REGIONAL SEAS

UNITED NATIONS ENVIRONMENT PROGRAMME

*J. E. Portmann et al.:*

# *State of the marine environment: West and Central African Region*

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# PREFACE

The better understanding of the changing problems facing the marine environment is a continuing goal of UNEP's Ocean programme, as it provides the necessary scientific background for shaping UNEP's policy towards the protection of the oceans.

The main sources of factual information used in the assessment of the state of the marine environment are data published in open scientific literature, data available in various reports published as "grey literature" and data generated through numerous research and monitoring programmes sponsored by UNEP and other organizations.

Several procedures are used to evaluate critically the large amount of available data and to prepare consolidated site-specific or contaminant-specific reviews.

GESAMP, the IMO/FAO/Unesco/WMO/WHO/IAEA/UN/UNEP Joint Group of Experts on Scientific Aspects of Marine Pollution, is charged by its sponsoring bodies with preparation of global reviews. Reviews dealing with several contaminants have been already published by GESAMP and others are being prepared for publication. The first global review on the state of the marine environment was also published by GESAMP in 1982, and the second global review is being prepared for publication in late 1989 [1/].

In parallel with the preparation of global assessments, the preparation of a series of regional assessments, following the general format of the second global review of GESAMP, was initiated by UNEP in 1986, with co-operation of the Food and Agriculture Organization of the United Nations (FAO) and the Intergovernmental Oceanographic Commission (IOC). Fifteen task teams of scientists were set up, involving primarily experts from the relevant regions, to prepare the regional reports under the joint overall co-ordination of UNEP, FAO and IOC, and with the collaboration of a number of other organizations.

The present document is the product of the Task Team for the West and Central African Region. The final text of the report was prepared by J.E. Portmann, as Rapporteur of the Task Team for the West and Central African region, with collaboration of C. Biney, A. C. Ibe and S. Zabi, whose contributions are gratefully acknowledged.

1/ Publications of GESAMP are available from the organizations sponsoring GESAMP.

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# 1. INTRODUCTION

## 1.1 Aims of the report

This report attempts to summarise the information available about the State of the Marine Environment in the West and Central Africa region. The area is large and in many respects inhomogeneous e.g. linguistically and developmentally as well as having obvious climatic and hydrographic differences. It is perhaps therefore not surprising that the level of infórmation available varies markedly from country to country. In a sense this does not matter since the overall aim of the report is to extract aspects of commonality i.e. problems which arise in many of the countries, whether they be pollution oriented or simply lack of data or an appreciation of the causes of problems and how they can be solved most cost effectively.

## 1.2 Geographic coverage

The various documents and reports published by the UN organisations relative to the West and Central African (WACAF) region differ somewhat in their statements as to which countries are included in the area. Some include Mauritania, Cape Verde and Namibia but others have the region extending only from the northern border of Senegal to the southern border of Angola (Fig. 1). Either way the region concerned is large. For this reason the area is divided into three zones, the northern, middle and southern zones. No definition appears to have been made of the western boundary, i.e. how far offshore the area extends, it is assumed for this report that it is at least the continental shelf.

The countries range form small island communities like Sao Tome and Principe to very large mainland like Zaire, Angola and Nigeria. The state of development of the countries also varies, with some, like Nigeria and Senegal, being relatively industrialised in comparison to others, like Benin or Sao Tome and Principe, which have essentially handicraft based economies. Although in general the coastlines are sparsely populated, with an average of only about 10% of the population living on the coast, these people are concentrated in relatively few main centres and the proportion of the population living on the coast is growing. The capitals of all but three of the countries are situated on the coast and it is on the coast that the major industrial developments are taking place. For example, in Ghana 35% of the population live in towns and 60% of the industry is concentrated in the coastal Accra/Tema metropolis. Similarly in Nigeria about 10% of the total population of about 80 million live in Lagos which is also the centre for 85% of the country's industry.

## 1.3 Preparation of the review

The material on which this document is based has been drawn primarily from contributions provided by Dr. Biney (Ghana), Dr. Ibe (Nigeria) and Dr. Zabi (Côte d'Ivoire), material gleaned from the open literature and reports in the UNEP Regional Seas Reports and Studies Series and documents provided by FAO. The information is given under three main headings: Marine Contaminants, Human Activities affecting the Sea and Biological Effects. Information on prevention and control strategies and on trends and forecasts were also obtained from Drs. Biney and Ibe and from correspondents in Gambia, Côte d'Ivoire, and Congo following circulation by FAO of a short questionnaire on these subjects to contacts in all countries of the region. A short section on economics covers the value of fisheries in the area but no attempt has been made to attribute costs to effluent treatment or new discharge arrangements. This topic was covered by an experts visit to the area and the report was published by UNIDO/UNEP (1982). The information in that report is

**Northern**

1. Mauritania
2. Cape Verde
3. Senegal
4. Gambia
5. Guinea Bissau
6. Guinea
7. Sierra Leone
8. Liberia

**Middle**

9. Côte d'Ivoire
10. Ghana
11. Togo
12. Benin
13. Nigeria
14. Cameroon
15. Equatorial Guinea
16. Sao Tome and Principe
17. Gabon

