURES DANS LA ZONE D'ABIDJAN

	LENGTH (mm)	WEIGHT (G)	SEX	Cd	Co	Cu	Fe	Hg	Mn	Ni	Zn
PSEUDOTOLITHUS SENEGALENSIS	396	547.9	F	< 0.25	< 2.0	< 0.80	4.6	0.09	< 1.0	< 2.0	4.6
"	382	522.6	M	< 0.25	< 2.0	< 0.80	4.7	0.07	< 1.0	< 2.0	4.6
"	310	252.0	M	< 0.25	< 2.0	< 0.80	6.2	0.06	< 1.0	< 2.0	4.6
DENTEX CANARIENSIS	236	353.5	M	< 0.25	< 2.0	< 0.80	5.5	0.08	< 1.0	< 2.0	5.0
"	227	260.9	M	< 0.25	< 2.0	< 0.80	5.5	0.05	< 1.0	< 2.0	4.5
"	214	264.4	M	< 0.25	< 2.0	< 0.80	5.9	0.07	< 1.0	< 2.0	4.4
PAGELLUS BELLOTTII	196	149.1	F	< 0.25	< 2.0	< 0.80	4.5	0.07	< 1.0	< 2.0	10.8
"	186	125.2	ND	< 0.25	< 2.0	< 0.80	6.3	0.16	< 1.0	< 2.0	7.0
"	175	106.2	M	< 0.25	< 2.0	< 0.80	4.0	0.08	< 1.0	< 2.0	3.1
SARDINELLA AURITA	216	147.3	M	< 0.25	< 2.0	● 1.15	7.9	0.04	< 1.0	< 2.0	6.1
"	210	141.8	M	< 0.25	< 2.0	● 0.85	7.8	0.04	< 1.0	< 2.0	8.2
SARDINELLA EBA	148	47.2	ND	< 0.25	< 2.0	< 0.80	6.3	0.04	< 1.0	< 2.0	8.2

ND : NON DETERMINE

TABLEAU II : - TENEURS EN METAUX LOURDS (PPM EN POIDS FRAIS) DANS LES MUSCLES DE POISSONS CAPTURES DANS LA ZONE DE GRAND-BASSAM

	LENGTH (mm)	WEIGHT (G)	SEX	Cd	Co	Cu	Fe	Hg	Mn	Ni	Zn
PSEUDOTOLITHUS SENEGALENSIS	242	243.3	M	<0.25	<2.0	<0.80	2.1	0.07	<1.0	<2.0	4.4
"	230	196.3	F	<0.25	<2.0	<0.80	5.2	0.06	<1.0	<2.0	8.0
"	220	206.6	M	<0.25	<2.0	<0.80	5.2	0.06	<1.0	<2.0	3.2
DENTEX ANGOLENSIS	176	215.0	M	<0.25	<2.0	<0.80	3.2	0.05	<1.0	<2.0	4.6
"	175	175.7	M	<0.25	<2.0	<0.80	5.2	0.08	<1.0	<2.0	4.4
"	156	124.6	M	<0.25	<2.0	<0.80	6.1	0.08	<1.0	<2.0	4.1
SARDINELLA AURITA	192	128.6	F	<0.25	<2.0	•1.65	17.4	0.03	<1.0	<2.0	6.1
"	186	123.7	F	<0.25	<2.0	•1.20	17.4	0.03	<1.0	<2.0	4.8
"	175	91.3	F	<0.25	<2.0	•2.30	19.0	0.03	<1.0	<2.0	5.0
SARDINELLA EBA	180	115.3	F	<0.25	<2.0	•1.30	11.7	0.04	<1.0	<2.0	5.4
"	160	80.9	M	<0.25	<2.0	•1.31	12.0	0.05	<1.0	<2.0	4.8
"	154	77.2	M	<0.25	<2.0	•1.46	11.7	0.05	<1.0	<2.0	4.5

TABLEAU III : - TENEURS EN METAUX LOURDS (PPM EN POIDS FRAIS) DANS LES MUSCLES DE POISSONS CAPTURES DANS LA ZONE DE GRAND-LAHOU

	LENGTH (mm)	WEIGHT (G)	SEX	Cd	Co	Cu	Fe	Hg	Mn	Ni	Zn
PSEUDOTOLITHUS SENEGALENSIS	510	ND	F	< 0.25	< 2.0	< 0.80	2.0	0.18	< 1.0	< 2.0	5.1
"	460	1008.1	F	< 0.25	< 2.0	< 0.80	2.4	0.18	< 1.0	< 2.0	3.9
"	448	787.1	M	< 0.25	< 2.0	< 0.80	2.0	0.12	< 1.0	< 2.0	5.1
SPARUS PAGRUS AFRICANUS	370	725.2	ND	< 0.25	< 2.0	< 0.80	6.0	0.22	< 1.0	< 2.0	6.4
"	305	606.7	M	< 0.25	< 2.0	< 0.80	5.3	0.16	< 1.0	< 2.0	4.1
"	275	410.9	M	< 0.25	< 2.0	< 0.80	5.3	0.08	< 1.0	< 2.0	5.6
SARDINELLA AURITA	198	116.4	M	< 0.25	< 2.0	< 0.80	4.6	0.03	< 1.0	< 2.0	3.9
"	195	180.3	F	< 0.25	< 2.0	< 0.80	4.6	0.03	< 1.0	< 2.0	4.0
"	185	94.9	M	< 0.25	< 2.0	< 0.80	2.1	0.01	< 1.0	< 2.0	4.0

ND : NON DETERMINE

TABLEAU IV : - TENEURS EN METAUX LOURDS (PPM EN POIDS FRAIS) DANS LES MUSCLES DE POISSONS CAPTURES DANS LA LAGUNE ABY (ADIAKE)

	LENGTH (mm)	WEIGHT (G)	SEX	Cd	Co	Cu	Fe	Hg	Mn	Ni	Zn
CHRYSICHTHYS NIGRODIGITATUS	185	88.8	F	<0.25	< 2.0	<0.80	6.6	0.07	<1.0	<2.0	5.8
CHRYSICHTHYS FILAMENTOSUS	130	38.1	F	<0.25	< 2.0	< 0.80	5.2	0.05	<1.0	< 2.0	5.8
ELOPS LACERTA	175	46.5	ND	< 0.25	< 2.0	< 0.80	4.8	0.04	< 1.0	< 2.0	6.5
ETHMALOSA FIMBRIATA	158	69.0	M	< 0.25	< 2.0	< 0.80	5.9	0.05	< 1.0	< 2.0	5.1
GERRES NIGRI	100	22.5	M	< 0.25	< 2.0	< 0.80	6.6	0.05	< 1.0	< 2.0	5.8
TILAPIA GUINEENSIS	115	33.2	F	< 0.25	< 2.0	< 0.80	6.5	0.04	< 1.0	< 2.0	5.7
TILAPIA GUINEENSIS	111	30.2	ND	< 0.25	< 2.0	< 0.80	5.7	0.04	< 1.0	< 2.0	6.2
ETHMALOSA FIMBRIATA	165	92	M	< 0.25	< 2.0	< 0.80	6.0	0.07	< 1.0	< 2.0	3.0
ELOPS LACERTA	179	52.8	M	< 0.25	< 2.0	< 0.80	4.8	0.05	< 1.0	< 2.0	3.0

ND : NON DETERMINE

TABLEAU V : - TENEURS EN METAUX LOURDS (PPM EN POIDS FRAIS) DANS LES ARCA SINILIS CAPTURES EN LAGUNE EBRIE ET DE THONS ALBACORES DE MER

	LENGTH (mm)	WEIGHT (G)	SEX	Cd	Co	Cu	Fe	Hg	Mn	Ni	Zn
ARCA SENILIS	75	150.6	ND	● 0.41	< 2.0	< 0.80	123.7	0.04	● 1.61	< 2.0	5.6
"	70	124.9	ND	● 0.37	< 2.0	< 0.80	141.5	0.06	< 1.0	< 2.0	6.2
" ,,	67	122.5	ND	● 0.37	< 2.0	< 0.80	98.7	0.05	< 1.0	< 2.0	4.2
ARCA SENILIS	65	110.6	ND	● 0.46	< 2.0	< 0.80	164.7	0.05	< 1.0	< 2.0	8.3
THUNNUS ALBACARES	372	44900	M	< 0.25	< 2.0	< 0.80	9.7	0.49	< 1.0	< 2.0	5.3
THUNNUS ALBACARES	328	30900	M	< 0.25	< 2.0	< 0.80	10.1	0.71	< 1.0	< 2.0	5.4

ND : NON DETERMINE

N_i et Z_n a été réalisée par Spectrophotométrie d'absorption atomique à la flamme air-acétylène (Varian Série 1275). Le mercure a été atomisé par la technique de la vapeur froide selon les méthodes d'études pour la pollution marine du Programme des Nations-Unies pour l'Environnement (7; 8). La sensibilité de l'appareil a été calculée avec la méthode d'addition selon Julshamn et Braekkan (2).

3. RESULTATS ET DISCUSSION

Les résultats d'analyse sont donnés dans les tableaux ci-dessous. Les concentrations sont en ppm exprimées en fonction du poids frais d'échantillon.

Le mercure dans tous les échantillons étudiés et pour toutes les stations présente des valeurs comprises entre 0.22 et 0.01 ppm (0.09 ppm de moyenne) excepté pour le thon (0.60 ppm de moyenne). Ces valeurs sont considérées comme normales (4).

Le cadmium dans toutes les stations présente des valeurs inférieures à la limite de détection (0.25 ppm) pour les poissons. Dans les échantillons d'Arca senilis on a déterminé des concentrations significatives voisines de 0.4 ppm.

Le cobalt, le cuivre, le manganèse et le nickel présentent des teneurs inférieures à la limite de détection dans presque tous les échantillons examinés. Le zinc montre des concentrations équivalentes voisines de 5 ppm pour les poissons et les Arca senilis.

Le fer quant à lui montre des valeurs comprises entre 5 et 15 ppm dans les muscles de poissons et de 100 à 150 ppm pour Arca senilis.

De ces résultats préliminaires il ressort qu'il n'existe pas de différence significative selon les lieux d'origine des échantillons notamment entre la zone urbaine d'Abidjian et la lagune Aby. (Cf. Tableau VI). En lagune Aby le fer, le mercure et le zinc présentent des valeurs homogènes dont les coefficients de variation sont respectivement de 13%, 20% et 25% tandis que en zone urbaine d'Abidjian ils sont respectivement de 21%, 49% et 37%. Ceci dénote une dispersion accentuée des valeurs en particulier pour le mercure.

	ZONE D'ABIDJIAN		LAGUNE ABY	
		n		n
Fe	$3.33<5.76<8.19$	12	$4.33<5.78<7.23$	9
Hg	$0.01<0.07<0.13$	12	$0.03<0.05<0.07$	9
Z	$1.50<5.92<10.34$	12	$2.59<5.21<7.83$	9

TABLEAU VI : LIMITES DE CONFIANCE DES ECHANTILLONS EN ZONE URBAINE D'ABIDJIAN ET EN LAGUNE ABY. n = NOMBRE D'ECHANTILLONS.

Dans une étude précédante relative aux teneurs de métaux lourds dans les sédiments de la lagune Ebrié, Marchand et al (1983) avait montré que bien que les concentrations soient généralement faibles elles traduisent une légère augmentation de l'indice de pollution dans la zone urbaine d'Abidjian. Il est donc souhaitable dans les prochaines investigations de confirmer ces données au niveau des poissons mais surtout des mollusques benthiques colonisant les milieux sédimentaires des lagunes de Côte d'Ivoire.

CONCLUSION

Ces résultats d'analyse préliminaires ne permettent pas de formuler des conclusions définitives. Il est souhaitable dans les années à venir d'étendre le domaine de la recherche des pollutions par les métaux lourds dans le milieu marin aux crustacés et surtout aux mollusques. En effet ces derniers sont de bons bioindicateurs de niveau de pollution par les métaux autres que le mercure. Il est aussi nécessaire de connaître le niveau actuel de la pollution dans les lagunes de Côte d'Ivoire soumises aux fortes pressions industrielle, urbaine et portuaire et d'en contrôler sa tendance.

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THE MONITORING OF MARINE POLLUTION IN SIERRA LEONE

By D.F. Faulkner and Stephen J. Jusu

Sierra Leone's participation in WACAF Project 2 finally got off the ground in May 1985 after various setbacks ; water supply and energy being the two most responsible. Several reports have appeared about marine pollution in the Sierra Leone inshore waterways but none has dealt comprehensively with the levels of organochlorines and heavy metals in commercial fish and shellfish species. Fourteen species,(Table I), are to be studied under the current programme.

Only organochlorines have been analyzed at the moment because of technical problems and installation of the monochromator accessory for the Atomic Absorption Spectrophotometer. The Research Assistant has been working on "Levels of Pollutants in Fishes and Shell Fishes of Sierre Leone Inshore waterways". The study will try to correlate the levels of the various pollutants pecticides or PCB's with possible hot spots or sinks in the marine environment of Sierra Leone. The results obtained so far on organochlorines are shown in Table II. In almost all the species analyzed, unit sampling was done. No definitive deduction can therefore be made until more detailed studies with sampling of more than five per species is done.

The exact locus of each sample collected for the survey was not possible as the trawlers used lacked appropriate equipment. It is envisaged that future sampling will be in boats that have better facilities to give the geometric locus of each catch from which samples are drawn. The project faces a few teething problems, of which were indicated earlier. Basic to the research is the question of energy. This is beyond the research team. Everything is being done to remedy the situation. However it appears that a generator to run the equipment is absolutely necessary to enable results to be submitted against targets set.

Current thinking in Environmental Studies demands a more comprehensive look at various indicators of pollution levels. In this regard a survey of foliage and the atmosphere in various areas in the country is being considered by the author. Mind boggling questions that require investigation if not yet looked at are :

(i) possibility of shells being accumulators or better markers of the level of pollution. Shrimps are eaten with the shells on by some cultures. If there is accumulation what are the consequences ?

(ii) Does a correlation exist between lipid content and shell content of pollutants as heavy metals or pesticides.

These studies will complement those of the marine environment and give a better picture of the level of pollution in the Sierra Leone environment.

Last but not least the project team in Sierra Leone wishes to comment on the visit of Dr. Carlo Gaggi of the University of Siena who delivered a talk on "Current Trends in Pollution Studies". The visit, we hope, will apprise the coordinators and benefactors of the project of some of the dreams, realities and frustrations of those of us in the third world who become attached zealously and academically to studies that will hopefully lead to an improvement of the quality of life in our environment.

TABLE 1

Sphypreana sphyreana/atra	- barracuda
Epinephelus aeneus	- white grouper
Thunnus albacares	- yellow fin tuna
T. obesus	- bigeye tuna
Pseudotolithus senegalensis	- lady/cassava croaker
Mugil cephalus	- flat head grey mullet
Cynoglossus senegalensis/goreensis	- senegalese tongue sole
C. monodi	- guinean tongue sole
Pomadays peroteti/jubelini	- crocus
Ilisha africana	- lati
Callineetes ammicola	- big fisted crab
Penaeus duorarum notialis	- pink shrimp
P. kerathurus	- tiger shrimp

TABLE 2

Species	Date	Locus	Tissue	Ns.	Length cm.	Av. wt kg.	EOM	Mg 1 kg PCBS	LIN	DDE	DDT	DDD	BHC.	HER	HOX
Pseudotolithus senegalensis	20/5	S. L. estuary	Muscle	1	20.55	0.01	5.9	74.2	-	0.22	0.41	0.74	-	-	-
Pomadays peroteti			"	1	35.6	0.01	6.2	159.4	-	0.76	-	3.42	-	-	-
Ilisha africana			"	1	42.5	0.01	7.2	104.9	-	0.71	0.72	3.72	-	-	-
Thunnus albacares	10/7		"	1	35.5	0.985	8	70.2	2.4	3.2	4.6	5.4	4.3	-	8.2
T. obesus			"	1	43.4	1.245	9.6	58.23	12.6	14.25	10.38	3.42	5.01	2.01	6.84
Epinephelus aeneus			"		40.25	1.628	10	48.45	10.46	9.84	15.24	10.40	4.45	3.78	1.84
Penaesus duovarum notialis			Abdomen	4	11.5	0.035	8.7	89.82	20.14	18.58	32.91	25.35	15.53	9.8	3.27
P. kerathurus			"	1	24.5	0.546	9.10	80.21	25.67	30.18	23.18	18.19	17.08	13.19	7.92
Cynoglossus senegalensis/gorensis			soft part	1	14.05	0.035	8.56	92.47	30.74	27.18	25.72	14.85	4.07	22.52	3.08
C. monodi			"	1	17.5	0.04	8.09	95.01	36.1	21.05	23.06	17.15	3.5	13.4	2.58
Callinestes amnicola			"	1	10.5	0.684	9.82	73.4	47.2	29.3	27.2	13.8	10.5	15.9	7.01

GI : Parameters for

(i) PCBs
Column OV101
Column Temp. 200°
Detector Temp. 260°
Injector Temp. 210°
Sensitivity 8
Chart speed 0.25 cm/min
Syringe Vol. 2 UL

(ii) DDT
Column Temp. 210°
Detector Temp. 260°
Injector Temp. 200°
Sensitivity 8
Chart speed 0.25 cm/min
Vol. syringe 2 UL

MONITORING ORGANOCHLORINES IN FISH
BY THE GAMBIA FISHERIES DEPARTMENT, BANJUL

ABSTRACT

On the presentation of a scientific report on the assessment of marine pollution levels in the Gambia, it has been infeasible for my Institution to do so due to problems encountered.

However, producing a report at this first workshop has been inevitable so that this one has been managed. It discusses the implementation of the project and associated problems, and deals with the general use of pesticides in the Gambia.

INTRODUCTION

The Gambia lying within 13°45'N, 13°07'N and 16°15'W, 13°45'W has a land area of 10,403 km^2 and a population estimate of 700,000 inhabitants. Its shelf area extending to about 200 meters is 3,855 km^2 and the length of the coastline approximately 70 km.

Its important river divides the country into two parts along its length to form a north bank and a south bank, with agricultural land covering a large percentage of each of these banks.

The river serves many purposes : transportation, irrigation to name a few apart from its valuable source of fishery products for consumption by its inhabitants and export earnings of the country.

As participant in this project, the Gambia has been unable to present scientific data or report on the level of pollution in the environment, since pollution studies have not been going on until recently.

As far as the implementation of the WACAF2 Project in the Gambia is concerned, we have been unsuccessful up to now due to numerous problems encountered.

The studies involved in this Project are of great importance since the pollutants in our environment can be numerous but are not yet definitively identified.

Acute problems have occured which have been difficult to overcome. These problems range from the apparatus to be used in the analytical work to the national problems of electricity and water shortage. The apparatus available has been insufficient and water and electricity supplies have been very irregular and unstable when they were available.

In preparation for the Workshop Dr. C. Gaggi, FAO Consultant paid a visit to our Institution which lasted for five days. Although the visit has been most useful to us, in terms of discussions on methodology, instrumentation, problems solving and transport and fate of pollutants, it was not possible for us to produce any figures, due to the already mentioned problems.

RESULTS AND DISCUSSION

Pesticide usage in Gambia has been general and large quantities may have through the years been applied, according to sources from two agencies (Gambia Produce Marketing Board and the Crop Protection Services), who play a major role in the importation and use of pesticides in the country.

A wide variety has been tried, and reportedly effective ones have been in common use for many years and many are still used. New ones have been introduced as well.

The fate of these pesticides has not been studied and their transportation not understood. However, the following pesticides have been identified to be in use in the country :

1. INSECTICIDES

1.1 CHLORINATED HYDROCARBONS (ORGANOCHLORINES)

Aldrin 40% WP
*BHC (HCH) 3% D ; 25% D
DDT - Technical 15% EC ; 25% EC ; 50% WP
Didigam 55% EC ; 85% EC
*Didigam 20% EC ; 45% WP
*Endosulfan (Thimul) 35% EC ; Thiodan
Endrin 20% EC ; 50% EC
Heptachlor
*Lindane 0.5% D (Gammalin) ; 1% D ; 3% D

1.2 ORGANOPHOSPHATES

*Actellic (Pirimiphos methyl) 1% D ; 2% D
*Agrothion (Fenitrothion) 50% EC
*Basudin (Diazinon) 60% EC
Bromophos
Chlorpyrifos (Dursban)
* Diazinon 10% G ; 14% G ; 50% EC

Dichlorvos (DDVP)
Dicrotophos (Bidrin) 25% EC
*Dimethoate (Rogor) 40% EC ;(Perfekthion)
Dipterex (Trichlorfon) 5% D
Fenitrothion (Sumithion) 50% EC ;(Nuvanol)500% ULV ;(Iodofenfos)
Gardona (tetrachlorvinphos) 5% D
*Malathion 2% D ; 50% EC
Monocrotophos (Azodrin) 4% D ; (Nuvacron)
Morfotox oil (Ekatin)
Phorate (Thimet) 10% G
Phoxim (Baythion)
Supracide 40

1.3 CARBAMATES

Baygon (Propoxur)
*Carbaryl (Sevin) 85% WP ; (Ravyon) 50% WP
*Carbofuran (Furadan) 10% G ; 3% G ; 75% WP
Mesurol (methiocarb) 75

1.4 SYNTHETIC PYRETHROIDS

*Permethrine (Ambush) 0.5% D
*Cypermethrin (Ripcord) 50% EC

1.5 CITRUS OIL - MINERAL OILS

Biotrol (Bacillus thuringiensis) - Microbial Insecticide

2. FUNGICIDES

Bla. S
Bordeaux mixture (lime & Copper sulfate)
Benlate (Benomyl) 50% WP
Captan (orthocide) 50% WP
Kocide (copper hydroxide) 71% WP
Copper oxychloride 50% WP
Dithane D14 (Nabam) ; M22 (Maneb);M45 (Mancozeb); Z78 (Zineb)
Sulphur
*Thiram/Aldrin (Aldrex T)
*Thiram/Lindane (Fernasan D)
Hinosan
*Perenox

3. RODENTICIDES
*Ratilan (Coumachlor)
Warfarin (d - con)
Zinc phosphide
Rodine

4. FUMIGANTS
(Soil fumigants, Nematicides and Stored Product Fumigants)

Methyl bromide (Dowfume)
Chloropicrin
Nemagon
*Phostoxin (Aluminium phosphide) Tablets

5. HERBICIDES

Ronstar (oxadiazon) 2% D
*Roundup (Glyphosate)

6. AVICIDES
(Bird repellants etc)

Alpha chloralose
*Carbofuran (furadan) 3% G ; 10% G ; 75% WP

Note :

*Pesticides presently in use in the Gambia
WP : Wettable powder ; D : Dust ; EC : Emulpifiable concentrate ;
ULV : Ultra Low Volume ; G : Granule

From the statistics of the pesticides applied in various agricultural practices, it is evident that they may easily find their way into the environment, widely distributed and thus form part of the numerous pollutants found in not only the marine environment but the total environment.

The country being agricultural with a wide variety of crops affected by various pests, both during growth and at storage, the means for controlling them inevitably involves the use of pesticides in uncontrolled quantities. These, and particularly organochlorines, can be easily washed into the river and eventually find themselves in the marine environment to be incorporated into the marine ecosystem. Another very important route of transport of these pesticides is through the troposphere, and eventually these pesticides may reach the marine environment. Some of these compounds may have a low water solubility but are highly lipophilic and thus high concentration could be found in marine biota.

As there exists no regulations to the use of pesticides in the Gambia studies on levels of contamination of the environment are very essential so that advice could be given to legislative authorities and action taken to introduce measures against use.

Also due to lack of regulations the quantities that are used annually in the country are not documented. Similar problems are expected for the PCBs, whose presence in our environment are unknown to what levels they may exist. Another important aspect of the study is that the transportation fate and distribution in the environment of these pecticides evoke concern.

With the expectation of a regular supply in water and electricity and the provision of metal ferrules etc, in the near future analytical work could begin since the instrument has been optimised, for use.

ECHANTILLONNAGE DU GOUDRON DE PLACE
STATION DE MONDOUKOU ET GRAND BASSAM KM 26

par Philibert Koffi KOFFI

INTRODUCTION

Le suivi de la pollution des plages par les résidus de goudron est réalisé depuis novembre 1984 aux stations de Mondoukou (5°11'N - 3°41'W) et Grand Bassam km 26 (5°13'N et 3°50'W) (Fig. 1). Cette étude qui constitue un des volets du programme "WACAF 2" a pour objet de déterminer les concentrations de goudron qui se déposent sur l'Estran. Les mesures sont réalisées à la faveur d'un programme de dynamique sédimentaire littorale en cours au Centre de Recherches Océanographiques.

1. GENERALITES ET PARAMETRES DYNAMIQUES

1.1 SECTEUR D'ETUDE

Le littoral ivoirien est formé de trois types de côtes : les côtes mixtes rocheuses (Série métamorphique) et sableuses à l'Ouest (Tabou - Sassandra), les côtes à plateaux avec un cordon littoral sableux quaternaire (Sassandra - Fresno) et les côtes basses à l'Est formées exclusivement de sables quaternaires (Grand-Lahou - frontière du Ghana). Le secteur d'étude de Mondoukou et Grand-Bassam Km 26 est une côte basse et sableuse.

La plage à Grand-Bassam Km 26 a une pente assez forte qui varie entre 5 et 10% pour les différents profils lévés. Cependant le haut-estran et la mi-estran sont soulignés par une berme avec une pente très faible. Le sable de plage est moyen à grossier ($500 < 0 < 315$ um).

La plage à Mondoukou est en pente relativement douce (4 à 6%). Le sable de plage est fin (315 um $< 0 < 163$ um).

1.2 PARAMETRES DYNAMIQUES

La région du Golfe de Guinée se situe dans la zone des calmes équatoriaux et ne connaît pas de dépressions importantes. Les facteurs océaniques sont modérés.

- Le vent :

Le vent est modéré à faible et la déflation éolienne sur la plage est quasi nulle. Les vents enregistrés(**) pendant l'échantillonnage sont faibles (2 à 4 m/s) et proviennent du secteur Sud à Sud-Sud-Ouest (180 à 240°) (cf. tableaux résultats).

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* Centre de Recherches Océanographiques; B.P. V 18 Abidjan (Côte d'Ivoire)

** Enregistrement à 10 m du sol - ANAM Port-Bouët

- La marée :

La marée du type semi-diurne provoque un marnage faible 0.50 à 1.50 m sur le littoral. La plage découvre à Mondoukou et Grand Bassam km 26 au maximum sur une cinquantaine de mètres.

- La houle :

La houle provient des secteurs SS et SSW et à une amplitude moyenne (hauteur comprise entre 1 et 2 m). Elle attaque la côte avec un angle d'incidence de l'ordre de 11° à 42° et entraîne une dérive littorale Ouest-Est. La période la plus agitée est juin-juillet-août.

Les hauteurs de vagues observées pendant les périodes d'échantillonnage sont comprises entre 1 et 2 mètres. L'état exceptionnel du 23 août 1985 correspond à une houle de tempête (hauteur estimée entre 3 et 4 mètres).

- La courantologie :

Il existe sur le plateau continental deux courants :

- un courant superficiel orienté vers l'Est, le courant de Guinée (Plutohark, 1966) dont l'épaisseur est variable (20 à 50 m) et le maximum de vitesse varie de 30 à 110 cm/s.
- un sous-courant orienté vers l'Ouest dont la vitesse varie de 30 à 70 cm sur une épaisseur de 50 mètres.

L'influence de ces courants est primordiale pour la répartition des sédiments sur le plateau continental (Martin, 1971).

2. RESULTATS

2.1 METHODOLOGIE

2.1.1 Implantation des stations

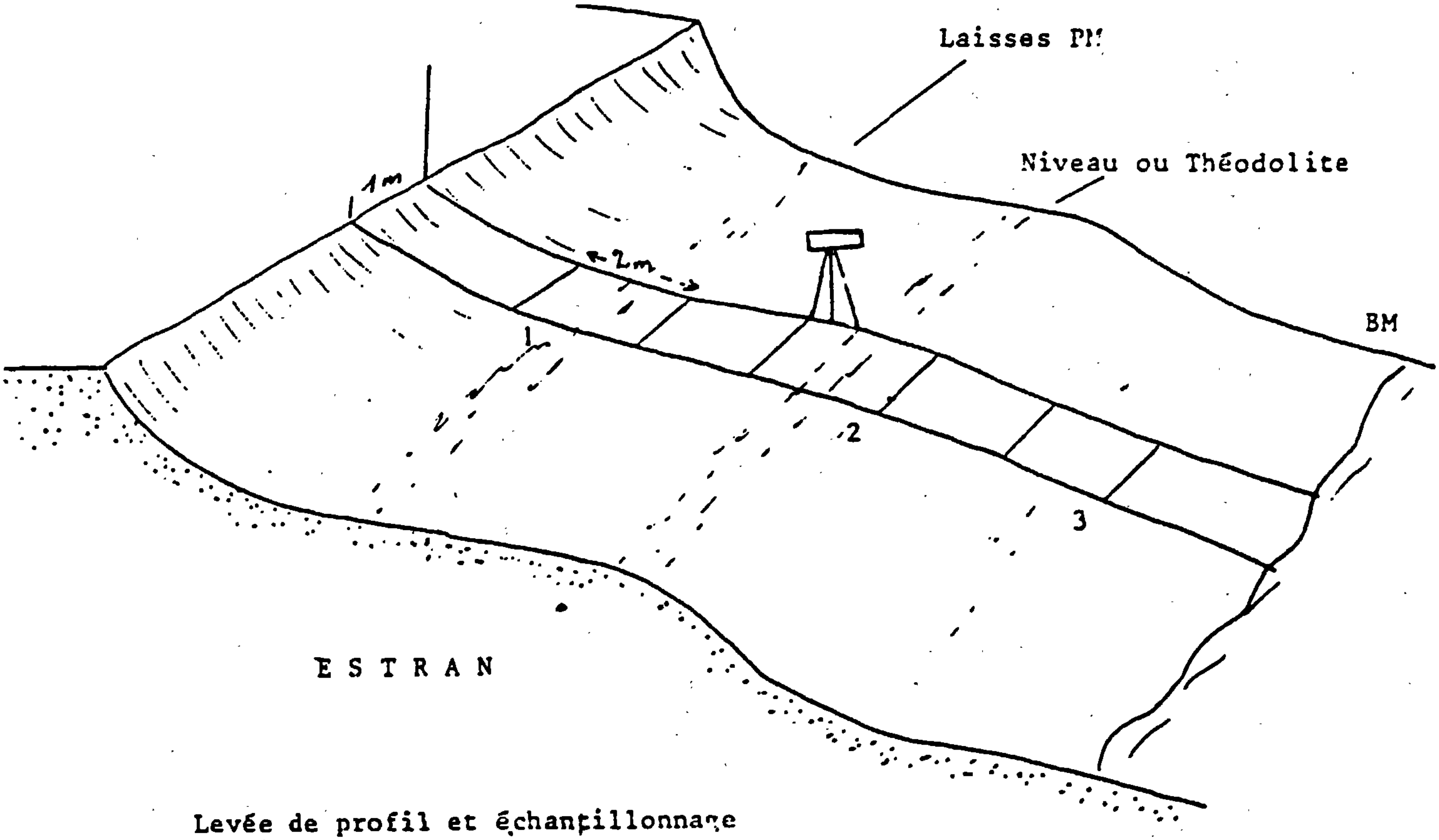
Pour le secteur d'étude, les stations de Mondougou et de Bassam km 26 répondaient le mieux au critère défini dans le protocole du projet COI-IAEA 1985 à savoir une plage à pente douce et relativement isolée de certaines activités humaines (industries et autres sources de pollution).

2.1.2 Echantillonnage

L'échantillonnage des boulettes de goudron est effectué dans le profil de l'estran sur un mètre linéaire de plage.

- Les points de prélèvements sont positionnés dans le profil du niveau (ou théodolite) ou au cordage pour les expériences du 7 novembre 1984 et 14 décembre 1984.

- Les prélèvements s'effectuent sur une surface de 2 m2 et généralement au niveau des laisses de pleine mer (PM) et consistent à ramasser avec une raclette le goudron visible dans le profil. Les échantillons sont recueillis dans des bocaux.



Levée de profil et échantillonnage

1, 2, 3 points de prélèvement du goudron

2.1.3 Traitement au laboratoire

Les échantillons séchés à l'airsont triés par tamisage sommaire (tamis 0 mm), puis à la main afin de séparer le goudron des sédiments (sable) et autres débris.

Le goudron est pesé et on détermine le poids de chaque échantillon ainsi que la moyenne et le cumul par profil.

2.2 RESULTATS (cf. tableaux des résultats)*

Il a été prélevé au total 30 échantillons sur les deux stations Pour les états du 13 juin 1985 et 16 octobre 1985 il n'a pas été observé de goudron sur la plage (les mois de janvier-février-avril et mai 1985 n'ont pas été échantillonnés).

Les concentrations (poids) de goudron pour l'ensemble des échantillons sur les deux stations varient entre 0.5 g et 30 g. La concentration maximale de goudron a été mesurée le 22 mars 1985 à Mondoukou avec 101.32 g.

Pour l'état exceptionnel du 23 août (tempête) il n'a pas été observé des concentrations de goudron plus importantes que celles des autres états sur les deux sites : Mondoukou 0.39 g à 9.79 g et Bassam Km 26; 6.81 g à 21.87 g.

Les concentrations de goudron sont sensiblement équivalentes sur les deux stations. Les poids cumulés par mètre linéaire de plage sont du même ordre de grandeur (Tableaux des résultats).

La répartition du goudron dans le profil de plage. Le goudron est remonté progressivement par "l'Up-rush" et le "Swash" vers la mi-estran et le haut de plage où il se dépose. Les prélèvements sur les deux stations se localisent du haut de plage à la mi-estran (Fig. 2, Fig. 3).

CONCLUSION

Les résultats présentés dans le cadre de cette étude sont plus qu'indicatifs du phénomène de pollution des plages par les résidus de goudron. Cette forme de pollution n'est pas négligeable avec des concentrations de 20 à 30 g par mètre linéaire de plage (voire même 100 g) sur des sites qui, à notre sens ne sont pas les plus pollués du littoral ivoirien. Toutefois le suivi d'un seul secteur comme celui de Mondoukou et Bassam Km 26 situé à une trentaine de kilomètres seulement du pôle industriel Abidjan, n'est pas représentatif de l'ensemble du littoral. Il faut envisager étendre ces mesures à d'autres stations plus éloignées d'Abidjan.

---

* E = échantillonnage sur une surface de $2m^2$, le poids (concentration) est donc exprimé $Xg/2m^2$

Moyenne des poids M : $M = \frac{E_1 + E_2 + \dots E_n}{n}$, les échantillons E_1, E_2, ... E_n sur le même profil, le même jour

Cumul des poids, C : $C = E_1 + E_2 + \dots E_n$ C est exprimé en g/m linéaire de plage

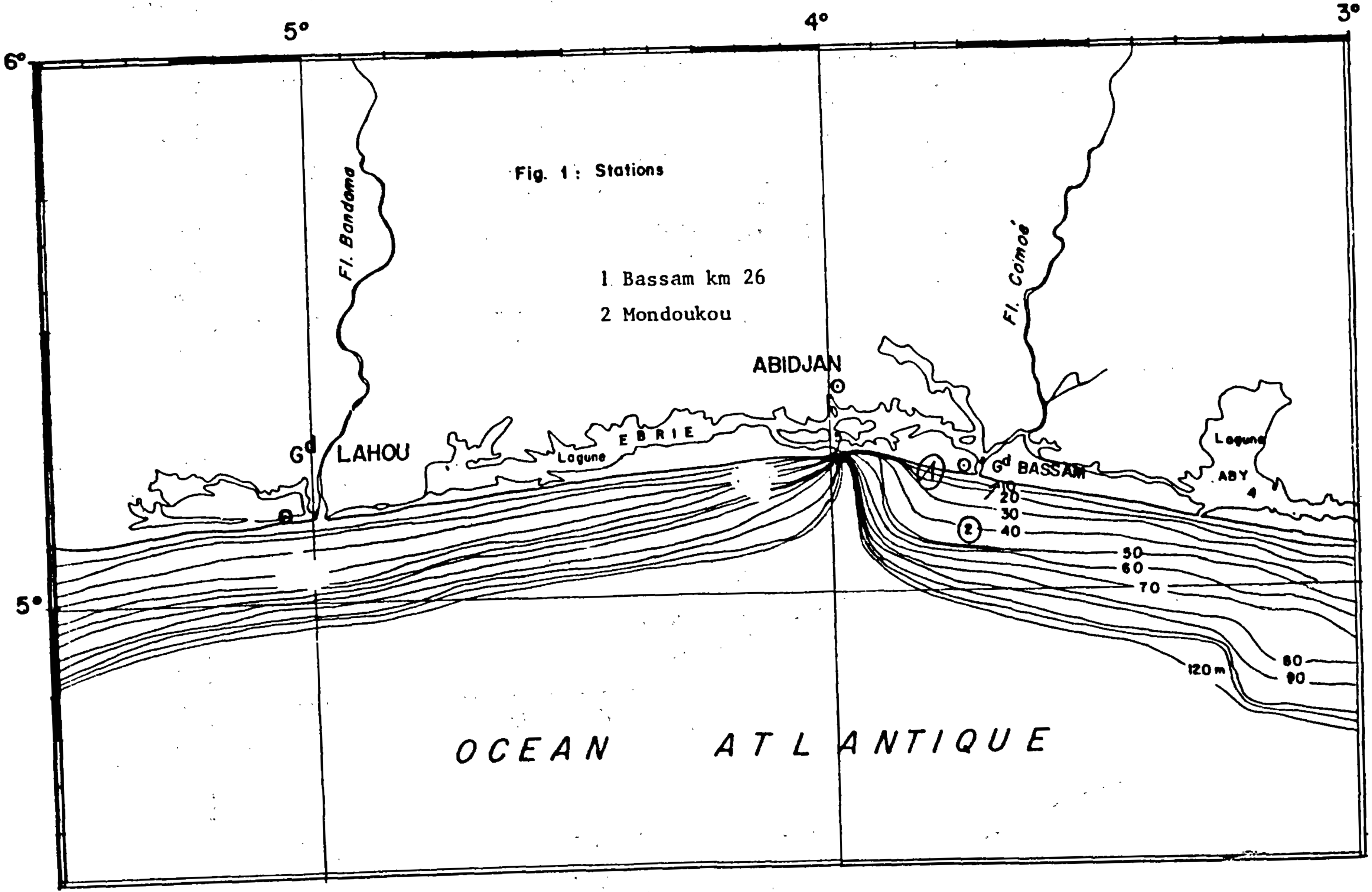


Fig. 1 : Stations

1 Bassam km 26
2 Mondoukou

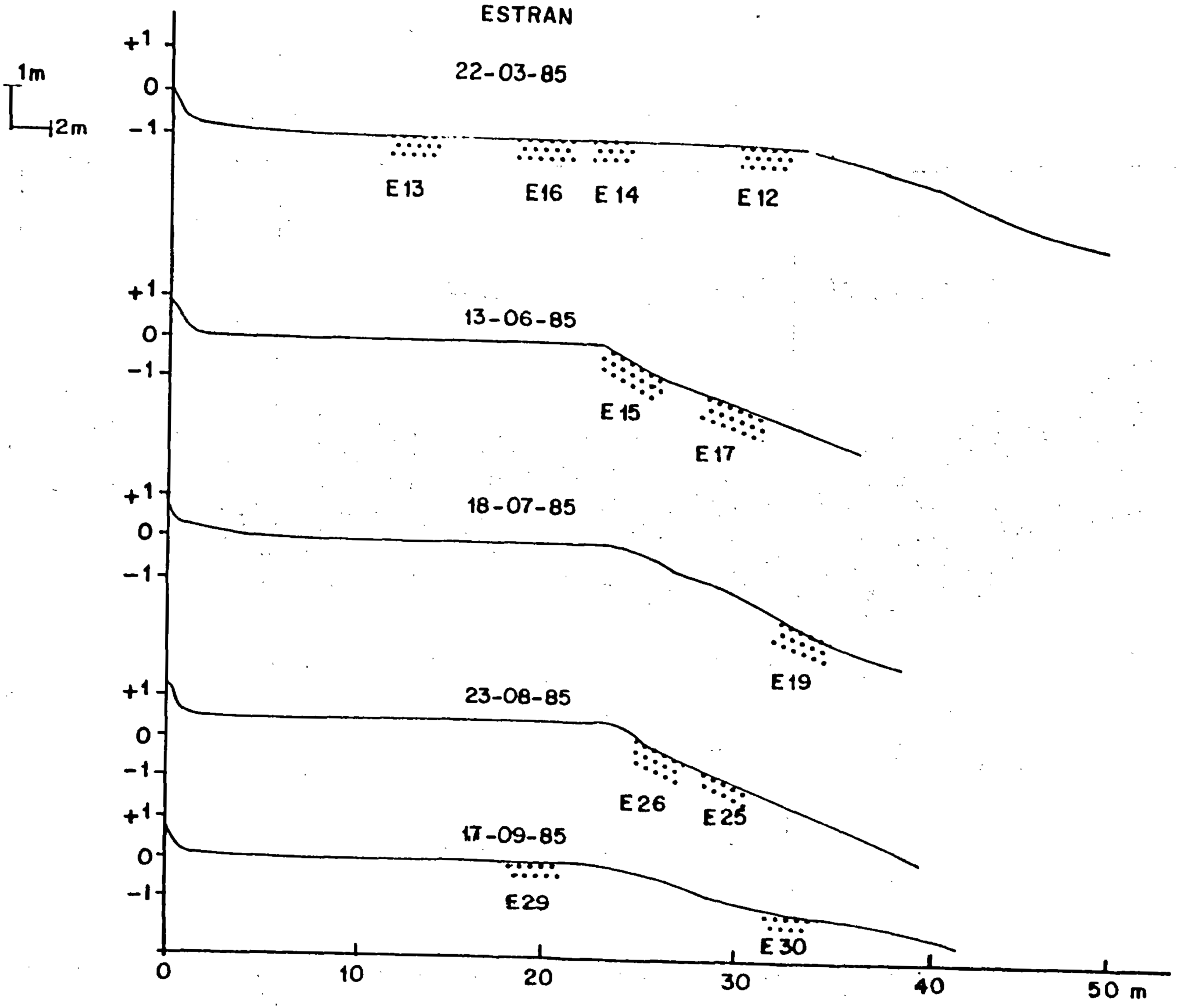


Fig.2 Echantillonnage sur le profil P1 Km 26

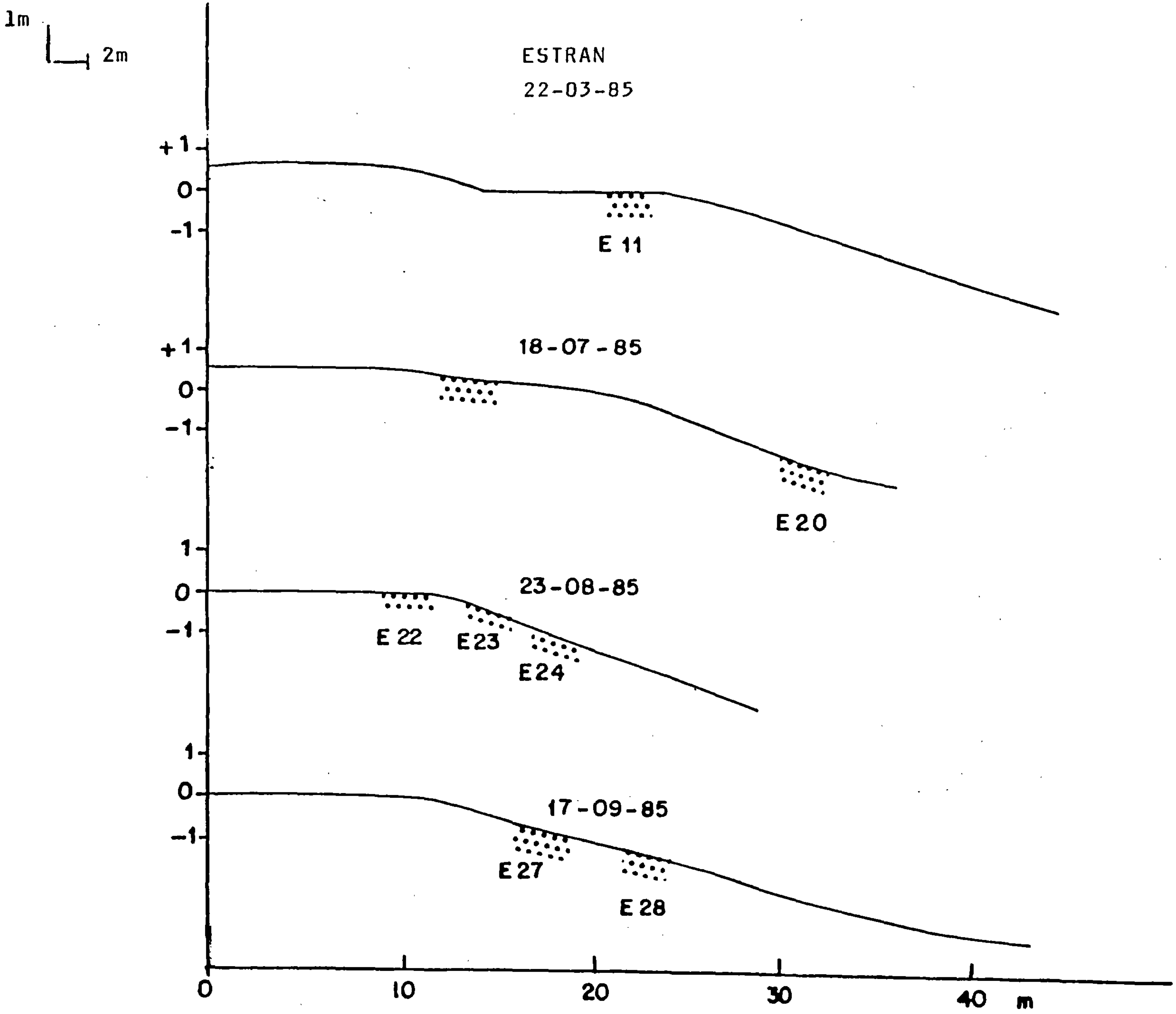


Fig.3 **Echantillonnage sur profil P1 MONDOUKOU**

MONITORING OF TAR ON BEACHES IN CAMEROON

by J.C. Njock; Flavius E. Ikome *

INTRODUCTION

Since the month of February 1984, the amount of tar deposited on beaches was recorded twice a month on three miles along a 35km portion of shore running from Limbe to Debauncha.

(lat. 4° 1'N long 9° 13'E)
(lat. 4° 6'N long 8° 58'E)

The sites all met the recommended criteria, viz:
- a uniform shoreline
- a gentle slope
- a minimum of human activity.

In addition, the sites were chosen in such a way that, sampling could be done on fine sand, rock slabs and something between fine and coarse sand.

At each station three narrow strips of 1 1/2m were chosen randomly and sampled, running across the beach from the backshore to the water mark (low-tide mark). Sampling was done near time of low tide.

MATERIALS AND METHODS

Sampling consisted in picking up with a small rake, all semi-solid and solid particles of tar after having broken up the beach surface to a depth of about 3cm (for what concerns fine sand and coarse sand).

As regards the rocky beach sampled, the particles of tar were scraped from the rocks with the rake, or just simply picked up.

A few time, when the particles were densely covered with sand, they were introduced into a graduated cylinder and water added to cover them entirely. The water was then decanted into a second cylinder and the smaller volume subtracted from the larger. A density of 0.859ml was assumed. All this was done in the lab.