**Southern**

18. Congo
19. Zaire
20. Angola
21. Namibia

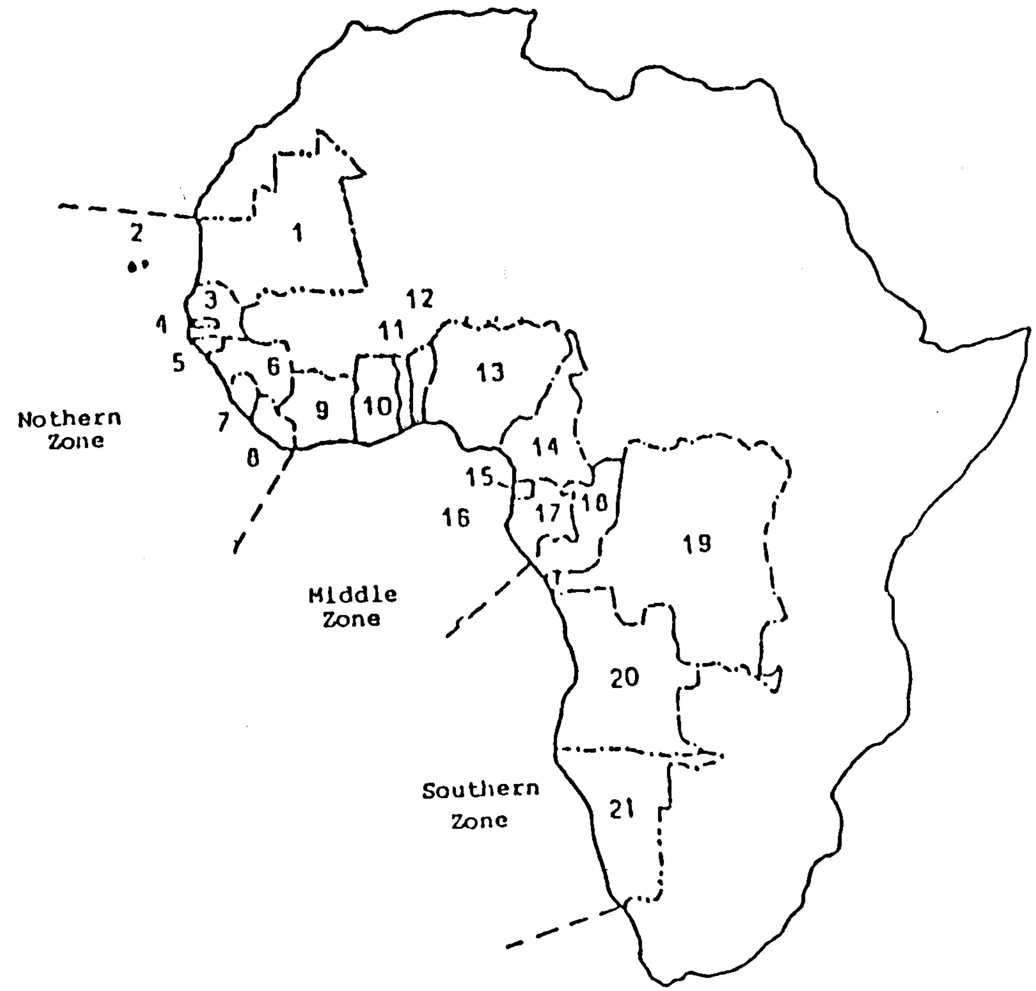


Figure 1: Countries and zones of the WACAF region

however dated and does not take account of what level of treatment is required to alleviate the particular problems or level of pollution faced in the area concerned.

## 2. CHARACTERISTICS OF THE REGION

As has already been mentioned the WACAF area is large, stretching from 16°N to 18°S. As might be expected the nature of the coastline varies markedly from North to South, as does the climate. The coastal regions range from dune through marshy delta lands and mangroves to Rias with steep cliffs and back to dunes again. The coastal shelf has an average width of 30-50 km but has a range of from only about 4 km off Angola and Zaire to about 70 km in the Gulf of Guinea. The climate ranges from desert in the North (Sahara) through a humid tropical belt, which contains two of Africa's largest rivers, the Niger and the Congo-Zaire, to desert again in the south (Kalahari). The main features of the climate and oceanography have been summarised in a UNIDO/UNEP report published in 1982 (UNIDO/UNEP 1982).

In the equatorial zone of the Gulf of Guinea the average precipitation is high with 200 cm/yr and close to the coast of Liberia the average rainfull can be as high as 550 cm/yr. Nigeria in fact has the wettest place in the world with an annual rainfall of almost 1000 cm. Temperatures in the region average 20 to 26°C for most of the year with little real difference summer to winter. Maximum temperatures are usually encountered near the coast of Liberia and along the coast of the northern part of the Gulf of Guinea 32 to 36°C. The minimum temperatures are usually found off the coast of Namibia and may fall as low as about 12°C.

The main oceanographic currents of the region were described as long ago as 1962 by Longhurst (1962). Five distinct and relatively persistent oceanic currents are of importance in respect of the transport of substances, water temperature, meteorology and biological conditions. They are the Benguela Current flowing along the coast of the south west African zone veering offshore at about 6°S; the Guinea Current flowing eastwards and south-eastwards along the coast of the Gulf of Guinea, almost to the Equator, and which essentially constitutes a continuation of the Equatorial Counter-Current; the South Equatorial Current which flows west some distance from the coast between about 10°S and the Equator and the Canary Current which flows south-westwards along the coast in the northern part of the region feeding both the Guinea Current and the North Equatorial Current. Both the Canary Current and the Benguela Current transport cool water towards the Equator and have current speeds of about 20 cm/sea. The Guinea Current carries warm water towards the coast and has speeds of 1-3 knots with the highest currents in the summer months. All the currents are essentially wind-driven.