CONCLUSIONS

First of all it must be remarked that an oil refinery operates at about half-way between our sampling sites, since 1981. The first sampling on rock slabs showed a tremendous quantity of tar (4.800q!). On the sand beaches, the amount of tar found was generally low but persistent.

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* Fisheries Research Station, Limbe, Cameroon

TABLE I

RESULTS:

Results (presented as mean of 2 samplings) of sampling of tar on beaches.

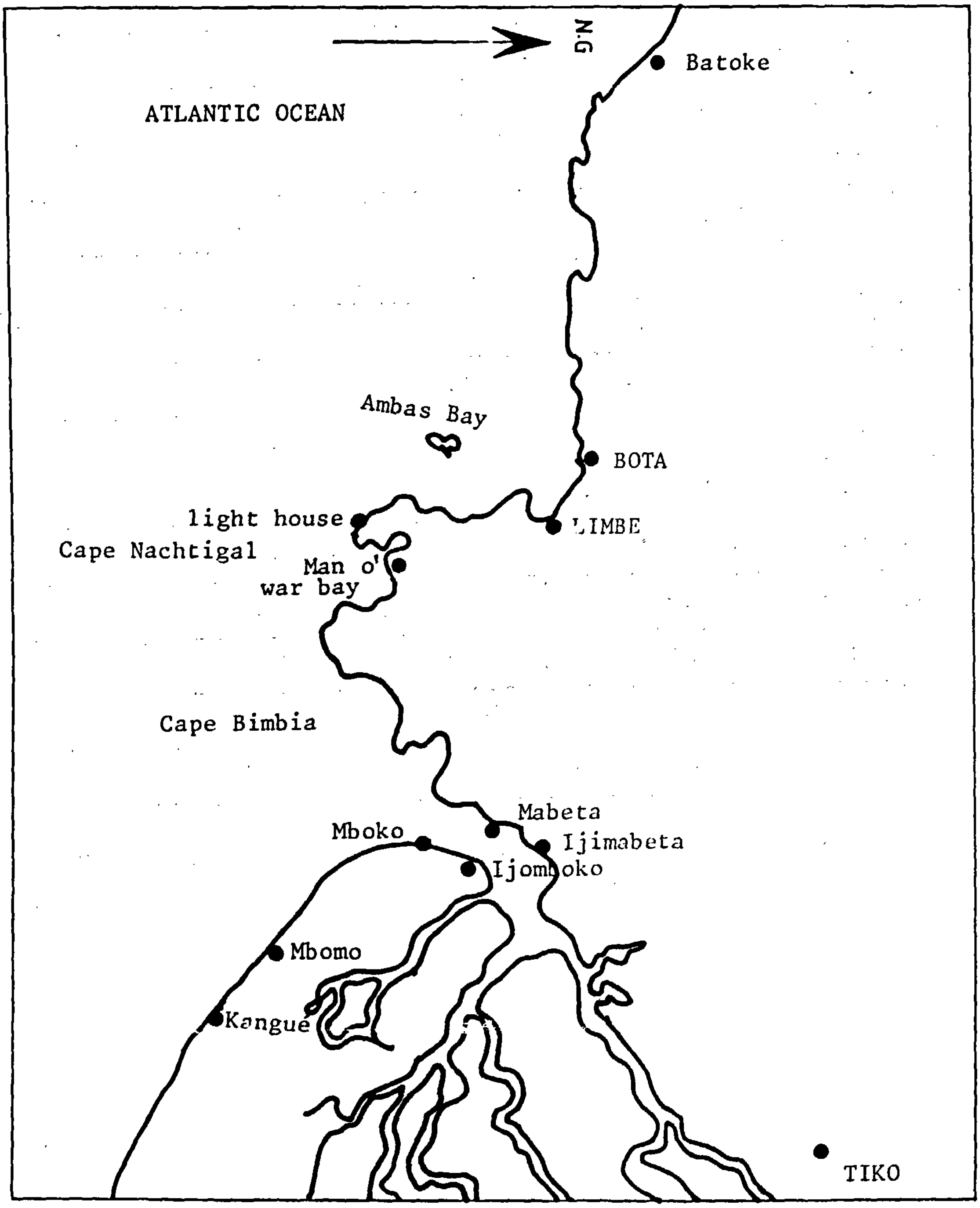
1984	Location	Seashore surface	Length of shorefront	Weight of tar (g)	Observation
FEBRUARY	Bota	Rock slabs	75m	4.800 *	
	Essongo	Fine sand	400m	1.47	
	Debauncha	Coarse sand	175m	1.46	
MARCH	Bota	Rock slabs	75m	111	remnants of first
	Essongo	Fine sand	400m	2.4	
	Debauncha	Coarse sand	175m	4.4	
APRIL	Bota	Rock slabs	75m	66.0	
	Essongo	Fine sand	400m	1.8	
	Debauncha	Coarse sand	175m	2.2	
MAY	Bota	Rock slabs	75m	55.7	
	Essongo	Fine sand	400m	1.6	
	Debauncha	Coarse sand	175m	1.4	
JUNE	Bota	Rock slabs	75m	44.2	
	Essongo	Fine sand	400m	2.2	
	Debauncha	Coarse sand	175m	2.6	
JULY	Bota	Rock slabs	75m	77.7	
	Essongo	Fine sand	400m	1.2	
	Debauncha	Coarse sand	175m	0.9	
AUGUST	Bota	Rock slabs	75m	33.9	Rains heavy
	Essongo	Fine sand	400m	10.5	
	Debauncha	Coarse sand	175m	10.6	

.../...

TABLE I Continue

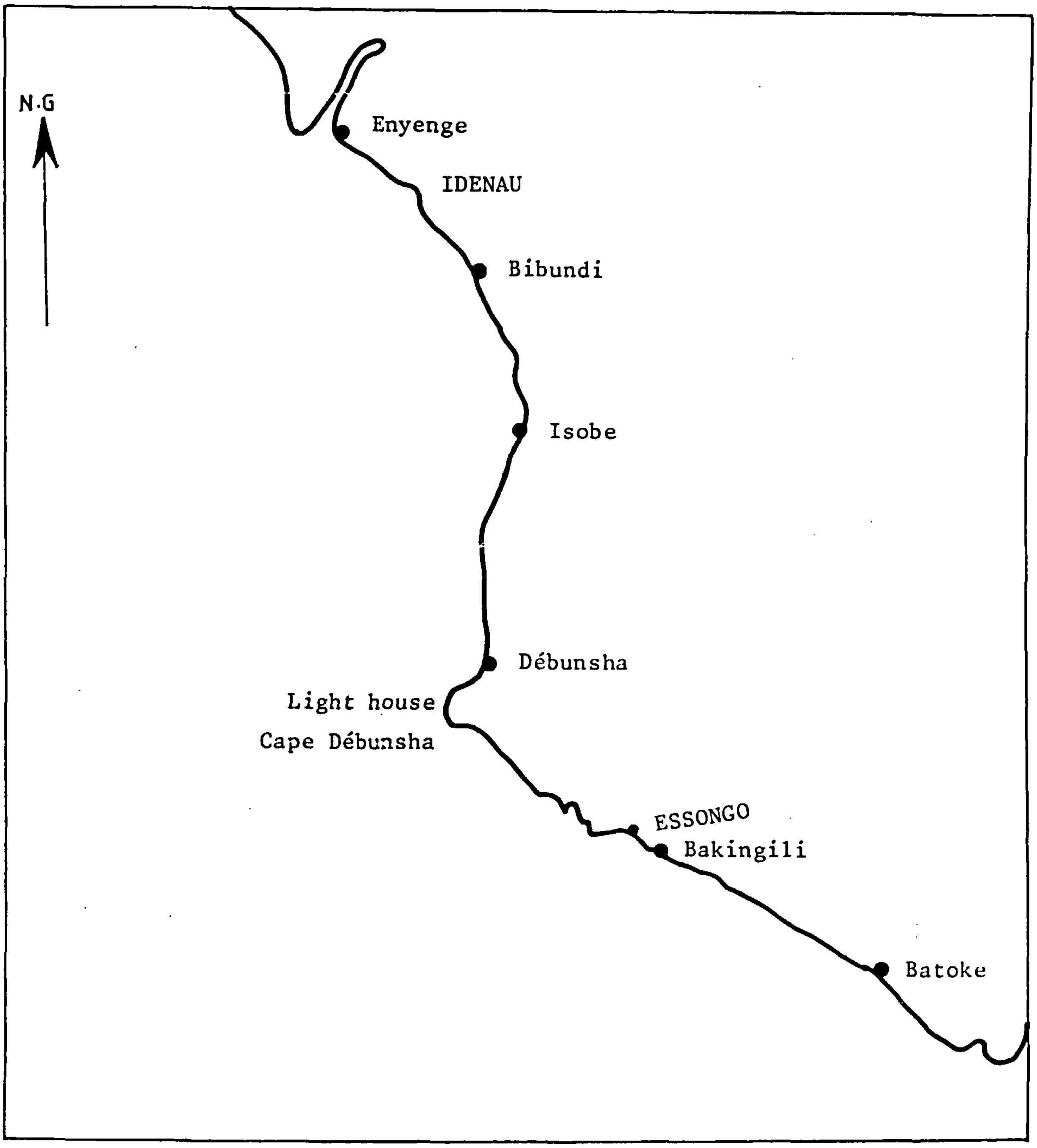
1984	Location	Seashore surface	Length of shorefront	Weight of tar (g)	Observation
SEPTEMBER	Bota	Rock slabs	75m	66.9	
	Essongo	Fine sand	400m	3.2	
	Debauncha	Coarse sand	175m	2.6	
OCTOBER	Bota	Rock slabs	75m	93.6	
	Essongo	Fine sand	400m	3.6	
	Debauncha	Coarse sand	175m	3.7	
NOVEMBER	Bota	Rock slabs	75m	26.2	
	Essongo	Fine sand	400m	13.2	
	Debauncha	Coarse sand	175m	11.0	
DECEMBER	Bota	Rock slabs	75m	40.4	
	Essongo	Fine sand	400m	7.3	
	Debauncha	Coarse sand	175m	3.8	
1985 JANUARY	Bota	Rock slabs	75m	80.4	
	Essongo	Fine sand	400m	6.2	
	Debauncha	Coarse sand	175m	4.4	
FEBRUARY	Bota	Rock slabs	75m	80.4	
	Essongo	Fine sand	400m	3.2	
	Debauncha	Coarse sand	175m	3.4	

* There was a very huge deposit on rock slabs when the work just started.



SAMPLING CITE : BOTA

(Scale : 1/200 000)



SAMPLING CITES : ESSONGO , DEBUNSHA

(Scale : 1/200 000)

TAR BALLS AS INDICATOR OF CRUDE PETROLEUM POLLUTION OF THE BEACHES OF CROSS RIVER STATE, NIGERIA

by Prof. Ulo K. Enyenihi
and Mr E. E. Antia*

ABSTRACT

Environmental impact assessment and strategies to combat pollution arising from petroleum exploration and production activities have generated considerable interest in Nigeria within this decade. However, corresponding field studies to evaluate, in time and space, the distribution and dynamics of pollutants in the marine environment are sparse. This paper briefly details the latter based on a 13-month inventory of tar balls and transport processes along representative segments of the Ibeno beaches on the Cross River State Atlantic littoral.

Values ranging from 0.40 gm to 2.84 gm of tar balls per metre of linear length of the mesotidal (3.2m) low gradient and fine grained beach were recorded between July 1984 and August 1985. An average cumulative deposit of 1.01 gm of tar balls per linear metre of the 2.5 km beach was recorded while a maximum cumulative deposit of 1546.81 gm was recorded for segment G (East) and a minimum cumulative deposit of 118.48 gm was indicated for segment A (West).

The tar transport and deposition was controlled by such littoral factors as winds, waves, breakers and longshore current. Wave periods ranged from 8 per second on the western margin to 10 per second in the extreme eastern segment. Mean breaker heights ranged from 48 cm in the western margin (segment A) to 75 cm in the extreme eastern margin (segment H). These ended up on shore as mainly spilling breakers (65%) which approached the coast mainly (75%) from the South West. They were driven by mainly on-shore (84%) winds which generated an eastward longshore current of 0.37 metre per second. The implications of these processes on the net transport of pollutants originating from the sea in the Gulf of Guinea with many oil platforms and heavy tanker traffic are discussed.

INTRODUCTION

Nigeria is a major oil producing nation. Exploration activities is undertaken both within the coastal zone and offshore with the former constituting over 75%. In view of the ecologic and economic importance of the coastal zone, successive Governments in Nigeria have in the last decade intensified efforts aimed at evolving policies and strategies to protect the environment from deleterious pollutants. Also of prime concern is cost-effective and efficient remedial measures to combat coastal degradation accentuated by apparently inevitable and equally unpredictable oil spillages. The biennial conference of impact of the petroleum industry on the environment sponsored by Agencies of the Federal Government is a clear indication of concern to safe-guard the environment from degradation.

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However, notwithstanding the high level of consciousness of environmental impact of oil pollutants, actual field monitoring of the distribution and dynamics of these pollutants over time are rare. Also sparse are ecological studies aimed at establishing baseline data for the present and projected pollution levels.

This study details the results of tarball inventory on a segment of the Cross River State coastline. It was initiated principally to provide information on ambient levels and trend of marine pollution from oil spills. Presented data on transport processes is indispensable in developing reliable contingency plans for responding to oil spillage in the locality.

STUDY SITE AND METHOD

The Cross River State coastline (Fig. 1) is mesotidal and in general fronted by sandy beaches. The beaches have low gradient ranging from almost flat at the low tide waterline to between 2° and 4° at the mid-tide level and rarely exceed 10° at the steepest portion of the upper foreshore. Texturally, the beaches are fine grained and well sorted.

Fronting the 2.5km segment of the coastline studied, are petroleum exploration and production activities (see Fig. I). The study site stretches coastwards from the Qua-Iboe estuary to the vicinity of the Mobil oil tank farm. In order to evaluate spatial distribution in amount of deposited tar balls from offshore and longshore, inequidistant (mostly between 150-500m) monitoring stations were established and designated AI to HI. The configuration of the coastline and the nearshore morphology were some of the salient factors considered in siting the stations. Furthermore, the somewhat short beach length chosen was designed for effective monitoring of the processes that influence dynamics of tar balls within the litoral zone.

In most cases, tar collection was done during a 24-hour observation period at or near low tide. Also observed from the monitoring stations was the presence of oil slick. Tar sampling however entailed picking all visible tar balls from the surface and the upper 2 cm of a meter strip of beach between the backshore and the water line. Length of beach front during sampling was also recorded with aid of a tape.

At the commencement of investigation in July 1984, data were collected at monthly intervals. The frequency was later increased by bi-weekly between April and August 1985. During each field visit of 1-4 days, processes and parameters of tar transport namely wave period and direction, breaker height, longshore current velocity and direction as well as wind direction were documented.

Wave period and longshore current velocity were obtained with the aid of a stop watch. In the former, time taken for successive wave crests to pass a given point was divided by one less the number of crests counted. Current velocity on the other hand was obtained by noting the time taken by a buoyant object to freely drift alongshore over known distances. All directions were determined with a clinometer while breaker height was estimated with the aid of a graduated staff held close to the breaker point. Breaker type was visualy determined from observations of various sets of breakers. Collected tar samples were carefully labelled and quantified in the laboratory.

RESULTS AND DISCUSSION

Data on tar ball and litoral processes for the study period (July, 1985-August 1985) are presented in Tables 1 and 2. No field visit was made in September, 1985. Evident from table 1 is the absence of tar at all the stations between July, 1984 and February, 1985. Oil slick was never observed throughout the study period. Furthermore, with the exception of station A1, quantity of tar deposited was highest during the month of June at each of the monitoring stations. Available data tend to suggest a general eastward increase in both absolute amount and montly monitoring variation in tar weight per metre of beach front from the estuary. Over the time interval under consideration, total amount of deposited tar was highest at station G1 and least in station A1.

Data on mean weight of tar per metre of beach front depicts a more pronounced longshore increasing pattern compared with monthly variations or total amount. However, because of paucity of data, temporal variability of deposited tar can not at present be linked with any meteorologic or other periodic changes in coastal condition. Also in view of the multivariable nature of factors affecting amount of tar, deposited on the beach, the present discussion on spatial distribution can at best be viewed as a preliminary attempt.

However, while transport processes can be fairly predicted, pollution load and point of discharge as well as the residence time of pollutants are vital information which were not thoroughly evaluated during the investigation documented in this report. Nevertheless, based on existing data onlittoral processes previously documented by Ibe and Antia (1983) and from on-going studies, dynamics and deposition of available pollutants on beach segments would be largely influenced by breaker height, breaker type, wave approach and period, and longshore current velocity and direction. In addition to the aforementioned factors are intensity of tidal currents and characteristics of the beach profile.

Breaker height which is a function of wave energy would generally influence the amount of tar balls transportable: The higher waves would transport larger amount of tar balls compared with the low waves typical of station A1. Since depositional processes on beach foreshores progress through swash action, breaker type is considered significant in determining the accumulation of tar balls on beach foreshores. Apart from the lower degree of entrainment of transported materials by spilling breakers compared with plunging reported earlier, spilling breakers characteristic of very flat foreshore profile of stations A1 - O1 have relatively lower swash force associated with plunging and surging breakers results from minimal interaction between the shoaling wave and the sea bottom topography. Thus intense swash will enhance tar accumulation on the beach foreshores.

Recorded variations in wave period and longshore current velocity are not significant enough to influence the distribution pattern of tar balls. However, shorter wave period of the order of 6 seconds and less often associated with storm activities have a seaward transport tendency of entrained materials which would ultimately deplete the amount of tar reaching the beach. Similarly, low rate of tar ball transport associated with low values of longshore current velocity as in station BI would tend to enhance the competency of swash to accumulate tar balls on foreshore.

However, by far the most significant factors controlling the distribution pattern of available tar balls are the directions of wave approach and longshore current. With the exception of refraction associated with wave shoaling and the interaction of offshore wind, one would generally expect wave inclination data to correlate highly with observation of current direction. This expectation is well effected in the present study.

The importance of current direction is indicated by a higher rarity of tar balls on the beach segment between AI and BI compared with other stations. At stations AI and BI net direction of current is westwards hence available tar ball in these locations are susceptible to being transported away from the study site. Absence of tar balls at stations other than AI at certain instances may be attributed to a general scarcity of tar as on May 31 1985 on seaward transport by rip currents.

Of particular interest in this study is the consistent low value of tar balls deposited on beach segment adjacent to the estuary. The outcome of this would beside the net westward transport direction, appear to be related to the extremely short residence time of tar and the action of tidal currents. The low lying profile in the vicinity of the estuary is most vulnerable to wave incursion resulting in resuspension of previously deposited tar balls. Coupled with the tidal currents, especially during load stage, entrained tar would be transported along the estuary and ultimately into the creeks and nearby mangrove swamps where they finally undergo sedimentation processes.

On the contrary, because of the relatively steeper foreshore profile at stations DI, EI, GI and HI and the presence of bern scarp howbeit transient in some cases, vulnerability to wave overstopping would be low and consequently residence time of tar ball higher. Station FI has foreshore characteristics comparable to that of station AI.

CONCLUSION

This study was intended to document and relate the standing stock of tar on a representative segment of the mesotidal coastline of Cross River State to the transport processes. The object was to provide, in addition, data which would greatly aid in ascertaining the degree of oil pollution and the sensitivity of the coastline in the event of a major oil spill. To some extent, these objectives have been realized. Presented data and foregone discussion indicate that the vicinity of the Qua Iboe River estuary and other low lying beach segments devoid of berm scarp eastward of it are likely to be more susceptible to pollutants emanating from offshore oil spill.

It is premature at this stage to predict any future trends or ascertain seasonal or other cyclic changes in magnitude or intensity of pollution in the environment. However, average values of tar weight per metre of beach front from all the monitoring stations for the 7-10 instances when tar was visible and collections made range between 0.40 and 2.84 g/m. The generally low values of tar weight per metre of beach front documented from this 13-month pilot monitoring is indicative of a low or light level oil pollution.

TABLE 2 - SUMMARY OF OBSERVATIONS ON LITTORAL PROCESSES FROM STUDY SITE (JULY 1984 - AUGUST 1985)

STATION	Breaker height (cm)		Breaker type (%)				Mean wave period (secs)	Longshore current					Wave approach relative to shoreline (%)			Wind direction relative to shoreline (%)		
								Velocity (m/s)		Direction (%)								
	Mean	Range	Sp	Pl	Su	Co		Mean	Range	East	West	Net	SE	SW	Parallel	ON	OFF	AL
AI	48.00	22-84	92.41	4.68	1.30	1.67	8.70	0.33	0.04-0.92	29.27	70.73	W	33.33	44.44	22.22	52.94	41.18	5.88
BI	54.00	26-80	81.14	10.87	3.68	4.32	10.28	0.26	0.06-0.44	44.83	55.17	W	27.27	45.46	27.27	61.54	38.46	0.00
CI	60.00	40-90	75.00	15.00	7.00	3.00	10.00	0.38	0.05-0.85	83.78	16.22	E	0.00	78.57	21.43	81.82	18.18	0.00
DI	62.00	44-100	68.00	23.00	5.50	3.50	8.64	0.31	0.09-0.67	96.67	3.33	E	0.00	92.31	7.69	90.91	9.09	0.00
EI	66.00	48.86	62.00	21.00	11.00	6.00	9.03	0.43	0.17-0.75	94.29	5.71	E	0.00	100	0.00	91.67	0.00	7.33
FI	56.00	38-86	66.47	17.31	10.26	5.96	9.73	0.45	0.20-0.80	94.87	5.13	E	9.09	81.82	9.09	100	0.00	0.00
GI	67.00	30-100	36.00	49.00	10.00	4.30	10.13	0.43	0.10-0.73	97.37	2.63	E	14.29	78.57	7.14	100	0.00	0.00
HI	75.00	52-150	41.53	44.90	10.26	3.08	10.01	0.38	0.08-0.80	85.19	14.82	E	7.69	76.92	15.39	92.31	7.69	0.00

NOTE

Sp - spilling
Pl - plunging
Su - surging
Co - collapsing
ON - onshore
OF - offshore
Al - alonshore
W - west
E - east

TABLE I : TAR BALL RECORDS AT STUDY SITE FROM JULY 1984 TO AUGUST 1985
in units of $g.m^{-2}$

DATES	STATIONS															
	A		B		C		D		E		F		G		H	
July 7, 1984	0.10	0.20	1	2	1	2	1	2	1	2	1	2	1	2	1	2
August 22	0.0	0.0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
September	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
October, 27	-	-	0.0	0.0	0.1	0	0	0	0	0	0	0	0	0	0	0
November, 25	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
December, 21	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
January, 31	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
February, 28	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
March, 31	157.3	0.98	35.7	0.24	95.6	0.84	68.0	0.74	76.5	0.92	59.3	1.22	82.9	0.93	178.5	2.01
April, 15	52.8	0.42	6.0	0.04	8.01	0.07	4.03	0.04	7.35	0.12	51.8	0.46	16.35	0.23	198.25	2.13
April, 28	0.0	0.0	4.75	0.04	7.74	0.08	6.87	0.01	9.17	0.13	26.01	0.23	2.94	0.01	60.35	0.68
May, 18	0.0	0.0	0.0	0.0	0.0	0.0	7.28	0.06	8.18	0.10	1.98	0.02	7.22	0.10	19.20	0.21
May, 31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	0.25	30.88	0.39
June 13	48.73	0.31	45.8	3.55	245	2.36	134.5	1.40	58.75	0.61	302.5	1.82	1357.8	19.91	2.45	0.03
June, 28	42.7	0.26	13.3	0.12	102	1.42	115.6	1.82	201.8	3.59	313.5	2.70	12.6	0.27	211.6	2.44
May, 18	0.0	0.0	0.0	0.0	0.0	0.0	7.28	0.06	8.18	0.10	1.98	0.02	7.22	0.10	19.20	0.21
May, 31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	15.3	0.25	30.88	0.39
June, 13	48.73	0.31	45.8	3.55	245	2.36	134.5	1.40	58.75	0.61	302.5	1.82	1357.8	19.91	2.45	0.03
June, 28	42.7	0.26	13.3	0.12	102	1.42	115.6	1.82	201.8	3.59	313.9	2.70	12.6	0.27	211.6	2.44
July, 17	77.8	0.57	0.0	0.0	1.05	0.015	125	1.69	24.3	0.43	166.8	1.19	0.0	0.0	0.0	0.0
August, 1	2.05	0.01	0.53	0.005	128	1.85	3.08	0.04	1.53	0.03	86.7	0.69	51.7	0.95	2.3	0.064
August, 17	36.7	0.24	12.4	0.13	136.0	0.56	104	1.20	214.9	3.85	44.7	0.41	0.0	0.0	0.0	0.0
August, 31	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
MEAN OF 2	0.40		0.59		0.90		0.77		0.98		0.97		2.84		0.994	

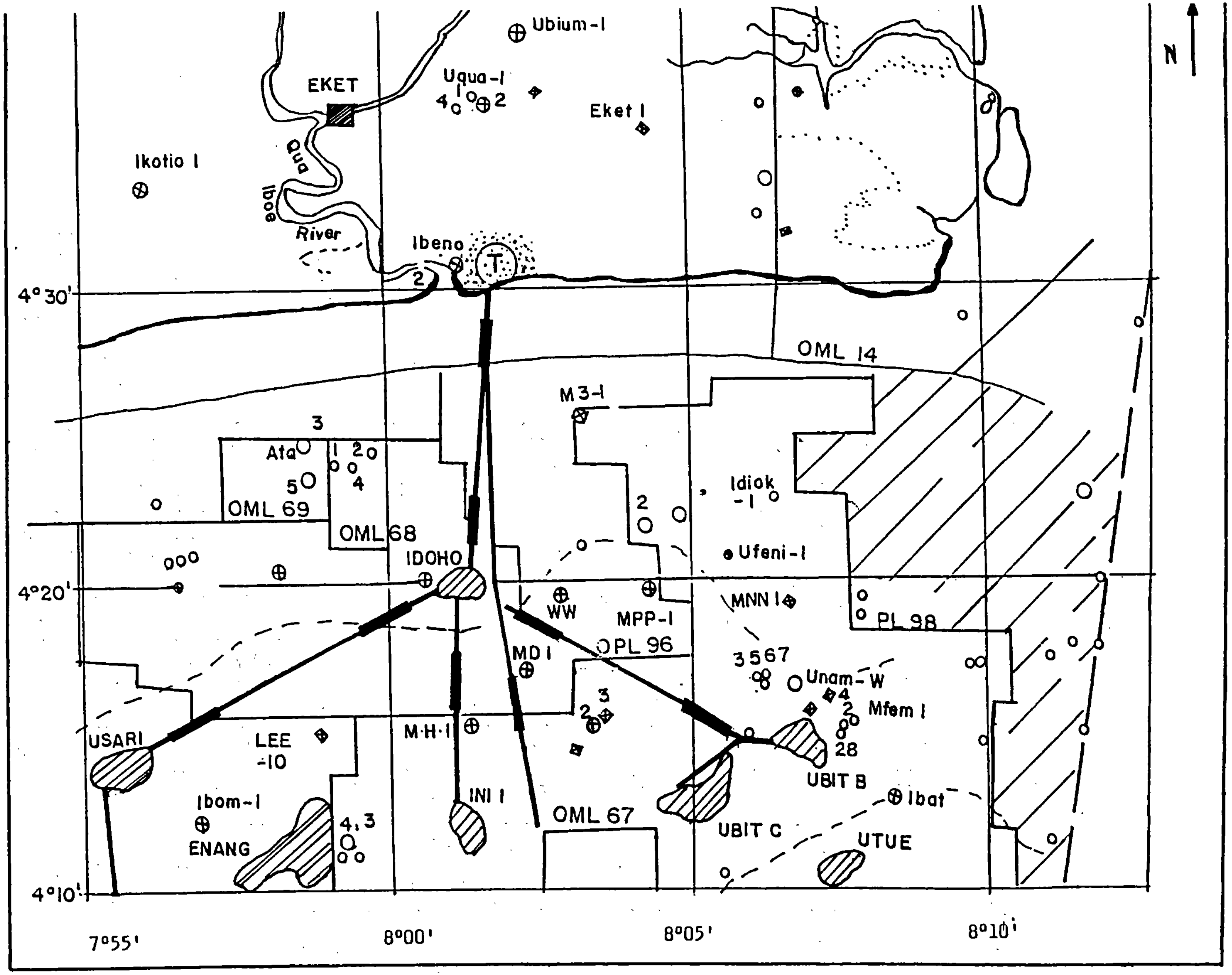

Fig.1 Part of the Cross River State coastline showing study site and offshore petroleum installations.

░ STUDY SITE

TABLE 2 - SUMMARY OF OBSERVATIONS ON LITTORAL PROCESSES FROM STUDY SITE (JULY 1984 - AUGUST 1985)

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EI	66.00	48.86	62.00	21.00	11.00	6.00	9.03	0.43	0.17-0.75	94.29	5.71	E	0.00	100	0.00	91.67	0.00	7.33
FI	56.00	38-86	66.47	17.31	10.26	5.96	9.73	0.45	0.20-0.80	94.87	5.13	E	9.09	81.82	9.09	100	0.00	0.00
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HI	75.00	52-150	41.53	44.90	10.26	3.08	10.01	0.38	0.08-0.80	85.19	14.82	E	7.69	76.92	15.39	92.31	7.69	0.00

NOTE
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ON - onshore
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STRANDED PELAGIC TARBALL LOADINGS ON BADAGRY BEACH, NIGERIA

by E.C. Okonya and A.C. Ibe*

INTRODUCTION

Petroleum and its products are the principal pollutants in coastal and marine environments. Sources of oil input into the marine environment are:

(i) Tanker ballasting
(ii) Pumping of bilges by vessels other than tankers
(iii) Inport losses during loading and unloading
(iv) Explorations (oil-based drilling mud)
(v) Production
(vi) Pipeline breaks
(vii) Natural seepages.

Oceans and coastal waters of the world therefore contain floating masses of weathered petroleum residues (pelagic tar) which come ashore as stranded pelagic or beach tar through the influence of tides, waves and their generated currents. The presence of petroleum tar or lumps on coastal beaches not only poses public health hazard but also constitutes a serious threat to the productive potential of coastal and marine fisheries resources.

Judging by the volume and intensity of oil exploration, production and tanker traffic, Nigeria would be expected to have large quantities of pelagic tar. Indeed a vast majority of the sandy beaches of the barrier bar complexes that much of the Nigerian coastline are almost always littered with tar balls. It is more so in the Niger Delta where much of the oil production comes from.

LOCATION AND METHOD OF STUDY

This paper presents the results and interpretations from a quantitative sampling of stranded pelagic tarballs at the Badagry Beach which began in May 1984 and is continuing. The study is part of the pilot phase of the FAO/IOC/WHO/IAEA/UNEP/WACAF/2 Project on Monitoring pollution in the marine environment of the West and Central African Region.

Badagry Beach (Lat 6°22'N, Long. 2°52'E) is an open coarse-grained sandy beach close to the Nigeria/Benin border. It was chosen for study because of its location away from any known area of crude oil production in Nigeria.

Sampling and calculations were carried out as described in IOC Manuals and Guides No. 13 (Unesco, 1984).

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RESULTS AND DISCUSSION

The incidence of stranded pelagic tarballs on Badagry Beach between 1984 and October 1985 is shown in Table I. Tar loadings range between 13.96 and 57.24 gm^{-2} $month^{-1}$.

The distribution of tar balls was not uniform. Some parts of the beach were almost free of tarballs whereas other parts were heavily loaded. Maximum deposition occurred nearly always at the high side mark. This suggests the importance of tides and waves in the transportation of these pollutants. In many cases tarballs were found in soft or almost melting conditions because of heat as they became mixed with or buried by sand.

The size of tarballs varied a great deal from as small as a pin head to almost the size of a normal football. Extraneous materials found on the tarballs were debris, pieces of plastics, polyethylene strips, sand grains, broken pieces of wood, bivalve mollusc shells, broken pieces of glass and mangrove (Rhizophora) seedlings and fruits.

Some deposition also occurred in the backshore. This was mostly flattened tarballs and were either partially or fully buried having been brought this far by the occasional storm waves.

The origin of the tarballs found on the beach is not entirely clear. As stated earlier, Badagry is remote from any known area of crude oil production in Nigeria. However, it is known that countries such as Benin, Togo, Ghana and Ivory Coast to the West of Nigeria, produce very modest quantities of petroleum mostly from fields in the coastal and shallow marine environment. Crude oil from these sources would be transported by longshore currents which originate from as far West as the Ivory Coast and which are reinforced locally in the vicinity of Badagry Beach to attain velocities of up to meters per second (7).

Another likely source of the tarballs is the area of oil production in the north-western flank of the Niger Delta. Increased onshore and offshore production in Nigeria between 1958 (onshore 250,000 m tons) and the oil glut by late 1977-79, (on shore over 1 million m tons) was accompanied by increased incidents of oil spillage (petroleum inspectorate annual report, 1978). Awobajo (1) showed that between 1976 and 1980, 780 oil spill incidents occurred with the release of 1,336,875 barrels of oil into the environment. In 1981 there were 233 oil spillages with the loss of 22,840 barrels of oil. The corresponding figures for 1982 were 216 oil spill incidents with the loss of 34,475 barrels (see Table 2).

Other sources of petroleum hydrocarbon input into the marine environment include natural seepages from the numerous growth faults and associated crustal faults that criss-cross the shallow continental shelf of Nigeria in particular Niger Delga (6).

Oil from these sources would be distributed offshore to the west either by large gyral system known to be operative in the Bright of Benin or by currents associated with the periodic reversal of the Guinea Currents in this sector (8). From offshore the tarballs would be washed ashore by swell waves.

In the same mechanism could be adduced for the transportation to the Badagry Beach of any petroleum residues contributed bia ebb tidal currents from shipping activities in the inlet as Lagos, about 86 km to the east of Badagry and from fluvial sources farther inland. The ebb currents at peak attaign average velocities of 3.5m/s (5).

The beach at Badagry is on the West African shipping lame because of the port of Lagos and the tarballs may drive their origin from the general pollution attributable to this marine activity.

Though the data obtained during this short period are not enough to highlight definite trends in the distribution of tarballs along Badagry Beach, they (data) show a slight decline in tarball loadings.

Robertson Smith and Knap (10) reported a decline in the amount of Tar stranding on Bermuda and attributed this decline to a reduction in operational discharges of oil tankers and a global decrease in the occurence of maritime oil spills since 1980. There have been no reports in the West African subregion since 1981 of any major oil spillages or tanker disaster.

CONCLUSION

This study shows that Badagry Beach and probably the entire marine beaches of Nigeria are continuously impacted by stranded tarballs.

The tarballs owe their origin to three or four possible sources, both national and international. A more definitive knowledge of the source(s) would depend on a better understanding of the physical oceanographic process operative in this region and which bear on the problem of pollutant transport in the coastal and marine environments in the region. It also would require perhaps more sophisticated analyses of the tarballs themselves by gas chromatography or gas chromatography/mass spectrometry.

ACKNOWLEDGEMENTS

The authors are grateful to Messrs. E. O. Oyewo, M. Nimako, J.P. Unyimadu, A.I. Irere and C.E. Ibe for field assistance at various times. The interest shown in the project by the Director, Mr. J.G. Tobor has been a source of inspiration to the authors.

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    United Nations Environmental Programme Regional Seas Reports and Studies n° 4 (1982)

    The status of oil pollution and oil pollution control in the West and Central African Region.

TABLE 1 RECORD OF STRANDED PELAGIC TARBALLS SAMPLED AT BADAGRY BEACH (LONG, 2°52', LAT. 6°22'N) NIGERIA FROM MAY 1984 TO 23rd OCTOBER 1985

DAY AND MONTH	YEAR	WEIGHT (G) PER STRIP	STRIP LENGTH (M)	WEIGHT M^{-2} (g)
2nd MAY	1984	1493	52.66	28.35
30 th MAY	1984	3867	40.20	96.19
13 th JUNE	1984	1317	38.66	34.06
5 th OCT	1984	486.30	38.0	12.80
6 th NOV	1984	635	37.0	17.16
7 th FEB	1985	680	18	37.78
18 th	1985	550	20	27.50
31 st MAY	1985	450	19	23.68
30 th JULY	1985	390	25	15.60
13 th AUG	1985	416	25	15.64
23 rd	1985	491	25	19.64
10 th SEPT	1985	451	25	18.04
24 th SEPT	1985	657	25	26.28
9 th OCT	1985	409	25	16.36
23 rd OCT	1985	289	25	11.56

TABLE 2 YEARLY DISTRIBUTION OF SPILLS 1970 - 82

n°	Year	n° of Spills	Net Vol. BBLS
1	1970	1	150
2	1971	14	15,11
3	1972	41	51,390
4	1973	59	95,580
5	1974	105	65,714
6	1975	128	56,854.82
7	1976	128	20,023
8	1977	104	31,144
9	1978	154	97,250
10	1979	157	630,405
11	1980	241	558,053
12	1981	233	22,840
13	1982	216	34,474.6
TOTAL	13 YRS	1,581	1,678,989.4

SURVEILLANCE CONTINUE DE LA POLLUTION PAR LES HYDROCARBURES

par P. N'Diaye*

1. DESCRIPTION DU PLATEAU CONTINENTAL SENEGALAIS

Le Sénégal a une façade maritime longue de 700 km (12° 20' N à 16° 20' N). La côte est basse et bordée d'un cordon dunaire, se poursuit par un plateau continental peu accidenté. La superficie de ce plateau est résumée dans le tableau ci-dessous.

Fonds de surface km^2	0-10 m	10-50 m	50-200	Total
	4 700	14 200	9 800	28 700

Elle n'est pas uniforme, à l'isobathe 200 m, sa largeur est de 27 milles marins au large de Saint Louis, 5 milles au niveau des Almadies et 54 milles au large de la Casamance.

2. IMPORTANCE DE CE PROJET POUR LE SENEGAL

Comme le Sénégal n'est pas un producteur de pétrole, il importe de l'extérieur du goudron et tous les produits pétroliers.

L'importance de ces approvisionnements est liée au développement économique. C'est ainsi que de 1970 à 1984 les importations pétrolières n'ont cessé d'augmenter, passant de 700.000 à 1.000.000 de tonnes.

Le transport est assuré par des bateaux de 30 à 80.000 tonnes à la cadence d'un à deux par mois. Ce trafic très important n'est pas à l'abri d'incidents sur les plages, d'où l'intérêt porté à ce sujet.

3. LES DIFFERENTES PHASES DU PROJET

3.1 OBSERVATIONS DE NAPPES DE PETROLE ET DE GOUDRON

Ce travail sera exécuté au niveau des plages de la région de Dakar qui est la capitale économique du Sénégal. Nous aurons à évaluer la quantité de goudron présente sur les plages.

3.2 ECHANTILLONNAGE ET RELEVE DES RESIDUS PETROLIERS PARTICULAIRES (agglomérats de goudron)

Il consiste à faire des échantillonnages d'agglomérats de goudron en mg/m^2 de surface océanographique. Nous essayerons de prospecter tout le plateau continental sénégalais à l'aide du navire de recherche océanographique.

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3.3 OBSERVATIONS DE NAPPES DE PETROLE ET AUTRES POLLUANTS

Ce travail concernera tout le plateau continental sénégalais.

3.4 OBSERVATIONS OCEANOGRAPHIQUES

Le transport de tous ces polluants dépend des conditions hydrologiques et météorologiques du plateau continental.

Pour la réussite de cette phase, nous travaillerons avec le Centre de Recherches Océanographiques Dakar-Thiaroye, la marine et l'aviation nationales. Nous avons néanmoins besoin de deux anémomètres.

4. COOPERATION AFRICAINE

Nous sommes disposés à coopérer avec tous les laboratoires de l'Afrique de l'Ouest et du Centre.

5. COOPERATION INTERNATIONALE

Sur le plan international, nous comptons effectuer un voyage d'études dans deux laboratoires (Centre IFREMER de Brest et le Laboratoire d'Océanographique Chimique de l'Université de Brest) qui ont accumulé beaucoup d'expériences pour de telles recherches à cause des nombreux accidents pétroliers survenus sur les côtes bretonnes.

SURVEILLANCE MICROBIOLOGIQUE DES EAUX COTIERES ET DES FRUITS DE MER

par I. Sow

Le projet WACAF/2, dans sa composante OMS "Surveillance microbiologique des eaux côtières et des fruits de mer" est exécuté au Sénégal conjointement par la Direction de l'Environnement du Ministère de la Protection de la Nature (Point focal) et le laboratoire de microbiologie de l'ENSUT, Université de Dakar.

La Direction de l'Environnement est chargée d'effectuer les échantillonnages tandis que les analyses sont faites au laboratoire de microbiologie de l'Ensut.

1. LES OBJECTIFS DU PROJET

Les objectifs du projet consistent :

(i) à mettre au point des méthodes de référence uniformisées qui permettront de comparer les résultats obtenus par les différents laboratoires et organismes de surveillance, sur le plan national et sous-régional, voire international ;

(ii) à réunir des données de base pour l'évaluation sur le plan national de la pollution côtière résultant du déversement en mer d'effluents microbiologiques pathogènes d'origine terrestre ;

(iii) à élaborer des stratégies contre la pollution et à mettre en oeuvre des programmes qui en assurent l'efficacité pratique ;

(iv) à contribuer à l'évaluation globale de la situation dans la sous-région.

2. ECHANTILLONNAGE

Les zones de prélèvement ont été sélectionnées en fonction des critères suivants :

- Importance sur l'économie nationale
- Zones de pêche et de tourisme
- Zones de commercialisation des produits de mer (poissons notamment)
- Présence de matières fécales
- Présence d'industries transformatrices de poissons
- Présence de canaux d'évacuation d'effluents domestiques.

2.1 STATIONS DE PRELEVEMENT

Les stations de prélèvement retenues sont les suivantes (voir localisation sur la carte en annexe) :

- HANN
  - . Hann 1 = Terminal Pont Plaisanciers
  - . Hann 2 = Hann Pêcheurs
  - . Hann 3 = Hann Capas

- SOUMBEDIOUNE
  - . Soumbedioune Pêcheurs
- NGOR
  - . Ngor Pêcheurs (Zone d'embarquement vers Ile)

2.2 METHODES D'ECHANTILLONNAGE

Les méthodes d'échantillonnage utilisées sont celles prescrites par l'OMS dans les "Directives applicables à la surveillance sanitaire de la qualité des eaux littorales" :

- Les matériels et les échantillons sont conservés à l'abri de la lumière
- Les échantillons sont pris à l'aide de flacons stérilisés
- Les échantillons sont prélevés à 20 m de la côte en général à une profondeur de 20 cm
- Le transport des échantillons des stations de prélèvement au laboratoire d'analyse s'effectue en moins de deux heures de temps, ce qui fait éviter les risques de dégradation.

Par ailleurs, il est prévu l'amélioration des méthodes de prélèvement notamment par l'utilisation du système de conservation (refroidissement des échantillons durant leur conservation).

2.3 PARAMETRES

Les paramètres suivants ont été considérés durant les échantillonnages :

- Température
- Marée
- Date et heure de prélèvement

2.3 DEMARRAGE DU PROJET

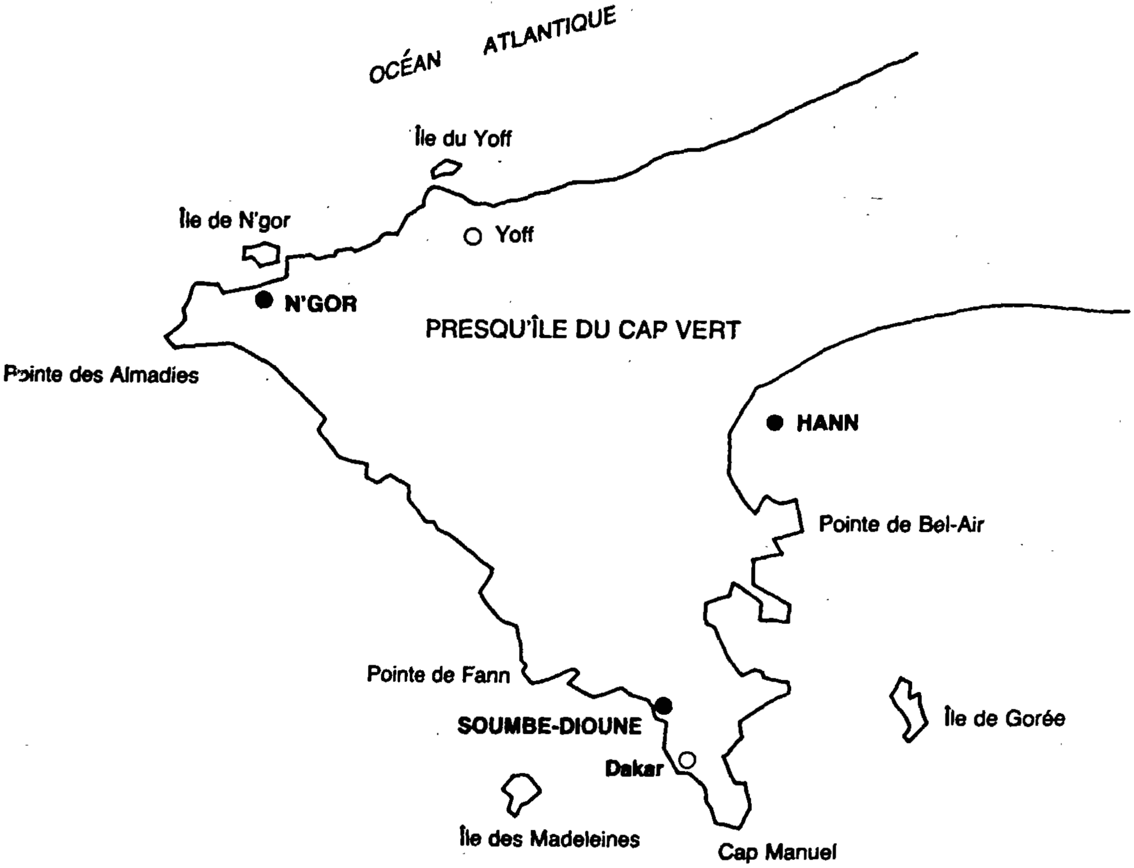
10 avril 1985.

2.4 PERIODICITE ECHANTILLONAGE

Une (1) fois par semaine.

2.5 OBSERVATIONS

Le projet n'a pu se dérouler pendant la période des vacances, le personnel du laboratoire de microbiologie de l'ENSUT étant en congé durant cette période. Il faut signaler également que le laboratoire de l'ENSUT n'a pas actuellement à sa disposition un technicien pour faire les analyses. Cependant, des négociations entre la Direction de l'Environnement et de l'ENSUT sont en cours afin de contourner cet obstacle, et que le principe de continuer le projet a été retenu par les deux parties.



● Stations de prélèvements

SURVEILLANCE BACTERIOLOGIQUE DES EAUX COTIERES

par Mme Renée Paris et M. Babacar Diallo*

La surveillance des eaux côtières dans la région de Dakar a été effectuée chaque semaine du 10 avril 1985 au 12 juin 1985.

OBJECTIFS

Il s'agit de se rendre compte de l'évolution de la qualité bactériologique de ces eaux.

L'intérêt de cette étude réside dans le fait qu'il existe une relation entre la qualité bactériologique de l'eau de mer et la qualité des produits marins y vivant et consommés par la population.