The prevailing regional wind-systems along the coasts of the region generate an offshore flow component in the surface layer of the sea due to the combined action of the wind stress and the rotation of the earth. The offshore transport is compensated by onshore flow at intermediate, 50-300 m depths and vertical flow towards the surface layer (upwelling) in a band of some tens of kilometres width adjacent to the coast. This is a very important feature along large parts of the coastline; along the north west part from October to April; along limited parts of the northern Gulf of Guinea coast in summer months and along the southern coastline in the Benguela current system with very strong upwelling in winter (August) and weaker upwelling in summer (November to February).

The areas of upwelling are characterised by high productivity and the southern part of the region is a particularly rich fish production area. In the northern area the pelagic fish population is dominated by <u>Sardina pilchardus</u>, whereas in the Benguela Current regime it is <u>Sardinops ocellata</u>. Two groups of pelagic species are found throughout the region <u>Sardinella aurita</u> mainly in the intertropical waters and various <u>Trachurus</u> sp. Demersal fish are also found, with a wide variety of species, but in the equatorial zone fisheries exploitation of demersal species is not important. Various species of crustacea are found in the area and there are important fisheries for lobsters in the northern and southern zones, for deep water shrimp off the coast of Senegal and Angola and prawns in the Gulf of Guinea. In the coastal regions and in the lagoons unaffected by man's activities exploitable marine resources are abundant with both fish species and prawns and molluscs being found.

With ten major rivers draining the region, land run-off is potentially both an important source of nutrients and suspended matter to the coastal zone. The rivers are also liable to carry industrial wastes, especially from mining. Alterations to flow regimes due to dam construction for irrigation and power generation schemes have altered the flow characteristics of most of the rivers with the result that flows are usually slower. This has potential consequences both for flushing characteristics of lagoons and for siltation in delta and mangrove areas. Harbour construction schemes also have a potential to alter long-shore current transport and in some areas have led to major erosion and siltation problems.

As mentioned earlier most of the countries of the region have their capitals on or close to the coast and the industries that have been attracted to these centres of population and the coastal ports have a potential to markedly affect either the availability of the marine living resources of the area or their acceptability as a source of human food. The latter aspect may also be affected by micro-organisms discharged with the sewage from the large numbers of inhabitants of these coastal cities.

## 3. MARINE CONTAMINANTS

### 3.1 Concentrations of contaminants in water, sediments and biota

Summary tables giving data believed to be typical of the concentrations of contaminants found in various species and compartments from the area are to be found in Tables 1 and 2.

#### 3.1.1 Metals

The range of mercury concentrations reportedly found in sea water samples collected offshore is high (5-1090 ng $l^{-1}$ (UNIDO/UNEP, 1982) but in coastal waters the average levels are around 40 ng $l^{-1}$ (Ibe, Pers. Comm.) and off Ghana (Biney, Pers. Comm.) reports less than 20 ng$l^{-1}$, suggesting that there is little input of mercury from the coast. Jones (1975) found cadmium concentrations of 80-620 ng $l^{-1}$ in waters off northwest Africa, compared to a range of 40-170 ng $l^{-1}$ in the open Atlantic (Chester and Stoner, 1974). More recent data reported by Kremling (1985) suggest that the typical background level is at the lower end of these ranges. The background concentrations of copper in sea water appear to be of the order of 1-3 $\mu g\ l^{-1}$ (Riley and Taylor, 1972; Chester and Stoner, 1974), although Kremling (1985) has recently reported $0.054 \pm 0.022\ \mu g\ l^{-1}$ for offshore waters west of Senegal. For zinc, concentrations of 2.1 - 22 $\mu g\ l^{-1}$ were reported by Riley and Taylor (1972) but Chester and Stoner (1974) gave somewhat lower values of 0.9-5.2 $\mu g\ l^{-1}$ in the north-east Atlantic and 0.06 to 2.2 $\mu g\ l^{-1}$ in the South Atlantic, attributing the higher concentrations to biological activity in the upwelling area.

In line with the levels of mercury found in water, fish generally do not appear to be contaminated by mercury. As early as 1972 Establier reported that fish caught in waters north of Dakar did not contain more than 1 mg $kg^{-1}$ mercury. Gras and Mondain (1978) reported finding concentrations of between 0.02 and 1.14 mg $kg^{-1}$ in fish caught off Senegal. More recent data suggest that levels are really quite low, for example Kakulu and Osibanjo (1986) reported average concentrations ranging from 0.01 to 0.18 mg $kg^{-1}$ in fish and crustacea from the Niger delta; (Mbome et.al. 1985), 0.035 to 0.12 mg $kg^{-1}$ in fish from lagoons in Cameroon and Metongo (1985) 0.04 to 0.16 mg $kg^{-1}$ in fish caught off Côte d'Ivoire. Concentrations of mercury in molluscs and crustacea appear to be even lower, e.g. 0.083 to 0.091 mg $kg^{-1}$ in periwinkles collected from two