Cette pollution a donc une influence sur la santé des populations ainsi que sur l'économie du pays.

Pour évaluer cette contamination, nous faisons appel à des indicateurs de pollution d'origine fécale qui sont les espèces microbiennes suivantes :

- les coliformes fécaux,
- les streptocoques fécaux.

Ces germes ont été choisis pour les raisons suivantes :

1) ce sont des hôtes habituels du milieu intestinals,
2) leur durée de vie dans l'eau n'est pas très importante et leur présence signe donc une contamination relativement récente,
3) leur mise en évidence peut se faire à l'aide de techniques simples et rapides.

La présence de ces germes : coliformes et streptocoques fécaux dans l'eau indique qu'un risque de pollution par des germes pathogènes transmis par voie intestinale (salmonella, sbigella par exemple) existe. Ces germes pathogènes peuvent contaminer les animaux marins et être par le suite responsables de maladies chez l'homme consommant ces produits.

METHODOLOGIE

1. LES PRELEVEMENTS

Ils ont été réalisés par le service de l'Environnement régulièrement chaque semaine. Trois sites ont été choisis :

- Ngor,
- Soumbédioune,
- Hann ; au niveau de ce dernier site, 3 produits de prélèvement ont été choisis.

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Le laboratoire de l'ENSUT recevait les flacons d'eau dès le retour des agents chargés des prélèvements et réalisait les analyses immédiatement.

Les flacons d'eau étaient conservés au réfrigérateur à +4°C jusqu'à lecture des résultats.

2. L'ANALYSE BACTERIOLOGIQUE

2.1 La technique utilisée a été la méthode par filtration sur membranne Millipore (0,45u).

2.2 Les volumes filtrés ont été
- de 100 ml pour l'eau non diluée,
- de 10 ml pour les dilutions.

Nous avons travaillé sur les dilutions de 10^{-1} à 10^{-5} en milieu tryptone-sel.

2.3 Les milieux de culture utilisés

Au départ, nous avons fait une étude parallèle utilisant :

- d'une part les milieux utilisés habituellement au laboratoire,

- d'autre part, les milieux Difco fournis par l'OMS.

(Nous n'avions pas l'habitude de ces milieux Difco et nous n'avions aucune indication les concernant).

Par la suite, nous n'avons travaillé qu'avec les milieux Difco. Nous avons également réalisé des tests de confirmation afin d'être sûrs des résultats avancés.

2.3.1 Recherche des streptocoques fécaux :

Le dénombrement a été réalisé :
- sur milieu MK streptococcus agar (Difco)
- sur milieu de Slanetz.

Ce test de confirmation a été fait sur le milieu de Sitsky.

2.3.2 Recherche des coliformes fécaux

Le dénombrement a été réalisé :
- sur milieu m FC Bioth base (Difco) auquel nous ajoutions 15 g d'agar par litre,
- sur gélose lactosée au TTC +

Pour la confirmation, nous avons utilisé les milieux de Schubert et de Kligler Hajna R. Tous les essais ont été réalisés en double.

RESULTATS

1) Streptocoques fécaux : les résultats ont toujours été négatifs.

2) Coliformes fécaux (voir tableau).

Ces résultats ne peuvent donner lieu à une interprétation valable car la durée de surveillance n'a pas été assez longue. Les travaux ont été arrêtés par manque de technicien à partir des vacances scolaires.

Pour la reprise des travaux, il serait nécessaire que le technicien promis par la Direction de l'Environnement soit affecté au laboratoire de l'ENSUT. La seule conclusion partielle possible est l'existance d'une pollution d'origine bactériologique qui semble présenter des variations dans le temps sans que l'on puisse en préciser les causes possibles.

Cette expérimentation demanderait à être poursuivie afin de pouvoir tirer des conclusions valables.

RESUTATS COLIFORMES FECAUX

(par 100ml d'eau)

	HANN I	HANN II	HANN III	NGOR	SOUMBEDIOUNE
10/04/85	1.600	0	0	2.600	0
17/04/85	0	0	175	0	0
24/04/85	90	6.000	0	240	6.000
6/05/85	10	9.800	34	250	710
8/05/85	4.400	11.000	30	140	6.300
15/05/85	4.100	11.500	30	3.000	8.400
23/05/85	4.500	8.700	7.00	19.500	7.800
29/05/85	2.300	5.000	30	3.900	1.900
5/06/85	1.000	6.000	210	53.900	40.800
12/06/85	800	1.600	90	32.000	22.000

SURVEILLANCE MICROBIOLOGIQUE DES EAUX COTIERES

par Kouamé M. Djamabara*

(Extrait)

Le Laboratoire de Microbiologie du Centre Médical des Gens de Mer a été nommé comme participant au projet WACAF 2 en 1983. J'ai pour ce faire, assisté à un exercice d'intercalibrage à Barcelone (Espagne) en novembre 1983.

Le matériel de base (pompe, rampe de filtration, milieux) pour mettre en oeuvre la méthode recommandée, a été envoyé en 1984 par inadvertance en Côte d'Ivoire au Ministère de l'Environnement qui quelque temps après a été dissout. Des négociations sont actuellement en cours en vue du transfert dudit matériel au Ministère de la Marine pour sa mise en service dans les activités de projet WACAF 2.

Cependant, le Ministère de la Marine a signé un accord avec le C.R.O. (Centre de Recherches Océanographiques) pour la mise en oeuvre du programme de surveillance. Les résultats des analyses effectuées par le C.R.O. seront disponibles d'ici la fin de l'année 1985.

Tout le personnel du Laboratoire de Microbiologie du Centre Médical des Gens de Mer a participé à un séminaire technique, organisé par l'OMS en juillet 1985. Ce séminaire, animé par un consultant de l'OMS (Dr. Rafael Mujeriego) a porté sur les aspects méthodologiques relatifs à l'échantillonnage, à l'analyse, à l'interprétation et au compte rendu des résultats obtenus au cours du programme de WACAF 2. Ce personnel formé est disposible pour la mise en oeuvre du programme. Notre seul handicap est le manque de matériel. Nous espérons que l'OMS nous aidera à entrer en possession de l'équipement dont nous avons fait mention plus haut.

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ANNEX VI

THE STATE OF CONTAMINATION OF THE MARINE ENVIRONMENT IN THE WACAF REGION

PRESENT TRENDS IN ENVIRONMENTAL POLLUTION STUDIES

by E. Bacci and C. Gaggi*

ABSTRACT

Physico-chemical and partitioning properties driving the environmental transport, distribution and persistence of synthetic organic chemicals are reported. The use of chemical monitoring data to assess the environmental behaviour of pollutants is discussed.

INTRODUCTION

The technological growth characterising the last 50 years has been largely based on the development of industrial chemistry. On the other hand several synthetic chemicals, probably unknown to the biota before (xenobiotics), have been introduced in large quantities (for some of them, millions of tons) in the natural system. Some of them are quickly degraded to inert substances, other are long-living and easily carried far away from the immission area.

From the sixties to the first half of the seventies an exponential growth of literature about the environment has been observed. A great number of papers have dealt with the chemical monitoring of pollutants, mainly with a retrospective approach, describing environmental distribution of chemicals already in the environment. Some of them, as in the 'historical' Minamata Disease case, pointed up the link between a certain pollution source and observed deleterious effects on the environment (man included). In other circumstances 'hot-spots' were put in evidence, leading to environmental recovery actions. From these experiences analytical methods were greatly improved and regulations and restrictions for the use of more persistent chemicals (e.g. organochlorine insecticide, polychlorinated biphenyls) were approved by several governments. Tolerance limits in sewage, foodstuffs and feed promoted the activation of analytical routines in governmental and private laboratories.

The studies on environmental impact assessment of chemicals received an important and essential impulse from the passing, in the USA, of the Toxic Substances Control Act (TSCA), in 1976 (1), followed, after 3 years by the European Economic Community Directive No. 831 (2). In these the need of predictive tools concerning the environmental behaviour of new chemicals was formalized.

This paper emphasizes the use of chemical monitoring data to assess the environmental distribution and fate of chemicals.

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ENVIRONMENTAL DISTRIBUTION OF ORGANIC CHEMICALS

Just as toxic potential is strictly dependent on the molecular structure (3), the transport, dispersion and reconcentration processes, as well as the persistence in the environmental compartments are also driven by physico-chemical properties.

PHYSICO-CHEMICAL PROPERTIES: S, P^o, M.P.

Water solubility (S) and saturation vapour pressure (P^o), are essential in determining the environmental distribution of a given substance: with an high S the chemical will show considerable affinity for the aqueous phase, while a low S value indicate a tendency to escape from the water. S also regulates uptake by biota and adsorption-desorption in water media on solid substrates. Vapour pressure indicates the tendency of a chemical to leave, as vapour, its pure phase; volatilization phenomena are strictly related to this property. Melting point (M.P.) indicates the interaction energy in crystals, which opposes solvent actions.

PARTITIONING PROPERTIES: H and K_{aw}, K_{ow}, BCG, K_p and K_{oc}, Ø

The Henry's law constant (H) and the air/water partition coefficient (K_{ow})

These constants indicate the equilibrium partitioning between air and water of a chemical. If the dilution is high and if there is not strong association or dissociation, H can be calculated from P^o and S as follow:

$$H = P^o/S$$

with P^o and S referring to the same temperature and the same phase.

The dimensionless K_{aw} can be calculated from H, as indicated below:

$$K_{aw} = H/RT$$

where R is the gas constant and T the absolute temperature.

The information contained in a partitioning property is higher than that from a simple physico-chemical one: chemicals with low P^o values can flow into the air from the water phase if S is low too.

The octanol/water partition coefficient, K_{ow}

This coefficient represents the ratio between the concentration in the n-octanol phase and in the water phase at equilibrium. From the K_{ow} an estimation of the hydrophobicity and then lipoaffinity of a substance dissolved in water can be derived. Water solubility and K_{ow} together, contribute to the bioconcentration and bioaccumulation phenomena.

The bioconcentration factor, BCF

Among the properties here discussed, the BCF is probably the least accurate. Generally it refers to aquatic systems and can be defined as the ratio between the concentration of a chemical in a test organism and the concentration of the same chemical in the surrounding water, at equilibrium. Generally the BCF is calculated experimentally for relatively large animals, like fish or molluscs, to evaluate the intake through the gills. The application of the BCF in planktonic organisms can result in over-estimations, owing to the interference by adsorption phenomena. In calculating BCF, the accumulation and clearance kinetics of a given chemical, should be known. In general I-order kinetics are assumed and a linear two-compartment model is used to represent the intake and clearance of a chemical by a selected organism (i.e. fish):

$$\mathrm{WATER} \underset{k_2}{\overset{k_1}{\rightleftarrows}} \mathrm{FISH}$$

with k_1 and k_2 the intake and clearance rate constants (t^{-1}), respectively.

The organism is considered as a single homogeneous compartment.

Keeping the concentration of the chemical in the fortified water (C_w) constant,the intake in the organism will be constant, at a rate $V_1 = k_1C_w$, calculable as the slope of a regression line C_f versus t, where C_f indicates the measured levels in the test organism at the beginning of the accumulation (where C_f is low and the elimination rate negligible), and t the exposure time.

The intake-rate constant k_1 can be then calculated from the ratio V_1/C_w.

The clearance-rate constant k_2 can be calculated from the clearance equation, after logarithmic transformation:

$$\ln C_f = \ln C_{fo} - k_2t$$

where k_2 becomes the slope of the empirical function, easily calculatable with current statistical methods (i.e., least squares).

When the model is verified by experimental results, BCF can be calculated as follows:

$$BCF = k_1/k_2$$

as has been proposed by Branson et al. (4).

The sorption coefficient K_p and the organic carbon sorption coefficient K_{oc}

The adsoprtion processes in soils, sediments and particulate matter in aqueous solutions have been described by different approaches (adsorption isotherms) as reported by Huang (5) and Choudhry (6).

According to Freundlich (7) the adsorption isotherms for many dilute solutions could be fitted by the following equation:

$$x/m = K\,C^{1/n}$$

where x/m is the amount of adsorbate per unit amount of adsorbent, C is the equilibrium concentration of adsorbate, K and n are constants related to the bonding energy.

At low pollutant concentrations, lower than half the solubility, with neutral hydrophobic substances (i.e. DDT, PCBs), the sorption isotherms onto soils and sediments are linear and reversible (8):

$$S = K_p\,C$$

where S is the concentration of the chemical in the adsorbed phase, C the concentration of the chemical in the water phase, and K_p the partition coefficient.

Different soils and sediments, normalized to the organic carbon (oc) can show very similar K_p values, the adsorption being mostly on organic materials. If so the previous relation between S and C becomes:

$$S = K_{oc}\,C$$

where K_{oc} is the organic carbon sorption coefficient, related to K_p as follows:

$$K_{oc} = K_p/F_{oc}$$

where F_{oc} represents the organic carbon fraction in the soil and sediment phase.

The aerosol/vapor partitioning coefficient, Ø

Organic traces in the atmosphere exist both as vapours and adsorbed to particulate matter. As reported by Eisenreich (9) the aerosol/vapour partitioning depends on the vapour pressure of the chemical, the surface and organic content of suspended particles. According to Junge (10), aerosol/vapour partitioning can be represented as follows:

$$\emptyset = c\theta/(P^{o} + c\theta)$$

where: Ø is the ratio of adsorbed organic vapour in the air, θ the aerosol surface, P^{o} the saturation vapour pressure and c a constant depending on heat of condensation and molecular weight.

From this approach, in 'clean' air conditions, chemicals with P^{o} levels greater than 10^{-6} mm Hg are characterized by small Ø values (9). The implications of Ø in the environmental transport of pollutants are of great concern.

SEARCHING FOR THE MINIMUM OF NEEDED DATA: THE RELATIONSHIPS BETWEEN PROPERTIES

During the last years a growing effort has been made to examine quantitative relationships between one of the above reported properties and another. Thus in the case of many hydrophobic organic chemicals, starting from water solubility, S, as Mol l^{-1}, and melting point, M.P., such as °C, K_{ow}, K_{oc} and BCF can be obtained:

for liquids:

$$\text{Log } K_{ow} = -\text{Log } S + 0.515 \qquad (11)$$

for solids:

$$\text{Log } K_{ow} = -\text{Log } S - 0.01\,(\text{M.P.} - 25) + 0.51 \qquad (11)$$

then:

$$K_{oc} = 0.41\, K_{ow} \qquad (8)$$

$$\text{Log BCF} = 0.851\, \text{Log } K_{ow} - 0.70 \qquad (12)$$

If P^{o} is also known too, the Henry's law constant H, as well as K_{ow}, can be calculated and information on Ø derived.

Therefore a possible minimum series of data to obtain the principal environmental distribution properties of a chemical could be:

name of the compound

molecular weight

saturation vapour pressure

water solubility

melting point (only if solid).

Differences in reported figures concerning these basic properties are often evident in current literature and manuals. Probably in the near future more accurate data will be available.

PERSISTENCE

Chemical transformations, transfer to other compartment and advection determinate the persistence of a chemical in a given environmental phase. Photolysis, hydrolysis, oxidation and biodegradation represent the main reactions that may occur in the environment. All these reactions can be assumed as following I-order kinetics. If so, the rate of each degradative process is expressed as the product of the concentration of the chemical in the compartment considered and the rate constant (t^{-1}). Consequently, all reactions rates in a given phase can be added, obtaining a total I-order rate constant, K, and by multiplying this and the concentration of the chemical in the compartment, C, the total degradation rate in the compartment, KC, can be calculated (13):

$$\text{degradation rate} = K_1C+K_2C+K_3C+\ldots+K_nC = KC$$

As can easily be seen, the importance of an environmental compartment as sink of a given chemical is strictly dependent on its total degradation rate constant and on its potential for attaining a high concentration of the pollutant.

Advection, which is generally negligible for soils, is particularly important for fluid phases (air, water), can be considered as a I-order process with rate constant K_a (as t^{-1}), defined as follows (assuming steady-state conditions):

$$K_a = I/Q$$

where I is the input rate (or output), and Q is the total amount of the chemical in the compartment.

The overall persistence, or mean residence time of the chemical in the compartment in steady-state conditions, T, will be:

$$T = 1/(K+K_a)$$

where K and K_a are the overall degradation rate constant and the advection rate constant, respectively, previously defined.

MODELS

Hazard assessment and risk evaluation require both an estimation of the environmental distribution and fate, and information about the toxic potential of a chemical.

The development of environmental studies justifies separating the former and latter, as two specific research fields. In the field of the environmental distribution and fate of chemicals, with which the present paper deals, models are classifiable as follows:

- laboratory microecosystems;
- mathematical simulations.

Metcalf et al. (14) studied the biodegradability and ecological magnification of some chlorinated insecticides introducing a small laboratory model ecosystem, which has since been used to test the environmental fate of more than 100 chemicals (15).

Other systems have been tried, as is reported in Gillet's review (15), like the Terrestrial Microcosm Chamber (16). This model ecosystem consisted of a synthethic soil, agricultural crops, invertebrates and voles, and was used to test the fate of dieldrin. Nash (17) studied pesticide volatilization rates by means of microagroecosystems and small green-houses were recently employed to study the mechanism of PCB uptake in plant foliage (18).

Mathematical models have been recently grouped into two main categories (19): models for Potential Environmental Distribution (PED) and for Potential Environmental Concentration (PEC).

PED models deal with equilibrium distribution of chemicals between environmental phases (e.g. air, water, soil, biota), in arbitrary ecosystems, indicating potential reservoirs and sinks. Therefore the PED approach has the limitation of not referring to any actual system. However this can be useful for regulatory purposes and in decision making, where general trends are more important than particular situations.

PEC are simulations of actual environments. Generally their aim is the calculation of spatial and temporal variations of the concentration of a chemical in the principal environmental phases, in natural conditions. Owing to that, PEC models are complicated and difficult to use for nonspecialists and need a great number of experimental measurements for gradual adjustment. Besides PEC models are often rigid, the results not being applicable to other systems, not even to a same one studied at another time.

Of course PED models may become PEC if suitably modified, and vice versa. However the dominant philosophy of each can be easily recognized.

PED models seem to be a very useful tool both in interpreting environmental data from chemical monitoring and for predictive approaches.

The PED philosophy began a few years ago, when Baughman and Lassiter (20) suggested the use of 'evaluative models' to describe essential mechanisms in the transport and fate of chemicals, rather than complicatedsimulations of actual environment. One of the best PED models is Mackay's fugacity approach (13, 21, 22).

Mackay's PED model

In an arbitrary ecosystem ('unit world') equilibrium partitioning between the principal environmental compartments can be determined by calculating the fugacity (a pressure indicating the escaping tendency of a chemical from the phase in which it is calculated). If the rate constants of degradative processes and of advection are known, assuming a steady-state condition and I-order kinetics, environmental compartments where the degradation potential is highest can be indicated. Higher levels of complications are also proposed bringing the model up to PEC refinement.

By this approach potential environmental reservoirs (level I) and sinks (level II) can be pointed out.

CONCLUSIONS

Chemical monitoring, i.e. the repeated analysis of chemical residues in environmental compartments (biotic and abiotic), should be directed to the interpretation of environmental distribution and fate of pollutants, rather than to describe 'fish pollution', 'marine pollution', 'air pollution', and so forth.

Therefore the first step in environmental pollution-research planning should be the selection of chemicals, on the basis of expected environmental inputs, persistence and toxic potential.

The second step should be the identification of possible pollution sources (e.g.: industrial effluents, dumps, pesticide application areas) and their description.

The third step could be the calculation of the potential environmental distribution of the selected chemicals, using PED model, followed by laboratory model ecosystem validation, at least for the principal environmental phases (air, water, soil).

The fourth step could be chemical monitoring both where pollution is assumed to exist ('local' problems) and where pollution does not theoretically exist (background level, possible 'global' implications).

The last one is the interpretation of all data obtained.

Regarding the WACAF 2 Project, concerning the analysis of some heavy metals and organochlorine residues in fish samples, the first step has already been taken. The second should be carried out with particular care: looking at marine fish pollution only, it is possible that strong contamination problems might be overlooked. The third step only needs to be performed once and results for PCBs and chlorinated pesticides are already available (23), or in preparation (24). The fourth calls for an extension of monitoring programmes, according to the findings from step II and III.

From such an approach, it is likely that conclusions of far greater scope than the description of the degree of contamination of some item of human food (i.e. fish) could be reached.

A final aspect to be kept in mind is the scientific significance of information on the environmental behaviour of chemicals in tropical and equatorial regions, as in West Africa.

ACKNOWLEDGEMENTS

The authors are greatly indebted to Mrs. Ann Henderson for the accurate correction of the English text.

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FACTORS INFLUENCING MARINE POLLUTION SURVEYS IN WEST AND CENTRAL AFRICA

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ABSTRACT

Marine pollution monitoring for trace metals and chlorinated hydrocarbons in the West and Central African region is starting under the WACAF/2 programme. Important factors influencing the probable results are surveyed. They include the discharge of large rivers, the input of aeolian Saharan dust and other natural precipitation, and the high phytoplankton productivity of the area. Sources for the pollution in likely descending order of importance include municipal wastes, spills and drilling mud release from the oil industry, then other industries, car emissions, and use of agricultural fertilizers. Possible features important for interpreting the pollution and its causes are the tropical promotion of rapid biogeochemical turnover, and the lagoons and mangrove ecosystems in some areas. The erosion in the area is likely to dilute pollution at least 1000 times through mixing. Suggested background figures for metals and chlorinated hydrocarbons are presented and it is emphasised that since there are so few data from the region it presents a fine opportunity for fresh research.

INTRODUCTION

The occasion for this paper is the commencement of analysis by personnel of the laboratories of the region as part of the WACAF/2 (West and Central Africa Fund) project, initially funded by the United Nations Environment Programme and now being brought under more local control with the establishment of a trust fund by the nations concerned, to finance the development and maintenance of a marine pollution monitoring network.

Little attention will therefore be paid in this paper to the inland environment, though many of the factors mentioned will also be relevant to it.

The purpose of this paper is to summarise information known about the marine occurrence of trace metals and chlorinated hydrocarbons in the region, as a resource for participants. The literature is scattered and data of local concern may have been omitted. The author would appreciate gaps being brought to his attention, because a revised edition of the material on trace elements may be submitted for publication later.

Even for studies done outside the region the facts are scattered and this document cannot be complete. It is almost impossible to consider in detail all possible backgrounds and sources of pollution.

This paper considers trace metals and chlorinated hydrocarbons. Both may produce pollution in ecosystems. The subject of petroleum hydrocarbons is covered in a different paper by a representative of the Intergovernmental Oceanic Commission of UNESCO. However it will be suggested in this paper that oil spills can also influence the metal content of sediments and possibly affect chlorinated hydrocarbon distribution. Other important pollutants such as greases, phenols, fluoride, and ammonia, are not considered here but mentioned in UNEP (1984).

Also not included though a possible source of pollution for the marine environment is one material included in the large onchocerciasis control programme (Antwi (1985)). Although this material, chlorophoxim, contains chlorine, it is 0,0-diethyl-2chloro-α-cyanobenzylidine amino-oxyphosphonothioate, hence not strictly a chlorinated hydrocarbon and will not be further considered. Similarly there is a significant possibility of the marine environment being affected by use of the insecticide Deltamethrine, Dejoux (1983), but since it is a synthetic pyrethroid, it also falls outside the scope of this review.

When starting a pollution monitoring programme it is important to consider what the background or baseline values are likely to be and what natural biogeochemical features are likely to influence them. However it will be essential to reason on general grounds, because there are so few data from the region.

An excellent general introduction to the features of the region is given in UNEP (1984), but the present paper tries to apply those data more directly to marine trace analysis.