Table 1. Concentrations of trace metals in the marine environment of the WACAF Region ($mg\ kg^{-1}$ wet wt unless stated otherwise)

| | | MERCURY | LEAD | CADMIUM | ZINC | COPPER | ARSENIC |
|---|---|---|---|---|---|---|---|
| Sea water $ng\ l^{-1}$ | Ghana[1] | <20 | - | - | - | - | - |
| Sediments | Ghana[1] | 0.002-0.04 | 6-35 | - | 1-80 | 2-20 | - |
| | Nigeria[2] | 0.04-0.16 | 48-87 | 1.8-2.8 | 67-78 | - | 4.7-7.6 |
| | Ivory Coast[3] | 0.04-1.4 | 2-70 | 0.1-0.28 | 44-424 | 6-60 | 2.5-20 |
| | Ivory Coast[4] (lagoons) | 0.004-2.3 | 7-250 | - | 31-560 | 3.-86 | - |
| Algae | Ghana[1] | 0.02-20 | 1-2 | <0.1 | 2-5 | 1-2 | - |
| | Nigeria[2] | <0.001 | 1-1.5 | 0.1-0.3 | 15-26 | - | 1.7-3.4 |
| Periwinkles | Nigeria[5] | 0.05-0.07 | - | - | - | - | 1.5-2.4 |
| Oysters | Cameroon[6] | 0.061 | - | 0.57 | - | - | - |
| Crustacea (*Penaeus sp*) | Ghana[1] | <0.02 | 0.9-2.0 | <0.1 | 5.6-6.3 | 2.0-6.0 | - |
| | Senegal[7] | - | - | - | 13.5 | - | - |
| | Cameroon[6] | 0.057 | - | <0.1 | - | - | - |
| Fish | Ghana[1] | <0.02-0.30 | <0.2-0.65 | <0.1-0.3 | 0.5-16 | <0.2-5.6 | - |
| | Senegal[7] | - | - | - | 3.4-6.8 | - | - |
| | Cameroon[6] | 0.05-0.32 | - | <0.1-0.3 | - | - | - |
| | Ivory Coast[8] | 0.04-0.16 | - | <0.25 | - | <0.8 | - |

1 Biney, 1985 and Pers. Comm.
2 Ndiokwere, 1984
3 Marchand and Martin, 1985
4 Kouadio and Trefry, 1987
5 Ndiokwere, 1983
6 Ba *et.al.*, 1985
7 Mbome *et.al*., 1985
8 Metongo, 1985

sites on the Nigerian coast (Ndiokwere, 1983), <0.02 mg $kg^{-1}$ in prawns from Ghana (Biney, Pers. Comm.) and 0.02 - 0.034 in prawns from the Niger Delta (Kakulu and Osibanjo, 1986). As has been found in other areas, the highest concentrations of mercury tend to be found in predatory species such as tuna and Sphyraena sp. (Biney, 1985) and a substantial proportion of the burden (65% average) is present as methyl mercury (Gras and Mondain, 1978).

Table 2. Concentration ranges and mean values of chlorinated hydrocarbons in marine organisms of West and Central Africa

| | PCB | opDDD | ppDDE | ppDDT | ΣDDT | HCH |
|---|---|---|---|---|---|---|
| Fish µg/kg | 3–825<br>(90) | 3–50<br>(20) | 2–36<br>(15) | 2–30<br>(11) | 7–116<br>(46) | 2–55<br>(12.4) |
| Shrimp µg/kg | 74–102<br>(89) | 16–37<br>(27) | 16–47<br>(30) | 20–50<br>(34) | 52–134<br>(91) | 2–40<br>(20) |
| Crab µg/kg | 65–96<br>(82) | 10–26<br>(18) | 24–46<br>(34) | 25–48<br>(37) | 61–120<br>(89) | 7–65<br>(35) |

There seem to be few data available for metals in sediments but Biney (Pers. Comm.) has provided some relative to the coast of Ghana and Ndiokwere (1984) reported some for the coast of Nigeria. It is extremely difficult to interpret sediment data, without detailed information on the size fraction analysed and either the types of minerals naturally present or likely to be present in the areas, or data on e.g. aluminium concentrations, to allow the data to be normalised. As can be seen from the data in Table 1 the levels appear to be generally similar for the two areas and probably do not indicate serious contamination. Levels can however differ markedly from area to area and all sediment data must be interpreted with caution. Thus for example Biney (Pers. Comm.) reports that in the Korle lagoon of Accra concentrations of zinc and copper were at least an order of magnitude above those found in other neighbouring lagoons, pointing to contamination of the area, which is in fact subjected to a wide variety of industrial and sewage inputs.

A much more detailed investigation was carried out by Marchand and Martin (1985) in the Ebrie Lagoon in Côte d'Ivoire. The ranges of metal concentrations they found are also given in Table 1 and are generally wider and have higher maxima than those found in the Ghana and Nigerian studies. However, Marchand and Martin reported that only a few limited areas were affected by the very high levels and generally the concentrations found were less than half the maximum values cited in the table. Similar data, but with slightly higher maximum concentrations were reported for the same area by Kouadio and Trefry (1987) but as the methods used were somewhat different the data cannot be compared directly with those of Marchand and Martin.

### 3.1.2 Pesticides

The use of pesticides in the area is growing rapidly, for example in 1972 in only six countries of the Gulf of Guinea region use amounted to 10000 tonnes/year, but by 1974 two of these countries alone were using over 8000 tonnes (Cvjetanovic, 1977). Although most of the pesticides used in the area are imported, Middlebrooks et.al. (1980) report that there are production facilities in a number of countries e.g. 1690 t/yr in Senegal and 2300 t/yr in Côte d'Ivoire and others are known to be planning production (Ibe, Pers. Comm.).