PHYSICAL GEOGRAPHY

A good summary of this is found in UNEP (1984). The countries of the region are found in the Equatorial Humid Zone except Senegal and The Gambia which are partly in the North Arid Zone. This means high coastal rainfall and high temperatures and these are important factors in the geochemical environment. The average rainfall is 2 m y^{-1} and in some places more than 5.5 m y^{-1} are recorded. From the point of view of trace metals it is clear that geochemical leaching and weathering must be intense in such a region. The intense sunlight (1600-1800 MCal m^{-2} yr^{-1}) promotes very rapid growth and hence biogeochemical turnover. This could somewhat affect the persistence of the chlorinated hydrocarbons. It also has the consequence that any pollution event could make its effects felt faster than in temperate regions, because of faster diffusion and absorption processes, but some consequences would also vanish faster. It could be necessary to finish analysis and interpretation faster than would normally be the case, if action is necessary against the pollution.

It is possible that some rain in the region is relatively acidic. This is known for North Australia (Personal communication B.T.Hart). There, in a region almost without industry, the pH of rain is 3.9-4.5. This arises from volatilisation and oxidation of organic compounds from plants (especially isoprene). In the intense sunlight, that compound is photolysed to formaldehyde and ultimately formic acid. Acetic acid is also present. It is clear that such acidic rain will readily leach trace elements from soils. Whether the same situation holds for West Africa will depend on the precise vegetation and the organic compounds they exude, and the subsequent photochemistry.

Some information is available from Wright (1982) for the Jong river in Sierra Leone. He showed that rainfall was pH 5.4-6.0 and the pH of the river was 5.44-6.76. This suggests that the photochemistry may be different in the WACAF region, and the rain less acidic. However Wright (1982) also showed that the river he studied contained very low dissolved solids (less than 10 mg l^{-1}) and suggested that the region was already so heavily leached that little material remained accessible to leaching. He thought this would mean that growth of biota in the river (and by extension in the sea nearby) would be very likely limited because of lack of nutrients in the river.

When the rivers reach the sea the content of pollution, natural or anthropogenic will influence the natural marine background near the coast. This is because of the mixing of the fresh water with the saline. In general this causes a precipitation of many trace elements, especially if the origin is anthropogenic. The latter tend to be in forms which may be different from those from natural sources. For example, a fertiliser factory may release phosphate in particulate form to a river, which would be uncommon in the natural environment. These particulates may well precipitate in an estuary.

There is a general principle which tends to operate and is important for pollution surveys. Anthropogenic pollution released to rivers even if initially soluble, tends to remain close to the point of release. This is ironic, because the point of releasing it is to remove it far from the factory. But because of geochemical principles this will not usually work well. Polluters generally pollute their back doors, or the local coast.

In a lagoon or mangrove environment, there is greater residence time of water, and hence more time for precipitation of pollutants, or adsorption onto the sediments and local vegetation. It is almost certain that pollutant levels will be higher than in other coastal environments.

The site at which the elemental content of a river precipitates depends on where the mixing with salt water occurs. That depends again on the volume of water coming down the river, and also depends on the salinity of the sea water. The Niger and Congo are very significant rivers and have created their own large alluvial fans, and have a large and significant region around them where the salinity is quite low, strongly in contrast to the tropical Atlantic in general where the salinity is quite high. (Much of the general data presented here is derived from the Times Atlas (1983) unless otherwise indicated). Most precipitation of trace metals seems to take place at salinities of 5% or less, in any case, but it rather seems that the volume of water is such, that near the major rivers, precipitation of trace elements will be rather further out to sea than the polluters deserve. Some elements will desorb rather than precipitate, e.g. Ba (Edmond et al. 1978).

Some actual data on description is available from the work of Valenta et al (1983) for the Sierra Leone river. They compared it with the Ooster and Westerscheldt rivers, in Europe, and found that Cd and Pb were in the range 30-400 ng kg^{-1}, and Cu was 200 ng kg^{-1} or greater. Pb was mostly attached to the particulate matter, but Cu was dissolved and released to some extent in the estuary.

The types of trace elements coming down a river will also be a function of the different types of geology. In very simplified terms, (Emery and Noakes 1985) the geology of the region is mixed. However there are very significant regions of igneous intrusive rocks, and marine Tertiary sediments. How will these affect the output of trace elements?

One consequence of the presence of igneous or metamorphic rocks close to shore is the possibility of deposition of residual heavy minerals just offshore after the rest of the rock is weathered away. The usual minerals concerned are gold, tin, platinum, titanium (ilmenite, rutile), zirconium (zircon), thorium and rare earths (monazite). (Bruckner and Morgan (1964)) Diamonds also occur but obviously do not affect the trace element content.

Emery and Noakes (1985) show that there are significant coastal deposits which might be exploited in future. They include sources of thorium, rare earths, gold, iron and tin. Additional possible pollution from inland mining should be considered.

These deposits are not likely to produce widespread effects on background levels of metal concentrations in biota because these particular metals are, with the exception of iron, not essential elements and tend to be excluded from cells. They are also detrital and tend to be more insoluble than many other ores. However some very local effects could be found, and would be probably be very interesting.

The Tertiary sediments may produce a few minor unusual effects on trace metal concentrations when they erode and this is covered later.

The local oceanic currents produce a well-known eastward drift of material towards the mouth of the Niger and a northwards drift opposite Central Africa. Emery and Noakes (1985) point out that in general terms the region near the Niger can be considered as a general zone of deposition, and the other areas as areas of erosion. This coastal erosion, for the countries which suffer it, has at least the advantage that local pollution may also tend to be removed, but contrariwise pollution of the next country to the west or south may be deposited. It is certain that any pollution will have international dimensions and the WACAF group may therefore have a useful function to perform.

The coastal erosion itself is mostly likely to produce biological pollution, smothering colonies of living organisms, rather than altering the trace element balance significantly. Similarly the intense mixing this causes will rapidly dilute any pollution present. Following Akle (1985) and estimating a redistribution of 4 million tonne of sand in the Gulf of Benin each year, it will be clear later in this paper that pollution releases will be probably diluted several thousand times to harmless levels.

A possible source of alterations to concentrations of elements in ocean water is the presence of an area of upwelling. Middlebrooks et al. (1981) quote a region of upwelling from Cape Palmas to approximately Cotonou during the period June-October each year. This should bring to the surface, water containing greater amounts than normal of some elements, since they are regenerated at depth. This is true, for example, of copper, which is thought to diffuse out of sediments. It is certain that copper itself will be immediately involved in biological processes, which occur in great abundance in such upwelling regions and may not therefore survive very long to be carried north by currents. The intense biological productivity in such regions will also lead to a rather high sedimentation rate.

The marine sediments in the region can be broadly classed as terrigenous. However reasonably close to shore they become calcareous (See Seibold and Futterer (1982)). The Congo fan has beyond it, some significant quanities of silicaceous sediments, but they are sufficiently distant not to influence coastal studies.

Baselines

1.Waters

Some metals are deposited as a type of fallout in rain. There is an interesting recent study on this (GESAMP (1985)). Some results are given in table 1 which follows:

Table 1

Total deposition (mg m^{-2} yr^{-1})

	Pb	Cd
Enewetak	0.07	0.0035
N.Atlantic	3.1	0.050
Baltic	4-17.5	0.13-0.20
North Sea	7-26	0.20-0.85
Mediterranean	3-18	0.10-0.50

There will therefore be some trace element contribution from rain, but it is likely to be nearer the low levels found in Enewetak.

How do the local values of trace elements in the sea water influence the background of the region? Some reliable values, for the WACAF region, those of Kremling (1985), seem to exist. However some comment is necessary about the difficulty of such analyses. Up until about 1976 analyses of seawater were normally reported with values often in the ug l^{-1} range. With the advent of considerably more attention being paid to sampling techniques, it was found that for most elements, the values reported were far too high. The water samples were actually being contaminated in the process of collection by the nearby presence of metallic objects, such as the ship itself or the metallic wire holding the sampling apparatus. It proved necessary to construct the latter almost entirely of plastic, or plastic covered parts.

It also became apparent that values worldwide for many dissolved elements were much more uniform than one would think. In other words, the values should be oceanographically consistent, an assumption that will break down only when there are extreme changes in salinity (e.g. in an estuary) or very great amounts of suspended matter. Both these conditions are found in various parts of the study region.

Thus although Chester and Stoner (1974) specifically report results from the West African region, for Zn, Ni, Mn, Cd, Cu and Pb, all their levels are greater than 1 ug l^{-1} and must be reexamined.

The results of Kremling (1985) are open ocean results, not influenced by such considerations, but only consider the region about 5° west of Senegal. However Kremling found (nmol kg^{-1} ±1 standard deviation) 0.002-0.100 for Cd, 0.86±0.34 for Cu, 1.88±0.66 for Ni, 2.74±1.01 for Mn, and 25.4±7.3 for Al. The values for Mn and Al were elevated compared with the background values of around 1.0 for Mn and 15 for Al respectively. Kremling considered this was due to aeolian input from the Sahara dust. Thus there can in the WACAF region be alterations in the oceanic chemistry due to the natural environment.

Because of figures given in UNEP (1984) which are unreliable, I present here for background information, figures for ocean waters in addition to those given above by Kremling. They represent what are now considered to be reasonably accurate and representative levels: in ug l^{-1}: Co 0.05, Cu 0.1, Mn 0.2, Pb 0.003, V 2.5, Zn 0.1 (Martin and Whitfield 1983). In the same compilation is a series of representative figures for deep-sea clays and river waters and particulates, some of which will still be subject to later revision.

The difficulty of analyses of ocean water is coupled with the difficulty of actually noting any pollution which might alter the concentrations of elements in it. It has been calculated even for the Mediterranean, with its greater industrialisation, that even one hundred years input at current levels, would not produce significant elevation of the water content of most elements. This indicates that analysis of sediments is preferable, especially since pollution is likely to be concentrated there.

Another possibility for analysis, in theory is river water, but the same precautions as for sea water are needed, and many of the concentrations reported for river water in the literature need reeexamination, except perhaps where pollution is fairly obvious (Ndiokwere and Guinn 1983).

Also possibly affecting some river water analysis is the addition of rather heavily mineralised groundwater. For example Gaye and Travi (1982) report from Senegal that water leached from lower Marine Sediments may be extremely hard and contain significant quantities of fluoride ion. Similarly Lavoie et al (1982), report on amounts of manganese so high that the maximum permissible concentration may even be exceeded. It will be a general feature of tropical waters that manganese will be significantly high because of the intense leaching and results should be carefully interpreted in that light. However because of dilution the above groundwater factor is likely to be quite minor as an influence on results except locally.

Another influence on river water will be the large runoff. Flooding is known to alter the concentrations of trace metals. It is thought that the percentage dissolved (rather than in particulate form) increases during flooding at least for some metals, but the literature is somewhat contradictory (Bradley 1984, Habib and Minski 1982) and more clarification is needed.

Contamination problems have also arisen during sampling of suspended particulates making subsequent analysis futile, though the general recognition of this is slow to come. Many results reported for particulates from the open ocean or from rivers suggest that most metals in these particles are present in at least the 100's of mg kg^{-1} range and often much higher.

The results are much higher than for the corresponding sediments in the rivers or on the sea bed, but seem in many cases to be due to a type of contamination similar to that described for sea-water analysis. It is very easy to contaminate a sea-water or river-water sample to a level of a few tens of ug l^{-1} with a metal, when the true value is probably at least ten times lower. If that occurs how will it interact with the particulates present? Most of the particulates complex metal ions very strongly, and distribution ratios of 10^5 or more are possible. That will mean that a large part of the ions will attach themselves to the particulates which are generally present in small amounts. This artificially boosts the apparent metal content, and gives rise to the values mentioned earlier.

The effect becomes less and less significant the more the content of particulates in the sample. Our experience at Monaco is that if the content of solids in the water is greater than 10 mg l^{-1} then one can usually consider the effect of this adsorption to be small. I think it likely that such will be the case in many water samples in the region, and recommend this guideline. However we still recommend sampling with extensively precleaned bottles where possible, and much rinsing of the bottles with the sample before final closure. For sea water sampling quite special samplers are needed, beyond the scope of this paper.

For river particulates taken from regions in South France and in Italy we suggest background figures for copper of about 5-10 mg kg^{-1} and lead of 1-5 mg kg^{-1} (unpublished work). Other figures are reported in Martin and Whitfield (1983) - (all in mg kg^{-1}) As 5, Cd 1, Cr 100, Ni 90, B 70.

There exist a few specific figures for the Congo for which Martin and Meybeck (1979) should be consulted.

River waters certainly contribute significant amounts of metals to the marine environment, but how does this compare with the amounts mentioned earlier, which fall in rain? The following table 2 is an interesting comparison taken from GESAMP (1985) and is for the Mediterranean only:

Table 2

Element	Atmospheric input y^{-1}	Riverine input y^{-1}
Pb	5000-30000 tonnes	2200-3100 tonnes
Zn	4000-25000 "	11000-17000 "
Cr	200-1000 "	350-1900 "
Hg	20-100 "	30-150 "

The interpretation of these figures is complicated by the fact that some of this tonnage is natural and some anthropogenic. However the amounts are quite large. It is quite impossible to estimate the likely relative contributions in the WACAF region at present owing to lack of data, but obviously any full study would consider natural or background inputs like these and compare pollution with them. When that is finally done it is likely that as for the Mediterranean, deposition from the air to the marine environment will be a significant source.

2. Sediments

What are good background values likely to be for sediments in the coastal regions of the study area? To some extent this can be found only by studies in the area. However parts of this may already be affected by pollution before full scale monitoring can start. In such cases or to check whether such is the case it is important to analyse cores of sediments. The assumption is that the lower levels of such sediments are not contaminated, which for many elements which do not diffuse readily is probably true. If the sediment is anoxic, however, many elements are mobilised and the assumption probably will not be true.

However here are suggested sediment background figures for the Mediterranean, (Whitehead et al 1985 in press) which are quite similar to those from the Pacific, and may also be of interest in the study region: Cr 15 mg kg^{-1}, Cu 15 mg kg^{-1}, Zn 50 mg kg^{-1}, Cd 0.15 mg kg^{-1}, Pb 25 mg kg^{-1}, with standard deviation of 5 mg kg^{-1} or 0.05 mg kg^{-1} in the case of Cd.

Rather higher figures are reported for organic-rich sediments off South-West Africa by Calvert and Price (1970). They comment that the metals are associated with the organic fraction - Cu 130 mg kg^{-1}, Ni 460 mg kg^{-1}, Pb 30 mg kg^{-1}, Zn 340 mg kg^{-1}.

Ndiokwere (1984) reports some values for trace metals in sediments on the Nigerian coast and within the river Niger. The coastal figures are given in the table below.

Table 3

Element	Range (mg kg^{-1} dry weight)
As	4.7-7.6
Au	0.03-0.06
Cd	1.84-2.8
Hg	0.04-0.16
Mn	181-243
Ni	5.2-8.7
Pb	47.6-87.2
Sb	0.78-1.7
Zn	67.4-78

A few of the above figures may be compared with the background figures derived from elsewhere. It will be noted that they are slightly higher. The figure for the element Cd is ten times higher. The figures for the river environment were mostly a little higher, with an exception for Cd which is close to oceanic background figures elsewhere.

Chester (1982) comments about one feature of the sediments of West Africa which may affect analysis. The input from the Saharan dust is substantial, so much so that its content may be more than 20% of total (on a carbonate-free basis). This rather clearly indicates the probability of a need for a local determination of background, which is likely to be enriched in Al, Fe, Mn, Co, Cu, Zn.

The carbonate content and organic matter content will vary considerably also. Seibold and Futterer (1982) give a useful map for the Senegal region.

For a general background description of the Niger delta, the paper by Allen (1964) should be consulted. Generally sediments are likely to be organic rich in the mangrove areas, and at the river mouth, quartz sand, clean silt and clayey silt with plant debris. Much bioturbation is noted. There is likely to be some complexation of metals by the plant debris.

3. Biota

There are a few figures available for metal concentrations in biota from the region or near it.

According to Calvert and Price (1970) the plankton have Cu 300-6000 mg kg-1, Ni 60-90, Pb 1200-1800, Zn 6000-9000. This is in the Benguela current. However even though this is a zone of upwelling, it is feared that these figures are much too high and have fallen prey to the contamination problems during sampling mentioned earlier, where the material has a high affinity for the metals, and the sample mass is small.

A good compilation where great care was taken to avoid contamination, still remains that by Martin and Knauer (1973). Some typical figures are Pb 2-3.3 mg kg^{-1} (dry weight), Hg 0.08-0.014, Cd 2.3-6.4, Ni 2-8.4, Cu 6.5-15.6, Zn 70-180.

Some figures are available as a claimed baseline for various marine organisms in unpolluted areas on the West coast of Africa (Fourie 1976) which could prove of use to researchers. In terms of wet weight, Zn contents are often 1-20 mg kg^{-1}, Cu 0.2-4, Pb 0.1-1.6, Cd 0.1-0.9, Ni 0.1-1.2, Cr indetectable to 1.2. Several organisms are represented in the compilation.

Ndiokwere (1984) reports concentrations of metals in algae. The ranges found are given in table 4 below.

Table 4

Element	Range (mg kg^{-1} dry weight)
As	1.74-3.4
Au	less than 0.02
Cd	0.78-1.36
Hg	less than 0.001
Mn	35.6-67.4
Ni	1.5-3.1
Pb	4.8-7.63
Sb	0.16-0.43
Zn	78.5-104

These figures are for the sea. For the river Niger they were often about half the above values.

Ndiokwere (1983) also reports figures for intertidal molluscs, which had high levels of some of the elements. The molluscs were periwinkles and the figures in table 5 below are given in terms of mg kg^{-1} wet weight.

Table 5

	Samples from:	
Element	Port Harcourt	Warri
As	2.48±0.21	2.43±0.23
Au	0.083±0.007	0.091±0.006
Hg	0.053±0.025	0.072±0.04
Sb	less than 0.01	less than 0.01

Relatively high values were reported for the some of the major elements in the shells also. The author suspects pollution, though the details of the source are not clear.

Banus (1977) has suggested mangrove seedlings as pollution indicators and found unpolluted values of Cu 2.5 mg kg^{-1}, Fe 12 mg kg^{-1}, Mn 10 mg kg^{-1}. However only copper seemed to vary with pollution. The work was done with Red Mangroves at Puerto Rico. It is also worth noting that mangroves are known to accumulate Sn to ten times the normal level in mineralised areas (work from West Malaysia by Peterson *et al.* (1979)).

Finally there are some figures reported for fish analysis. Establier (1972) reported mercury concentrations in fish as far south as Dakar, and found values mostly less than or equal to 1 mg kg^{-1} Hg. However *Auxis thazard* and *Scylliorhinus stellaris* contained about 3 and 2 mg kg^{-1} respectively.

Similar results were found by Gras and Mondain (1978) for fish caught on the coast of Senegal. The values were 0.02-1.14 mg kg^{-1} depending on species. They report more values in later publications (Gras *et al.* 1980, Gras and Mondain 1981)

Some Russian work (Morozov et al 1974) reported a wide range of values for fish in the East Atlantic. They analysed for Fe, Zn, Sr, Mn, Ni, Cr, Pb, Cu, Co, Cd. In general Mn, Ni, Cr, Pb were 2-10 mg kg^{-1} with Co and Cd less than 2 mg kg^{-1}. The first three elements were mostly 10-100 mg kg^{-1}. Anchovy, herring and shark were among fish analysed.

Sources of pollution

As regards possible sources of metallic pollution they are many and a limited amount is known or may be inferred. As summed up in UNEP (1984) they are industrial pollution, muncipal sewage, agricultural waste and oil pollution.

1.Municipal wastes

Municipal wastes are an important source of trace metals with greater or lesser degrees of availability to biota. According to Forstner and Wittmann (1979), typical input to a sewage treatment plant may contain Cr 120 ug l^{-1}, Cu 100, Ni 160, Pb 60. Assuming the UNEP (1984) estimate of 400 l^{-1} person $^{-1}$ day^{-1}, and a total population on the coast of about 17 million in the region, and assuming no contribution from inland sources, we arrive at a total release per year of the order of 300 tonne Cr, 250 Cu, 400 Ni, and 150 tonne Pb.

These figures should be compared with those for oil spill contributions in the next section and it is clear they are larger for municipal wastes, and larger still if there is some contribution from inland sources.

It is highly important to compare these figures of hundreds of tonnes of trace metals with the 4 million tonne of sand moved by erosion each year (Akle (1985)). If mixing occurs, pollution is quite unlikely because of the dilution factor of 1000 present. Local pollution in lagoons, where erosion is not taking place, is much more credible.

It is possible to treat sewage by processes which produce sewage sludge rich in trace metals, and relatively pure effluent. However the problem of disposal of sludge then remains. Since one of the obvious routes of disposal for coastal areas is dumping at sea, (Forstner and Wittmann 1979) a conservative view must be that ultimately the trace metals will be released to the marine environment in any case. Chattopadhyay (1977), gives the following ranges of concentrations (in mg kg^{-1}) for raw sludge; V 9.5-38, Cr 600-5700, Mn 120-1000, Ni 20-1800, Cu 410-2400, Zn 230-2800, As 1.5-16, Cd 5-66, Hg 2.6-61, Pb 60-2900.

Cars also pollute, especially with lead and bromine. Studies usually show the amounts of these elements fall off exponentially with distance from the roads. Near roads vegetation may easily contain 1000 mg kg^{-1} of Pb, however effects are seldom seen more than a hundred metres from the road. This means that effects will generally be very localised, little lead and bromine will reach the sea, and this is not likely to be a source of significant pollution except where a road runs alongside the sea.

2.Oil Industry wastes

Crude oil contains various metals. The concentrations are low, but the amounts of crude produced each year are very large.

With an estimate of loss (UNEP 1984) of 0.5% of total oil shipment this would indicate at least 2,000,000 tonnes loss near West Africa each year based on some older figures for oil exports from the region. There could be a substantial amount of metal released. Even if a metal is present in oil at the mg kg^{-1} level we are talking about amounts potentially available for release to the environment of the order of one tonne of metal per year.

As examples, according to Carter et al (1975) Fuel oil has 0.3 mg kg^{-1} Pb and 0.01 mg kg^{-1} Cd, and according to Sheibley (1975) an NBS-EPA round-robin oil sample contained 0.25 mg kg^{-1} Co, 0.116 mg kg^{-1} Cr, 0.22 mg kg^{-1} Cu, 0.022 mg kg^{-1} Hg, 0.19 mg kg^{-1} Mn 39.5 mg kg^{-1} Ni, 0.0146 mg kg^{-1} Sb, 266 mg kg^{-1} V and 0.48 mg kg^{-1} Zn.

The nickel and vanadium figures are so high that if a crude oil contained them and was released at the above spillage rate, then we are talking about tens to hundreds of tonnes of vanadium and nickel released into the environment. However the amounts of the other elements are not negligible.

This is potentially one of the more serious sources of metallic pollution, and is the subject of current research since there are still gaps in our knowledge of how the metals distribute themselves in the environment from such spills.

In addition there is the possibility of pollution from the actual process of drilling. This arises from the discharge of drilling fluid to the marine environment. The subject is well dealt with in Panel.. et al. (1983). They mention that 1.1 tonne of drilling fluid are lost for each well 5 km deep, and that the composition (in mg kg^{-1}) includes Ba 37,400, Cr 191, Cd less than 1, Pb 3, Hg 3, Ni 4, V 5, Zn 50. The barium is the form of barite, or barium sulphate, and in theory should not be available to marine organisms. The chromium is thought to be in the Cr^{III} state and hence less toxic to biota, but significant fractions may be in the more toxic oxidised form. Studies have also shown that in spite of the theoretical non-availability of elements, drilling fluid is reasonable toxic to marine organisms and in addition the organisms contain significantly higher than normal amounts of barium and chromium. This is therefore potentially another source of pollution. The quantity of Cr discharged per well drilled is usually between 0.3-1.3 tonne.

Clearly if ten wells are being drilled somewhere in the WACAF region during the course of a year, the potential metal release is about equivalent to the nickel and vanadium released in oil spills.

The work of Armannsson et al. (1985) showed that copper could also be present in enhanced amounts in the sediments near an oil refinery. The amount was about 350 mg kg^{-1}, which is significantly above the results suggested earlier as representative of background ones.