The range of products used is wide, for example in Nigeria at least 200 brands are marketed and the range is increasing (Atuma and Okor, 1985), and in Ghana about 60 pesticides are officially recognised (Biney, Pers. Comm.). Atuma and Okor (1985) report that the organochlorine groups of compounds, notably DDT, HCH, aldrin, dieldrin, chlordane and pentachlorophenol are still widely used in countries such as Nigeria, Côte d'Ivoire and Cameroon, on crops such as cocoa, cotton, yams, cassava, groundnut and cowpeas and Ibe (Pers. Comm.) reports that DDT/dieldrin, and DDT/HCH are used on a wide scale for disease vector control in the north of Nigeria. There is however, an awareness of the potential harmful effects of the organochlorine group of compounds and Ibe (Pers. Comm.) reports that most pesticides now in use belong to the organo-phosphorus group (e.g. dichlorvos, malathion, fenthion) and the carbamate group.

Few data appear to be available for pesticide residues in marine fish but Faulkner (1985) has reported the results of some analyses of fish taken from the Sierra Leone estuary (Table 2) and when compared to the results reported in the world literature these do not seem particularly high. Perhaps not surprisingly, given the scale of use in agriculture and health protection much higher maximum concentrations have been found in freshwater fish. For example Osibanjo and Jensen (1980) found DDT concentrations of 0.08 to 4.3 mg $kg^{-1}$, HCH 0.08 to 4.4 mg $kg^{-1}$ and HCB 0.06 to 0.60 mg $kg^{-1}$ in fish from Oyo State, Nigeria and Atuma and Okor (1985) reported similar concentrations in freshwater fish from Bendel State in Nigeria.

Organo-phosphorus pesticides are widely used in the region but these generally break down fairly rapidly in the aquatic environment and are not expected to reach the marine environment in appreciable concentrations. Thus although between 1975 and 1983 1.4 x $10^6$ l of Temephos were used in a WHO campaign to control black fly (Simulium damnosum) and Onchocarcaisis in the savanna areas of Ghana, Côte d'Ivoire, Togo, Mali, Benin and Niger, Koeman and Weijand (1979) reported that concentrations in fish tissues decreased rapidly within 7 days of treatment.

### 3.1.3 Oil

Most of the countries in the region are oil producers and a few e.g. Nigeria and Gabon are net exporters (IMCO/UNEP 1982). Angola, Nigeria, Senegal, Gabon and Côte d'Ivoire have important refineries, but other smaller refineries are located in several of the other countries and the potential for further development of both production and refining is believed to be substantial. In addition the coastline lies downwind of the major tanker route from the middle-east oil fields to Europe and oil discharged from such vessels is likely to be washed up on beaches, especially those in the Gulf of Guinea region. Oil contamination of beaches is a not infrequent occurrence and as some of the incidents occur well away from sites of production, ports or refineries, it is probable that some at least of the oil comes from ships passing well offshore.

However, the number of offshore platforms in the region and the various export/import oil terminals mean that inevitably much of the oil pollution must be locally generated. Although there have been few major accidents or spillages in the area (see section 5.5) a survey conducted in 1980 by IMO consultants (IMCO/UNEP, 1982) found that small scale losses were a common feature of most port operations. Most, if not all of the refinery installations have API separators (UNIDO/UNEP, 1982) which ought to be capable of removing the worst of the oil if properly operated and maintained; few of the refineries however, have proper effluent treatment plants. The only oil refinery in Ghana for example discharges a completely untreated effluent with an oil content of between 0.4 and 1.0 mg $l^{-1}$ (Biney, Pers. Comm.).

A further source of oil, which is probably highly significant locally, is the discharge to streams, rivers and drains of used crank-case oil (UNIDO/UNEP, 1982). Few motor repair facilities have oil-traps on their drains. This could be highly significant since an assessment of waste oil arising in Nigeria from all sources, including tank sludges and oil slops, showed that of the 87.7 x $10^3$ t/yr potentially arising 97.5% was waste lubricating oil (Nwankwo and Ifeadi, 1985).

Despite the prevalence of oil pollution and the concern which seems to be commonly expressed about it (UNIDO/UNEP, 1982), few attempts seem to have been made to quantitatively assess the scale of the problem. The scattered data which do exist indicate however that in some areas the problem is very real. Biney (1982) reported that the occurrence of tar balls on Ghanaian beaches was non-uniform and without obvious pattern but found up to 30 g $m^{-2}$ in some areas and Okonya and Ibe (1985) found 11.6 to 96.2 mg $m^{-2}$ on Badagry beach in Nigeria, an area far removed from oil production. In the surface waters well offshore concentrations of oil were found to range from 1.3 to 13 $\mu g\ l^{-1}$ (Brown and Huffman, 1976) which compares to typical open North Sea concentrations of < 1 $\mu g\ l^{-1}$ (Law, 1981). Inshore, coastal and lagoon waters however, are markedly more heavily contaminated. For example, in the Niger Delta, Imevbore and Adeyemi (1983) found 10-65 mg $l^{-1}$ and in Lagos lagoon concentrations of 0.2 to 17.6 mg $l^{-1}$ have been found (Osibanjo, 1986).

### 3.1.4 Micro-organisms

The total population of the countries in the WACAF region is estimated to be about 175 million, of whom about 10% live in the town and villages of the coastal zone (UNEP, 1984). In almost all of these sewage is at present discharged untreated, usually to rivers and streams or to lagoons and coastal waters via short outfalls, most of which were installed with little attention to advance planning. Even at Tema, which was a planned development and is equipped with a one mile long sea outfall, the adjacent settlements suffer sewage pollution on the seafront (Biney, Pers. Comm.), though whether this is from the settlements or the Tema outfall is unclear. In many areas steps are now being taken to remedy the situation and it has been reported [UN(DIESA)/UNEP, 1984] that construction of sewage treatment facilities and/or longer discharge pipelines was underway in Senegal (Dakar and St. Louis), Gambia (Banjul), Côte d'Ivoire (Abidjan), Ghana (Accra), Nigeria (Lagos), Cameroon (Douala) and Gabon (Libreville).

With sewage discharges taking place in this way there is an obvious risk to human health through water contact and through the consumption of sea foods which might be contaminated by sewage organisms. This potential problem seems thus far to have received little attention, perhaps because many of the diseases likely to be transmitted by these routes are endemic in the area and sporadic outbreaks caused by this type of exposure would not readily be detectable. Nevertheless it has been reported that human diseases have been attributed to contact with faecal remains on beaches (UNEP, 1984).

The data which are available clearly point to there being a problem. For example, the oyster Crassostrea gasar is cultivated in an embayment in Lagos lagoon and Okonya et.al. (1985) report finding faecal bacteria present in the pond water at counts of up to 2.6 x $10^4$ and in oysters at counts of up to 6 x $10^5$. Salmonella typhi and Clostridium welchii were among the organisms identified as being positively present in both water and sediment. E. coli counts of between 2 and 140/100 ml were found in oyster flesh depending on season (Okonya et al 1985). E. coli are often used as indicators of sewage pollution and in the UK shellfish containing more than 230 E. coli/100 ml would be regarded as unsafe for direct human consumption. Achanwu (1984) had earlier found similar numbers of both E. coli and Salmonella typhi in oysters from the same area (220 and 250/100 ml respectively). High numbers of faecal coliforms were also apparent in the coastal waters of the Dakar region in a survey conducted between April and June 1985 by Paris and Diallo (1985), with numbers per 100 ml of water reaching 53.9 x $10^3$ in one area, although in some areas zero counts were obtained on some occasions. Odei et. al. (1981) reported finding numbers of faecal coliforms in excess of 1000/100 ml in certain reaches of the Volta estuary. Ibe (Pers. Comm.) points out that typhoid, cholera, infectious hepatitis, polio and dysentry are all endemic in the area and the organisms which cause these diseases must occur in the waters of lagoons and estuaries receiving sewage inputs.

## 3.2 Transport and fluxes across boundaries

A survey conducted by UNESCO consultants in 1980, on behalf of UNEP, of inputs to the marine environment via rivers (UNESCO/UNEP, 1982), illustrated the difficulties one encounters in attempting to construct transport flux and mass balance equations in areas like WACAF, where so much of the necessary data base is lacking. In the course of this survey twelve countries were visited, from Senegal to Zaire inclusive (Guinea Bissau, Guinea, Sierra Leone, Equatorial Guinea, Angola, Sao Tome and Principe were not visited). 41 major rivers were identified where monitoring of certain characteristics was undertaken, but for 30 of these no chemical data existed and for 34 no sediment data existed. Nevertheless for 28 of the rivers a good data base existed on annual discharge volumes and it was possible to estimate a long-term average discharge of river water of 80500 $m^3$ $sec^{-1}$. For a few of the rivers it was also possible to estimate the inputs of suspended matter e.g. 67 x $10^6$ t $yr^{-1}$ from the Niger and 68 x $10^6$ t $yr^{-1}$ for the Congo, the two largest rivers in the region. Most of the major rivers have had their natural flow regulated by dams in order to allow electric power generation or to create a source of irrigation water. These dams are reducing sediment transport to the coastal regions which in turn is affecting the ecology of several regions as well as being a cause of coastal erosion (see section 4.3).

Large though river inputs of sediments are they are small by comparison to the aeolian transport of material from the desert regions in the North and South of the WACAF region. For example, wind transport of Sahara origin material has been estimated to be between 60 and 250 x $10^3$ $m^3$ $yr^{-1}$ per kilometer of coast from Mauritania [UNEP/UNESCO/UN(DIESA), 1985]. Cliff erosion may also add significant amounts of particulate material to the marine environment in areas such as Senegal, Western Côte d'Ivoire, Ghana, South Cameroon and Angola [UNEP/UNESCO/UN(DIESA), 1985].

Apart from the information on sedimentary inputs via rivers referred to above, there seems to be little information on inputs of other substances via this route. However, basing his estimates on figures previously published for nutrients in some river waters for Ghana (Biney, 1984a) Biney (Pers. Comm.) has estimated the input of the nutrients nitrogen and phosphorus from the ten major Ghanaian rivers including the Volta system. The resulting totals are 2.94 x $10^6$ tonnes of P and 60 x $10^6$ tonnes of N per year.