3.Other Industrial wastes

Other industries may create pollution. For trace metals, only a few figures are readily available for likely trace metal outputs. The following data are from Forstner and Wittmann (1979). They are for a study of the New York bight and contrast municipal trace metal input with industrial. The greatest contributor to the percentages (not quoted here) was direct barge dumping of metal rich material.

Table 5

	% waste municipal	% waste industrial
Cd	5	0.6
Cr	22	0.8
Cu	11	9
Fe	5	0.5
Hg	71	2
Pb	19	3
Zn	8	2

This shows that even in New York, municipal wastes are an order of magnitude more important than industrial wastes. This is likely to be true for the WACAF region also. It suggests industrial wastes for a developed country are only one tenth as important as municipal wastes, and since the countries in the WACAF region are developing, it is likely industrial wastes will be much less important than oil industry wastes. We suggest therefore that they are third in order of importance.

The report also showed however that direct runoff of trace metals in rain cleansing contaminated urban surfaces was about as important as municipal releases, for its actual content of trace metals. This point is underemphasised. However probably most of the load is in the form of particulates and its metal availability may be somewhat diminished.

Mining can potentially contribute considerable quanitites of metals to rivers reaching the sea. For this region, it is important to consider the effects these may produce, which are very site and management dependent. It is obvious that mining a metallic ore may produce contamination of that particular metal. Geochemically most metal ores have been deposited under reducing conditions, and mining exposes them to oxidising conditions and hence solubilisation. This especially applies to the first transition series metals. In addition since many are essential elements they will be absorbed by biota, and the principle has even been used before mining, for prospecting. But the actual likelihood of significant quantities of these elements reaching the sea is not clear.

For other mining and processing of non-metallic resources, the trace metals involved are not so obvious. However bauxite, phosphate, cement industries give rise to various contaminants.

Production of aluminium from bauxite involves releases of significant quanities of fluoride to the environment from the molten electrolyte, the effects of which are summarised in UNEP (1984).

Rankama and Sahama (1950) suggest that elements concentrated in bauxite are Ti (35,000 mg kg^{-1}), Zr 500-900 mg kg^{-1}, V 600 mg kg^{-1}, Co 300 mg kg^{-1}, Ni 180 mg kg^{-1}, and Be, which is surprisingly high at 2-36 mg kg^{-1}. The consequences of these concentrations, and even whether they are accurately mirrored in West African deposits is not clear.

Phosphorite is known to contain large amounts of Zn, Cd, In and Bi, and 270-900 mg kg^{-1} Ba (Rankama and Sahama 1950). However again the ultimate fate of these elements during processing is not always known. For fertiliser factories Forstner and Wittmann (1979) quote Cd, Cr, Cu, Fe, Hg, Mn, Pb, Ni and Zn as possible contaminants of effluents and Cr from cement production. Chromium is also an important effluent from textile mills and leather tanning. Pulp mills or board mills potentially contribute Cr, Cu, Hg, Pb, Ni and Zn. Electroplating releases substantial quantities of Cu, Cr, Ni, Zn and Cd and Soap and candle factories also release Zn.

Finally the following table, adapted from Forstner and Wittmann (1979) is interesting as an indication of relative importances of effluents from various industries.

Table 6

Average concentrations in ug kg^{-1} effluent

Industry	Cu	Cr	Ni	Zn	Cd
Meat processing	150	150	70	460	11
Fish processing	240	230	140	1600	14
Brewery	150	60	40	470	5
Soft drinks	2040	180	220	3000	3
Textile dyeing	37	820	250	500	30

For some industries, such as edible oil production, figures do not seem so readily available.

It is obvious that the relative importance of any pollution caused by local industry will depend on the local circumstances, but overall it is unlikely that the effects will be greater than those contributed by the municipal wastes. This emphasises that it is people who pollute.

4. Agricultural wastes

Fertilisers used in agriculture contain trace elements. If these leach into rivers and into the sea, there is in theory the potential for pollution. To calculate this one must know the content of trace elements in the fertilisers and the tonnages of fertilisers used each year. Table 7 shows total tonnages for the WACAF region, of fertilisers actually consumed for various recent years (FAO 1983).

Table 7

Tonnes used per year.

Year	1979/80	80/81	81/82	82/83	86(extrapolated)
N	125000	154000	160000	160000	180000
P	70000	90000	122000	92000	110000
K	69000	74000	103000	90000	110000

Pollution from these should be a relatively minor problem. For potassium fertilisers it is known for example that the trace element content is not normally enough to supply the plants' needs. There is supposed to be a trace of cadmium in phosphate fertilisers which could potentially reach the sea. However there are many barriers on the way. Only a small proportion of the trace elements will be absorbed by the plants themselves. But a large proportion will be fixed strongly to the soils, and it will be easier for pollutant anions to reach waterways than pollutant cations.

It is possible to calculate an approximate figure for the overall scale of the trace elements introduced. We assume the total N+P+K tonneage is 500kTonne for next year.

Some approximate figures are available for trace element contents in fertilisers, both derived from sewage sludge, and chemical fertilisers (Chattopadhyay (1977)), as in table 8.

Table 8

mg kg^{-1}

	Sludge fertiliser	Chemical fertilisers
V	12-29	2-23
Cr	170-2200	10-40
Mn	120-580	10-700
Ni	46-123	1-14
Cu	110-860	10-50
Zn	100-410	30-500
As	1-13	0.5-1.6
Cd	15-38	0.16-4.8
Hg	1.4-26	0.1-1.3
Pb	132-1200	2.5-56

It is immediately obvious from this table that chemical fertilisers in general have much less content of most trace elements compared with sludge fertilisers and that in general the former are not likely to add more than about 20-30 mg kg^{-1} to the soil for most trace elements. This suggests that amounts added are likely to be of the order of perhaps 10 tonne per year given the calculated fertiliser consumption. That is less than the oil industry and much less than from municipal wastes.

The possible pollution from fungicides and pesticides containing mercury is another potential source of pollution but we have not yet found figures for the amounts of these used in the countries of the region.

Research is certainly needed for determining trace element distribution. Figure 1 shows how many papers were produced from the various regions of the world for occurrence of Zn, one of the commoner trace elements, and recorded in Chemical Abstracts for the year 1981. It is clear that there are few from the WACAF region, and there is therefore a vast field for research.

CHLORINATED HYDROCARBONS

There is a little scanty information on chlorinated hydrocarbon levels in the Atlantic. Harvey et al (1974) found an average of 30 ng l^{-1} of PCB's in the eastern Atlantic in 1971-2 compared with levels in the Sargasso Sea in 1973-4 of 0.8-1.0 ng l^{-1}. Harvey et al. (1972) reported DDT in zooplankton from western Atlantic areas from less than 0.001 to 0.95 ug kg^{-1} wet weight.

Clearly some of the environmental features of the WACAF region are important in the distribution and degradation of the chlorinated compounds. According to Goring et al (1975) organic matter content, temperature and rainfall and amount of aluminium and iron oxides in the soils, will all increase the rate of degradation significantly. The well known volatilisation of some pesticides will be increased by the high temperatures, but the high rainfall will produce a rainout effect. In addition the tendency of these compounds to attach themselves strongly to the surfaces of soil particles means that substantial transport will be under flood conditions in rivers when the bulk of particle transport occurs.

According to Larsson (1984) however, one of the features influencing most strongly the sedimentation rate of at least PCB's in relatively uncontaminated areas is direct precipitation from air. This is important since a major route for ecosystem cycling in the WACAF region will be through evaporation. He found no statistically significant differences in PCB content between Swedish lakes and the Baltic. He also records the possibility of recycling from the sediments for PCB's which is worthy of study.

GESAMP (1985) reports the following figures for the tropical N. Atlantic in air - PCB's 0.21-0.65 ng m^{-3}. Comparable figures for other regions are Mediterranean 0.04-0.3, North Sea 0.96, Central Pacific 0.19-0.32, N. Pacific Trades 0.049, S.Pacific Trades 0.012.

Some of this deposits in rain but some compounds deposit even in dry conditions.

Recent figures from our laboratory (Villeneuve et al 1985 unpublished) give the following table for dry deposition and concentrations in rain in the Western Mediterranean. They are likely to be higher figures than those for the WACAF region.

Table 9

Compound	Dry deposition ug m^{-2} y^{-1}	Rain ng l^{-1}
Arochlor 1254	14.6	1.3
pp'DDT	3.8	1.54
Toxaphene	40	7.2
HCB	0.08	0.64
Lindane	2.37	30
Alpha HCH	2.36	4.7
pp'DDE	2.44	0.06

There are no figures recorded for chlorinated hydrocarbons in sediments from the East Atlantic, even in the recent compilation of Sericano and Pucci (1984). However, they note the usual trend for the southern hemisphere - even though their results may have been influenced by the outflow of the main sewer of their local town, the concentrations found were lower than most others elsewhere.

All these factors combine to suggest these compounds will be available to marine organisms through river transport and deposition from the air and any filter-feeding organisms are likely to accumulate these compounds in fatty tissues, as reported in many other parts of the world.

One additional speculative factor is that hydrocarbon residues from oil spills may also tend to accumulate non-polar compounds such as some of those being considered, and any food chain which starts with the slow degradation and assimilation of oil spill residues is therefore interesting for study, though hardly for routine monitoring.

Tar balls indeed, are well known for their ability to accumulate pesticide residues with concentration factors ranging from 10^2 to 10^5. However the concentrations are quite erratic, with uneven distribution, and a considerable number would need to be analysed to obtain a mean representative of the local environment. In addition tar balls appear to absorb various metals from the environment not present in the original hydrocarbon material. (Sunay et al. 1979)

In addition to the above meager information it is possible to draw on work done under the aegis of the International Council for the Exploration of the Sea (ICES 1977). For open ocean areas pesticide levels in cod muscle varied from less than 0.1 to 1.0 ug kg^{-1} wet weight. Liver concentrations were considerably larger also showing variations between regions. Total DDT levels were about 1.8 ug kg^{-1}. PCB levels in cod liver were in the range 0.44-4.1 mg kg^{-1} (note that in UNEP (1984)they are erroneously given as ng kg^{-1}).

DDT figures for Nigeria seem only available for freshwater fish so far, rather than marine fish (Osibanjo and Jensen 1980).

It is well known that PCB's, DDT's and hexachlorocyclohexanes increase in concentration in higher trophic levels of a food chain (e.g. Tanabe et al. 1984). The overall bioconcentration of 10^7 found in striped dolphins is representative of the general concentrating that occurs, but the authors also emphasise the accumulation process is very complicated with the related factors varying according to the organisms, localities, temporal and spatial conditions. This suggests that specific studies in the WACAF region are not only useful but an essential part of the unravelling of the complexities worldwide, because they represent rather extreme conditions.

In earlier studies, Tanabe et al. (1983) it is pointed out that for historical reasons the concentrations of PCB's DDT's and HCH's are lower in the Southern Hemisphere than the Northern though use in the former is rapidly increasing. This does not necessarily apply to the concentrations at the highest trophic levels however, since the authors found in some cases such as the Dusky dolphin, that the concentrations were similar in both hemispheres. In the WACAF region detailed study is necessary. The authors recommend a "comprehensive study ....to trace the time trends on a global scale, especially in the southern hemisphere".

There therefore seems the necessity to establish baseline levels for each region. The lowest figures recorded for predatory marine mammals are those from Antarctica (McClurg 1984) (mostly less than 0.1 ug kg^{-1}) and in one sense are a type of world baseline, but figures from the WACAF region are likely to be much higher.

The main conclusion from these facts is that more research on chlorinated hydrocarbons is needed in the WACAF area, and results will be of interest to the scientific community. this conclusion is even stronger than for the case of Zn as reported in the section on trace metals.

As regards the sources of pollution, there seems rather little information easily available. Although UNEP (1984) mentions the substantial use of pesticides in the region, it does not present current figures of usage. However it must be several tens of thousands of tonnes per year when the figures for 1972 and 1974 are considered. Because of the constant need to control pests the usage is not likely to decrease in the foreseeable future.

In the case of trace elements, they were usually a small fraction of the wastes. In the case of chlorinated hydrocarbons it is the pure compound which is added to the ecosystem. Since this is tens of thousands of tonnes, the pollution could ultimately be more significant than for trace metals.

CONCLUSIONS

The paper has presented likely background figures for trace elements in sediments, water and marine biota and some data for chlorinated hydrocarbons. They are often an extrapolation from other parts of the world and it will be necessary to establish accurate figures for the WACAF region.

The tropical nature of the region will probably increase the rate of cycling of elements in the environment. The upwelling regions offshore may increase the levels of a few elements, and the erosion and deposition patterns must also be considered. The latter are likely to dilute most widespread pollution to harmless levels, except in very localised areas.

It is concluded that trace element levels in the the WACAF region are most likely to be increased above background levels by municipal wastes, then activities associated with the oil industry, then other industries, and contributions from the fertilisers used in agriculture. Many of the latter contributions are likely to be rather small, and possibly not detectable in the marine environment.

The levels of pesticides residues in various biota are likely to be measurable, but somewhat low compared with worldwide data. Very little data are available for the WACAF region. The distribution is again likely to be strongly influenced by the climate and deposition from air from evaporated compounds should be significant.

It is also emphasised that in view of the relative lack of data, a significant amount of research is possible which will produce new and useful results.

ACKNOWLEDGEMENTS

I would like to thank Ms C.Nauen and Mr H.Naeve of FAO, Rome for supplying data.

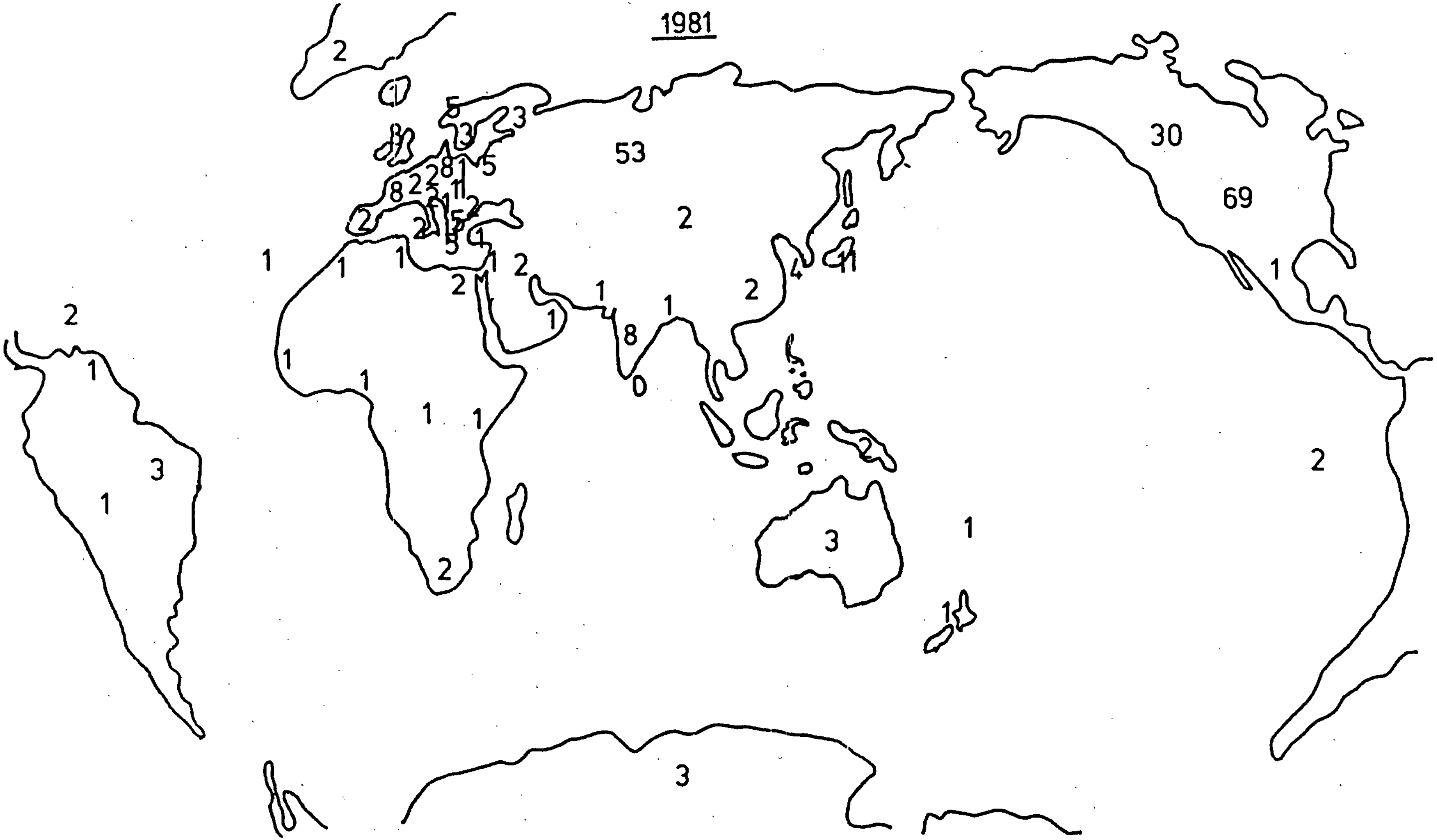

fig 1

Number of research papers on Zn produced from various region recorded in chemical abstracts for 1981

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A REVIEW OF THE HYDROGRAPHY AND PHYSICAL OCEANOGRAPHY OF WEST AND CENTRAL AFRICA

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INTRODUCTION

The objective of this review is to provide an overview of the physical oceanographic and hydrographic setting in the West and Central Africa Region in relation to the problem of marine and coastal pollution in the region.

A regional perspective is imperative because of the physical oceanographic phenomena that affect the transport and deposition of pollutants are usually large scale events that for the most part traverse national boundaries.

The report covers 20 countries from Mauritania to Angola (Fig.1) and is written for the benefit of participants in the joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the Sub-region.

West and Central Africa is a vast low table land dominated by a narrow coastal plain, a narrow continental shelf, a number of remnant erosion surfaces and an immature drainage. Generally, three main climatic zones are distinguishable, namely, the North and South Arid Zones separated by the Equatorial Humid Zone. The vegetation of West and Central Africa reflects the climatic (and in particular, rainfall) variations of the region. The region is relatively well endowed with rivers. Large drainage systems such as the Niger and Congo-Zaïre with extensive catchments debouch considerable quantities of water and sediment to the Atlantic Ocean.

The discussion on the hydrography and oceanography is preceded by background material on the Geology and Meteorology of the sub-region. Meteorology is especially important because most of the physical oceanographic phenomena have their trigger mechanisms in meteorologic events. Meteorology also has a bearing on the local redistribution of pollutants. The geology influences the mobility, affinity and fate of the pollutants and, hence, the nature of the impact of the pollutants on the environment.

GEOLOGY

The evolution of the continental margin of West and Central Africa is linked with the separation of South America from Africa. The dating of this separation is inexact as it consisted of a series of overlapping events.

According to an account by Emery et al (1974), the earliest of the events in the region was the development of small basins and troughs (the Liberia and Sierra Leone basins), when North America separated from Africa about 180 million years ago. Then followed the separation of South America from Africa which probably began at the south and proceeded northward occupying a time span of about 165 million years to about 135 million years. The general date of separation is indicated by the general continuity of Precambrian and Paleozoic strata and structures in Africa and South America and the disruption of Jurassic and younger structures. This separation led to the formation of the basins farther south (Mossamedes, Cuanza, Congo-cabinda, Gabon, Cameroon, Nigeria, Dahomey and Ivory Coast basins).

Continued separation of South America from Africa produced easily recognizable ocean - floor provinces (see Emery et al 1974 for details).

GEOMORPHOLOGY

The coasts in the West and Central Africa Region are mostly low plain, sandy and surf beatean. Four broad types are recognised; drowned coasts in the northern area; sand bar or lagoon coasts along the north of the Gulf of Guinea; deltas associated with most of the major rivers, e.g. Niger Delta usually with mangrove swamps and marshes; coasts with sand spits (and tombolos) formed by accumulation of longshore transported sand in bays found in the southern parts of Angola.

Landwards, the coastal lowlands rise through a series of steps which are essentially erosional surfaces to the highlands inland. The highlands are for the most part outcrops of the Basement complex although resistant sedimentary formations, mostly sandstones, are also common.

Oceanwards, the coasts descend to a generally narrow (100 km) continental shelf except near the northwestern limits of the region about 220 km northwest of Monrovia where the shelf reaches its greatest width. The shelf break occurs in an average water depth of 100 m except to the southeast, inshore of Walvis Ridge, where they are more nearly 400 m.

The shelf appears to be flat except off seacliffs of basement rocks and in areas where beachrock and coral - algal reefs are present. At least seven large submarine canyons etch the seaward edge of the shelf and one, the Congo Submarine Canyon, crosses the entire shelf from at least 25 km within an estuary (Veatch and Smith, 1939; Heezen et al, 1964; Shepard and Emery, 1973).

The continental shelf descends through the continental slope which is dominated by salt (or shale) diapirs and is disected by at least a score of submarine canyons into the continental Rises and Abyssal Plains.

Three continental rises located in turn by the Walvis Ridge, the Guinea Ridge (plus the Cameroon Volcanic Zone), the Ivory Coast Rise, and the Sierra Leone Rise occur in the region. The largest and best known is the Angola continental rise (about 2,800 by 800 km). The other two (guinea and Sierra Leone continental rises) are slightly shallowed and more irregular in outline because of greater influence by basement topography related to fracture zones. The continental rises show features known as continental rise swells that are similar but more subdued in relief than the lower continental rise hills off the eastern United States (Heezen et al 1959, p. 27; Emery and Uchipi, 1972, p. 71), Pagoda structures are also common on the continental rises and the adjacent abyssal plains, where probably most of the deepsea channels terminate.

Beyond the Abyssal plains are the Abyssal Hills, Mid Atlantic Ridge and other ridges.

SEDIMENTOLOGY

The land margin of West and Central Africa is bordered by lowlands that mark the areas of basins underlying major river valleys (such as the Niger - Benue) and the coastal zone. The basins date from the Mesozoic and therefore have been filled with continental, lacustrine, evaporitic and normal marine sediments. Seismic research and deepsea coring have revealed that the sedimentary basins in the region consists of huge piles of sediments, that range from 1.0 - 1.5 km or less off Sierra Leone through 5 - 6 km in much of the Gulf of Guinea to more than 8 km in the Niger Delta. The Gabon Basin contains 16 to 18 km of sediments (Brink, 1984) but in the southern most part of the region, the sedimentary layers again thin to about 3 - 4 km (Litvin, 1980). Calculated rates of sedimentation vary between 30 - 100 mm per 1,000 years north of the Congo decreasing to 10 - 30 mm per 1,000 years further south.

The fringing territory is mostly sandy beaches. Sediments of the shelf consist largely of sand being buried under recent silt and clay with an admixture of faecal pellets. The continental slope is covered by silt (e.g. Gabon basin and Cuanza basin) and Shale (e.g. Niger Delta).

Cores taken from the continental rises and abyssal plains show that they contain graded sand layers. Surface sediments of the continental rises and abyssal plains were indicated by Murray and Renard (1891) as terrigenous on the upper rise, with globigerina coze in most of the deeper region and red clay in the Angola Abyssal plain. The later Charts of Lisitzin (1969, Charts 5-8) show that sediments of the upper continental rises to be terrigenic silts and clays having 5-10 per cent iron. The lower rises and the abyssal plains on the other hand have chemogenic silts and clays with 10 - 30 per cent calcium carbonates, 3 - 10 per cent iron, and 0.1 to 0.5 per cent manganese.