By comparison to river inputs anthropogenic inputs are much smaller in volume, however they are generally much more localised and concentrated in their impact and by definition are more likely to upset the natural balance and cause problems. There is however, little hard information available on the scale of inputs from either sewage or industry. Most of what is available seems to have been derived from estimates rather than from detailed measurements, although a few attempts are now being made to quantify inputs from particular sources of interest such as oil production platforms (see section 4.8). The most comprehensive set of data on industrial inputs was collected in 1980 by UNIDO consultants on behalf of UNEP (UNIDO/UNEP, 1982). As it is doubtful whether this type of input, most of which is to lagoons and estuaries, really represents a flux away from the coast the details are included in section 4.1.2 rather than here.

## 3.3 Quality assurance, data validation and management

Prior to about 1970 few data on contaminant levels had been collected for the West and Central Africa (WACAF) region, either by workers from countries within the region or from outside. In any case, as with data generated elsewhere in the world those produced prior to at least the early 1970s can largely be disregarded, due to doubts as to their quality. A number of studies have since been made; some of them, under the auspices of the Regional Seas Programme, have included intercalibration exercises and generally the quality has improved. Most of the work has been concentrated in the inshore and lagoon areas, in order to assess the impact of industrial and general urban developments. In such areas the levels can be expected to be sufficiently above true background for the results of analyses conducted with reasonable care to be reliable.

For comparative purposes the results of a few limited scale investigations in offshore waters, by workers such as Riley and Taylor (1972), Chester and Stoner (1974), Jones (1975), Fitzgerald (1976) and Kremling (1985), provide an indication of the likely background levels of some trace metals. For most of the synthetic organic compounds, such as pesticides, the true baseline level is obviously zero but background levels have now built up from use elsewhere. An estimate of these can be obtained by reference to the levels typically found in open ocean waters and the less contaminated coastal areas of North America and Europe.

The quantity of data available on the status of marine pollution in the area makes it doubtful whether there is a serious need to organise regional data and information exchange. However, it is also true that much work has been done or is in progress, which is not systematically documented and to which there is no ready access via normal publication channels. Few of the scientific establishments in the region either own or have access to data storage facilities and some respondents suggested that very often data were not stored in any systematic way, thus making retrieval very difficult, even at laboratory level. Even when adequate data storage facilities do exist their operation is often made difficult by lack of proper power supplies, experienced staff to run the system and back up and service facilities.

# 4. HUMAN ACTIVITIES AFFECTING THE SEA

## 4.1 Disposal of urban and industrial waste waters

Since most of the countries of the West and Central Africa (WACAF) region have a relatively limited scale of industrial activity and the number of people who actually live on the coast is small in relation to the length of coastline, it might be argued that the potential for pollution is not large. Such a proposal would however ignore the fact that industrial development is proceeding rapidly and that industry and people tend to be concentrated in relatively few centres along the coast. As a consequence pollution problems do exist and the potential for them to get worse, if nothing is done, is very real. The problem can be divided into two types, although they may actually arise as a consequence of combined discharges, viz, those caused by discharges from industry and those caused by the disposal of wastes of human origin i.e. excreta, food and washing waters. These are discussed separately below.

### 4.1.1 Wastes of human origin

These constitute the major pollution load in terms of BOD in all the countries of the WACAF region. At the time of the UNIDO survey in 1980 (UNIDO/UNEP, 1982) 80% of all the waste discharged came from people and in only two sub-regions did the $BOD^5$ load from industry exceed 12% of the total discharge from municipal areas (Table 3). The report by Manful (1986) suggests that this has not changed in the last five years. Few of the large cities yet have either proper drainage facilities or sewage treatment plants. In most cases where sewage treatment facilities do exist, they are small and serve limited areas such as universities and corporate settlements. In some of the larger settlements like Lagos, Accra, Dakar and Abidjan, individual homes have their own sewers, although for the majority of city dwellers no toilet systems exist and the standard of hygiene is poor, with bucket collection and disposal of sewage common in the coastal areas.

As mentioned in section 3.1.4 although some treatment plants are now being planned or constructed, at present most discharges are made to the waters immediately inshore or to estuaries or, even worse, to lagoons most of which have only very poor exchange with the open coastal waters. Ibe (Pers. Comm.) describes the situation in Lagos as an example of common practice.

Table 3. Comparison of estimated pollution discharged to the ocean by the populations of the major coastal cities and industries in the West and Central African Region