Sediments in the complex topography of the abyssal hills, Mid Atlantic Ridge and the ridges that separate units of the continental rise are highly irregular (Ewing et al, 1964, 1966; Emery et al, 1974). As shown by Lisitzin (1969, Charts 5 - 8), the surface sediments of this region are mainly biogenic silts and fine sands with more than 50 per cent by weight composed of grains between 0.1 and 0.001 mm. Calcium carbonate is 70 to 90 per cent of total weight and consists of foraminiferams, coccoliths, and other calcareous skeletal debris. Iron and manganese each constitute less than 1 per cent by weight. Some volcanic sediments surround both St. Helena and Ascencion Islands as well as the volcanic islands of Fernado Poo, Principe and Sao Tome.

METEOROLOGY

TEMPERATURE

Temperatures in the West and Central Africa remain high throughout the year and reflect the perennial high level of solar radiation (insolation).

In general, mean temperatures vary between 23° to 36° giving a relatively small annual range. The lower temperatures occur during the rainy season although along the Coast of Mauritania, Senegal and Gabon, there is a curious situation in which the wet season's mean daily temperatures are higher than the dry season's temperature. This is thought to be related to the cooling effect on dry season temperature of the cool Canary current. Hardly anywhere in the region does the temperature fall below 20°C even for the coldest months. The highest temperatures occur in the desertlands to the North and South of the Region. Both the diurnal and annual range of temperature increases from the coast inland. Most coastal locations have a range of 3° - 8°C but farther inland the range reaches 10 - 12°C.

PRESURE FIELDS

In West and Central Africa, as indeed in the rest of Africa, seasonal characteristics of the surface atmospheric circulation and those of ground wind systems are determined by the position and intensity of four major pressure fields.

Two of these fields, the anticyclones of the Azors and St. Helen are permanent marine systems. The third, the Libyan or Maghrebian anticyclone is a seasonal continental system. The fourth pressure field is the Intertropical Discontinuity (ITD, also known variously as ITF, ITZ, etc.) and is situated in the intertropical low pressure zone where the marine and continental air masses converge.

The seasonal migration and dominance of these pressure fields determine the occurrence and characteristics of climatic seasons in West and Central Africa.

WINDS

The regime (i.e. direction, intensities and duration) of surface winds particularly those that influence the oceanography and hydrography of the region is linked to the barometric distribution, gradients and stability of the main pressure fields.

The Equatorial Maritime air mass is associated with the moisture laden south-west winds while the Equatorial Continental air mass is associated with the dry and dusty north-east trade or the Harmattan. The meeting zone of the two air masses is the Intertropical Discontinuity. The year in this region may be divided strictly into two seasons corresponding to the periods when each of these winds influence most of West Africa and further south although here the influence of the Benguela current on climatic patterns is more pronounced. Along the coast, the two seasonal winds are sometimes replaced by sea and land breezes. Sea breezes prevail during the afternoon and evening while the land breezes dominate in the night and early mornings.

PRECIPITATION

The commonest form of precipitation in the West and Central Africa region is rain. Another form is hail which consists of rounded lumps of ice and is usually associated with thunderstorms and linesqualls, which occur mostly at the onset and decline of the rainy season.

The narrow coastal belt (except for the Accra dry Belt) is under the influence of the southwest winds all the year round and receives the most rain. The rainfall season increases in duration from the coast inland except where local relief (e.g. Jos Plateau in Nigeria and Togo Highlands) results in higher total annual rainfall for inland areas. There is a general decrease in rainfall from 3,050mm per annum along the coast of Sierra Leone and Liberia and the Niger Delta to below 250mm in the areas north of latitude 15°N and south of 15°S. For instance, the high annual rainfall of 10,000 mm for Debuncha at the foot of the Cameroon mountain results from the relief effect of that mountain.

The south of the region including southern West Africa has a two-maxima rainfall regime in which the wettest months are June and October while the northwest areas of the region have a one maximum regime with September as the rainiest month.

HYDROGRAPHY AND PHYSICAL OCEANOGRAPHY

BATHYMETRY

The bathymetry of the West and Central Africa region is fairly complicated (see e.g. Emery et al 1974 reflecting in general the complex physiographic setting. The broad coastal indentation north of latitude 5°S is the Gulf of Guinea.

GENERAL OCEANIC CIRCULATION

The surface oceanic circulation of Western and Central Africa derive their origin from two oceanic gyral currents of the North and South Atlantic which in turn are fueled by the gyral surface wind system of the two hemispheres. Hence the following currents are observed in the area.

To the north, the south flowing cold Canary Current flows along the coasts of Mauritania and Senegal, warms up as the equator is approaching and splits into a west-ward North Equatorial Current and eastward flowing Guinea Current.

To the South of the region, the cold Benguela Current flows northwards along the coasts of Namibia and Angola, and warms up as the equator is approached. Its main mass goes westwards as the South Equatorial Current while a tongue of it streams northwards till it hits the Bight of Biafra (Bonny) where it perhaps contributes to the reversal of the Guinea Current.

An eastward flowing current, the Equatorial Counter Current is enbedded between the North and South Equatorial Currents and at its landward end contributes to the eastward flowing Guinea currents (Fig. 2).

Thus the oceanic currents directly affecting the hydrography of the West and Central Africa region are the Canary and Benguela currents, the Equatorial Counter Current, the South Equatorial Current and the Guinea Current.

Those principal currents are fairly constant in their main directions of flow, but locally along most coasts, their directions at any one time are influenced by local oceanic phenomena.

TIDES

The tides that affect the coasts of West and Central Africa are mainly semi-diurnal, with two daily maxima and minima.

The tidal range varies from one area to the other but as Table 1 shows, with a few exceptions, the coasts having a mean tidal range of 1 to 2 m. The following broad pattern is discernible :

(i) a decrease from a mean height of 1.9 m in Mauritania to 1.2m in Dakar, Senegal,

(ii) a significant increase southward to a mean range of 5.1m in Guinea Bissau,

(iii) a southward downward plunge to a mean range of 1m in Ivory Coast,

(iv) a slight rise southward to 1.4m at Togo,

(v) a drop eastward to a tidal range of 1.1m at Lagos in Western Nigeria,

(vi) a progressive rise to 3 m at Calabar in the eastern extremity of Nigeria,

(vii) a decrease southward with few exceptions to 2m in Cameroon and Gabon,

(viii) a further decrease southward to a mean range of 1.2 - 1.3m in Zaire and Angola with the exception of Cabinda (Angola) where it is 1.8m.

The tidal range is especially important because two energy factors of high significance in the consideration of the hydrographic regime, namely wave energy and tidal energy, can be directly related to tidal range. For example, the efficiency of wave action disminishes and tidal current action increases with increase in the vertical tidal range. On the basis of tidal range, Davis (1964) classified shorelines as follows :

Class	Tidal range
Microtidal coasts	0 - 2m
Mesotidal coasts	2 - 4m
Macrotidal coasts	4 - 7m

According to this classification, most of the coastlines in the region are microtidal. In general, coasts of this nature are dominated by wave energy while coasts with large tidal ranges are dominated by tidal currents. Only the coast of Guinea Bissau belongs to the later category.

WAVES

Detailed information on the wave climate is not uniformly available. In the area from Mauritania to North Senegal, the northwesterly swell with a period of 8 - 12 sec. and a wave length of 300m is very dominant (up to 98%) over the southwesterly one. This swell is stronger during the dry season than during the winter and during storms it affects the sea bottom as deep as 30m. It is the principal agent that controls sedimentation in the region. The swell regime from South Senegal to Gambia is similar to that described above. The Cape Verde Peninsula however, disturbs the hydrodynamic processes as it represents an obstacle to the swell direction. That strongly depletes the energy as the swell enters the Bay of Goree, a sheltered area north of the bay of Rufisque.

To the south, the northern boundary of Guinea-Bissau separates the two main regimes of swell affecting the shores in this region. It is in that area that the southerly and northerly swells run into each other and the drift direction remains uncertain; crossswell series are often observed.

There is a superposition of 2 swell series in the Sherbro Islands (Sierra-Leone) to Cape Palmas (Liberia) region: the first are long waves with 12 S. period generated by south Atlantic storms and the second are shorter period waves formed by local winds. Swells attaining a height of 4.8 - 6m occur with a 10 to 20 years periodicity. The strongest swells occur during the July to September period commonly approaching from the south to southwest.

Between Cape Palms to Cape Three Points the swells reaching the Ivorian Coast originate mainly (84%) from the south to southwest. They are strongest from March to July with a maximum in May. The mean significant height of swells is 0.80m, the mean height being 1.5m and the annual significant swell is 3.3m.

From Cape Three Points (Ghana) to Lagos (Nigeria), the southwesterly prevailing winds generate swells which reach the coast at oblique angles. Hydrodynamic parameters measured at Keta, Ghana showed significant wave heights of 1.2m occurring 50% of the time with period 10 - 15secs. At Lome (Togo), maximum and minimum wave height are 3.5 and 0.38m respectively with 75% of the waves being lower than 1.5m. The waves here have wave periods of between 5 and 19.5 S. with a 9.3. S. average value. At Cotonou (Benin), the most frequent period is 12 S., with mean wave amplitude of 1.4m. According to Nedecco (1984) waves off Cotonou are 20% higher than off Lome. Significant wave height at Lagos is 1.4m having a period of 5 - 13 S. because the swells are superimposed at nearshore by shorter period wind generated seas. (Ibe, 1985). The wave series along the nest of the Nigerian coast are similar to those at Lagos except around the major tidal inlets where some modification of wave characteristics results.

From Rio del Rey (Cameroon) to Cape Lopez (N. Gabon) the prevailing south-southwesterly swells are weak with amplitudes generally lower than 1m. At Cape Lopez, the characteristics of the swell at a depth of 8M are as follows: most frequent period 125; most frequent significant amplitude, 0.6; maximum significant amplitude, 1.5; mean direction, 260.

Southwards at Pointe Noire (Congo), the swell has a preferential southwest to west-southwest direction, a mean amplitude of 1.4m and a 12S period. Further south in Angola the southerly swell which has similar characteristics to that in the Congo reaches the coast with an oblique incidence.

COASTAL CURRENTS

The circulation pattern described above is in respect of oceanic currents that have broad regional implications. They have limited direct influence on the coast. In the immediate vicinity of the coasts, tidal waves generated currents are the dominant phenomena.

Tidal currents are particularly effective around river mouths where they modify sediment transport but less effective on continuous and straight shorelines except in areas with high tidal ranges (macrotidal coastlines). From the generally low mean tidal ranges observed along the coastlines of most of the countries in the region it is to be expected that tidal currents would be generally weak. The area extending from Guinea Bissau to Sierra Leone wheretidal range varies between 2.5 and 5.1m is about the only area where the tidal currents may attain significant velocities over the shelf. It is also to be expected that around river mouths and tidal inlets, the velocities would be higher than the average for the region. For example, Ibe et al (1985) have reported ebb tidal current velocities of up to 5m/s at tidal inlets on the Ondo Coastline of Nigeria.

The most important wave generated currents are the longshore currents. They are generated in situations where the waves approach the coast diagonally and they act largely parallel to the coastline. Longshore currents in the region, generally less than 1m/s are responsible for transporting phenomenal amount of sediments. Between Mauritania and Senegal estimates of longshore drift reach up to $1Mm^3$ per year. In the area from Cape Palms to Cape Three Points, littoral drift is about 0.8Mm^3 per year. Between Cape Three Points and Lagos estimates of longshore transport vary between 25Mm^3 per year in Ghana to 1.5Mm^3 per year in Nigeria. From Rio Del Rey (Cameroon) to Cape Lopez (N. Gabon) longshore transport is thought to drop to 2Mm^3/year in a dominantly northerly direction.

Another effect of the breaking waves along the coasts of this region is to set up rip currents. Although localised in their action, they have an appreciable impact on offward transportation of sediments from shore.

Apart from the current discussed above, other physical oceanographic phenomena that affect the transportation and dispersal of pollutants within the marine environment are turbulent mixing and the upwelling phenomenon. The latter play an important role along several parts of the coast, in the northern and central zones.

CONCLUSION

Oceanographic phenomena that affect the different national coastlines in the West and Central African Region derive directly or indirectly from large scale events that originate for the most part outside of national boundaries. The implication for pollution in the region is that a nation may suffer from deleterious effects of pollutants transported from outside its area of juridiction and therefore over which it has no control. The recognition of the interplay between hydrographic and physical oceanographic phenomena and the spread of pollutants in the region calls for co-operation between countries in the region. It is hoped thatthis recognition will fuel the co-operative acquisition of oceanographic data as part of the WACAF/2 Project.

It should be possible in the near future to organise periodic regional research cruises involving scientists from nations in the sub-region and aimed at obtaining an integrated picture of the physical oceanography and hydrography of this region. However, it is important as a prelude to this regional co-operation for countries to begin to understand the pattern within their individual boundaries. In this regard it is hoped that the countries which do not have the necessary expertise to initiate this kind of work would benefit from assistance provided under the WACAF/2 Scheme.

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Tableau 1 - Tableau des marées (vive-eau) dans les principaux ports de l'Afrique de l'Ouest et du Centre
Modified after Collins et al. (1983)

Table 1 - Western and Central African coastline tidal ranges
Modified after Collins et al. (1983)

COUNTRY	PORT	TIDAL RANGE (m) MARNAGE
Mauritania	Bahia de Villa Cisneros	1.9
	Nouadhibou	1.8
Senegal	St. Louis	1.2
	Dakar	1.3
Gambia	Banjul	1.6
Guinea Bissau	Bissau	5.1
Guinea	Conakry	3.2
Sierra Leone	Pepal	2.9
	Freetown	2.6
Liberia	Monrovia	1.1
	Buchanan	1.0
Ivory Coast	Abidjan	1.0
Ghana	Takoradi	1.3
	Accra	1.3
Togo	Lome	1.4
Benin	Cotonou	1.2
Nigeria	Lagos	1.1
	Forcados Estuary	1.5
	Imo Estuary	2.0
	Cross Estuary	3.0
Cameroon	Douala	2.0
Equatorial Guinea	Bata	1.6
Gabon	Libreville	1.6
	Cap Lopez	2.0
Congo	Pointe Noire	1.3
Zaire	Banana	1.3
Angola	Cabinda	1.8
	Luanda	1.2
	Lobito	1.2
	Mocamedes	1.2

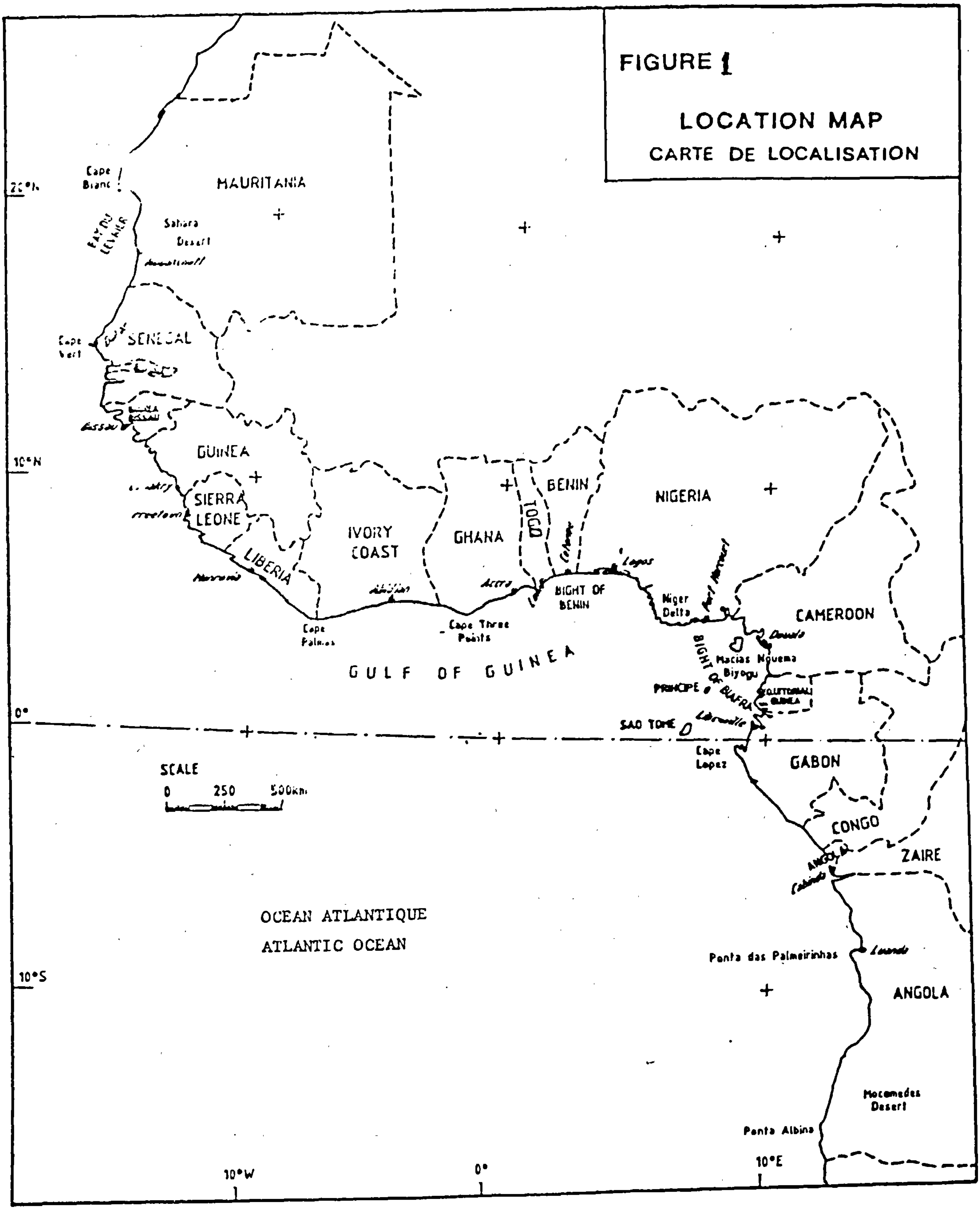

FIGURE 1

LOCATION MAP

CARTE DE LOCALISATION

Source : WACAF/3 Publication on Coastal Erosion (1985)

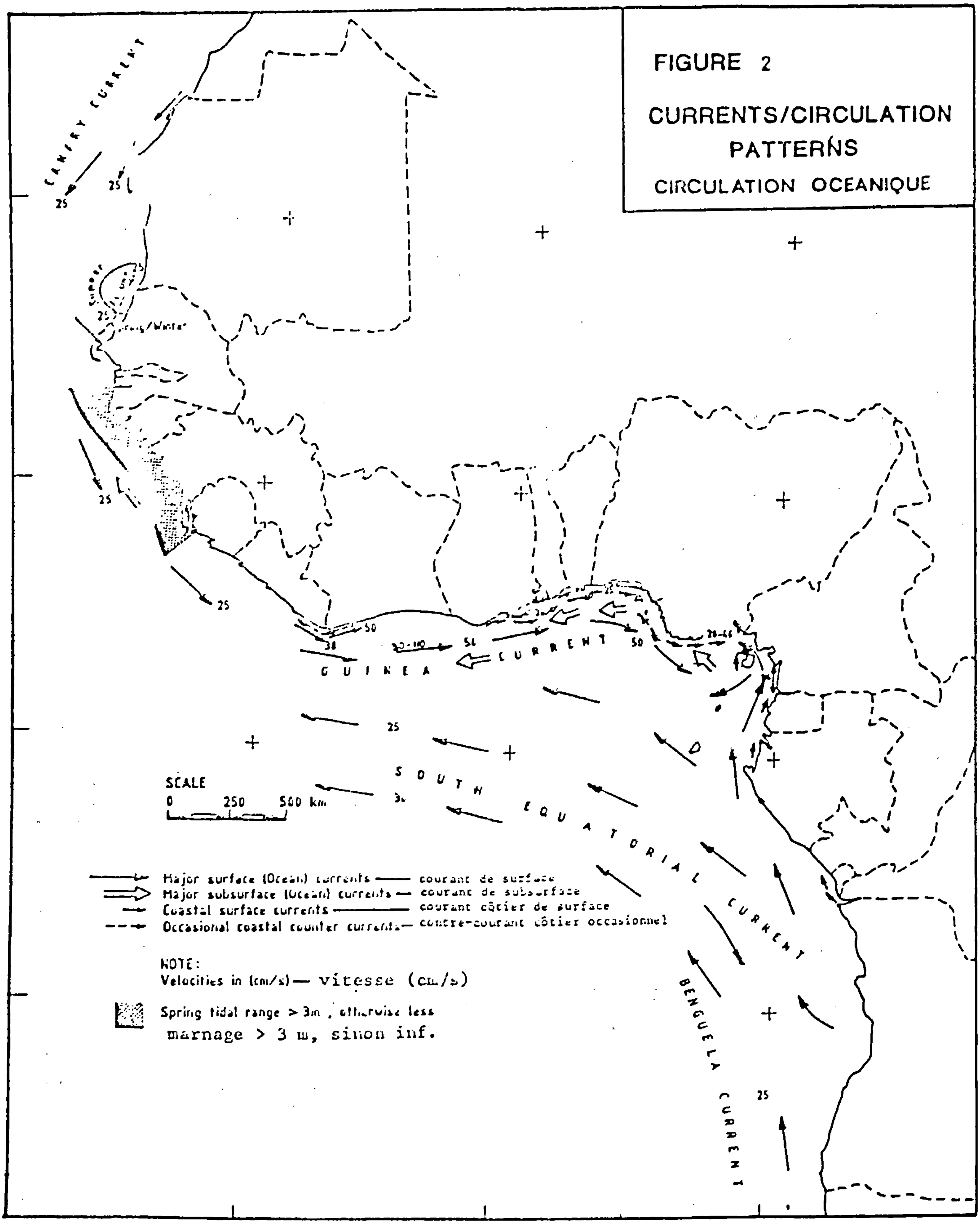

FIGURE 2

CURRENTS/CIRCULATION PATTERNS

CIRCULATION OCEANIQUE

Source : WACAF/3 Publication on Coastal Erosion (1985)

No.	Title	Publishing Body	Languages
32 Suppl.	Papers submitted to the UNU/IOC/Unesco Workshop on International Co-operation in the Development of Marine Science and the Transfer of Technology in the Context of the New Ocean Regime Paris, 27 September-1 October 1982	IOC, Unesco Place de Fontenoy Paris, France	English
33	Workshop on the IREP Component of the IOC Programme on Ocean Science in Relation to Living Resources (OSLR) Halifax, 26-30 September 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
34	IOC Workshop on Regional Co-operation in Marine Science in the Central Eastern Atlantic (Western Africa) Tenerife, 12-17 December 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English French Spanish
35	CCOP/SOPAC-IOC-UNU Workshop on Basic Geo-scientific Marine Research Required for Assessment of Minerals and Hydrocarbons in the South Pacific Suva, Fiji, 3-7 October 1983	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36	IOC/FAO Workshop on the Improved Uses of Research Vessels Lisbon, 28 May - 2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
36 Suppl.	Papers submitted to the IOC-FAO Workshop on Inproved Uses of Research Vessels Lisbon, 28 May-2 June 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
37	IOC/Unesco Workshop on Regional Co-operation in Marine Science in the Central Indian Ocean and Adjacent Seas and Gulfs Colombo, 8-13 July 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
38	IOC/ROPME/UNEP Symposium on Fate and Fluxes of Oil Pollutants in the Kuwait Action Plan Region Basrah, Iraq, 8-12 January 1984	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
39	CCOP (SOPAC)-IOC-IFREMER-ORSTOM Workshop on the Uses of Submersibles and Remotely Operated Vehicles in the South Pacific Suva, Fiji, 24-29 September 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
40	IOC Workshop on the Technical Aspects of Tsunami Analyses, Prediction and Communications Sidney, B.C., Canada, 29-31 July 1985 (in press)	IOC, Unesco Place de Fontenoy 75700 Paris, France	English
41	First Workshop of Participants in the Joint FAO/IOC/WHO/IAEA/UNEP Project on Monitoring of Pollution in the Marine Environment of the West and Central African Region (WACAF/2) Dakar, Senegal, 28 October - 1 November 1985	IOC, Unesco Place de Fontenoy 75700 Paris, France	English