| Zone | Country and major coastal cities | Estimated populations[a] in 1980 (In thousands) | Estimated pollution discharged (t/a) By population $BOD_5$ | By population SS | By industry $BOD_5$ | By industry SS |
|---|---|---|---|---|---|---|
| I | Senegal | 5 585 | | | 11 201 | 14 950 |
| | Saint Louis | 97 | 2 266 | 3 222 | | |
| | Dakar | 879 | 20 533 | 29 200 | | |
| | Ziguinchor | 80 | 1 869 | 2 658 | | |
| | Thiés | 129 | 3 013 | 4 285 | | |
| | Gambia | 591 | | | 310 | 438 |
| | Banjul | 45 | 1 051 | 1 495 | | |
| | Guinea Bissau | 1 006 | | | 622 | 557 |
| | Bissau | 100 | 2 336 | 3 322 | | |
| | Zone total | | 31 068 | 44 182 | 12 133 | 15 945 |
| | Industrial percentage | | | | 39 | 36 |
| II | Guinea | 4 983 | | | 427 | 370 |
| | Boffa | 134 | 3 130 | 4 451 | | |
| | Conakry | 530 | 12 381 | 17 607 | | |
| | Forécariah | 146 | 3 411 | 4 850 | | |
| | Sierra Leone | 3 421 | | | 1 677 | 1 179 |
| | Freetown | 316 | 7 382 | 10 498 | | |
| | Liberia | 1 766 | | | 1 083 | 1 048 |
| | Monrovia | 221 | 5 163 | 7 342 | | |
| | Zone total | | 31 467 | 44 748 | 3 187 | 2 597 |
| | Industrial percentage | | | | 10 | 6 |
| III | Côte d'Ivoire | 7 548 | | | 5 216 | 3 507 |
| | Abidjan | 1 573 | 36 745 | 52 255 | | |
| | Ghana | 11 473 | | | 1 414 | 3 669 |
| | Accra-Tema area | 965 | 22 542 | 32 057 | | |
| | Takoradi-Sekondi | 210 | 4 906 | 6 976 | | |
| | Cape Coast | 68 | 1 588 | 2 259 | | |
| | Togo | 2 548 | | | 1 708 | 23 899 |
| | Lomé | 249 | 5 817 | 8 272 | | |
| | Benin | 3 558 | | | 1 174 | 657 |
| | Porto-Novo | 119 | 2 780 | 3 953 | | |
| | Cotonou | 203 | 4 742 | 6 744 | | |
| | Zone total | | 79 120 | 112 516 | 9 512 | 31 732 |
| | Industrial percentage | | | | 12 | 28 |

a/ Africa South of the Sahara (London, Europa Publications 1978)

Table 3. (continued)

| Zone | Country and major coastal cities | Estimated populations[a/] in 1980 (In thousands) | Estimated pollution discharged (t/a) By population $BOD_5$ | By population SS | By industry $BOD_5$ | By industry SS |
|---|---|---|---|---|---|---|
| IV | Nigeria | 82 800 | | | 17 328 | 24 311 |
| | Lagos | 4 100 | 95 776 | 136 202 | | |
| | Port Harcourt | 276 | 6 447 | 9 169 | | |
| | United Republic of Cameroon | 8 355 | | | 2 187 | 4 800 |
| | Douala | 532 | 12 427 | 17 673 | | |
| | Victoria | 34 | 794 | 1 129 | | |
| | Equatorial Guinea | 298 | | | | |
| | Malabo | 37 | 864 | 1 229 | | |
| | Bata | 27 | 630 | 897 | | |
| | Sao Tome & Principe | 80 | 1 869 | 2 657 | 38 | 18 |
| | Gabon | 1 300 | | 897 | 381 | |
| | Libreville | 251 | 5 863 | 8 338 | | |
| | Port-Gentil | 78 | 1 822 | 2 591 | | |
| | Zone total | | 126 492 | 179 885 | 20 450 | 29 511 |
| | Industrial percentage | | | | 16 | 16 |
| V | Congo | 1 548 | | | 1 085 | 606 |
| | Pointe-Noire | 164 | 3 831 | 5 448 | | |
| | Zaire | 28 188 | | | 452 | 257 |
| | None | | | | | |
| | Angola | 7 067 | | | 449 | 497 |
| | Luanda | 602 | 14 063 | 19 998 | | |
| | Lobito | 74 | 1 729 | 2 458 | | |
| | Benguela | 51 | 1 191 | 1 694 | | |
| | Zone total | | 20 814 | 29 598 | 1 986 | 1 360 |
| | Industrial percentage | | | | 10 | 5 |
| | Region total | | 288 961 | 410 929 | 47 269 | 81 145 |
| | Total industrial percentage | | | | 16 | 20 |

a/ Africa South of the Sahara (London, Europa Publications, 1978)

"Untreated sewage in the form of faeces, is collected from about 55 depots in different parts of the city and dumped into the Lagoon at Iddo. In the first three months of 1974 Akpata and Ekundayo (1978) estimated that 7.5 million litres of untreated sewage were disposed of to the lagoon. In addition, the beaches and open water courses are used as toilets". Biney (Pers. Comm.) indicates that of 16 coastal lagoons which were studied in Ghana, 12 were found to be polluted, 2 of them (Korle and Chemu) grossly so.

Dufour and Slépoukha (1975) provided data on the volumes of sewage discharged to the Ebrie Lagoon relative to the volume of the receiving waters. In the area immediately around Abidjan alone the volume of domestic sewage discharged each year was equivalent to about 18% of the total lagoon volume. Domestic sewage accounts for just over half the total effluent volume and for the whole area the quantity of domestic and industrial waste waters discharged annually is double the volume of the lagoon (lagoon volume estimated at $2649 \times 10^6$ $m^3$). The Ebrie Lagoon is subject to marked seasonal variations (3-30°/₀₀) in salinity depending on season (Zabi, Pers. Comm.) and this flushing effect probably helps minimise impact. Nevertheless, at least four embayments regularly become anoxic due to the pollution load (Dufour and Slépoukha, 1975).

#### 4.1.2 **Wastes of industrial origin**

The UNIDO report on inputs of pollutants from industrial sources (IMCO/UNEP, 1982) indicated that few of the industries in the area treat their effluents, discharging them directly into the nearest stretch of water (river, estuary, lagoon or coast). Where treatment is given it is usually only rudimentary, e.g. grease trap or sand filter. The contributions received from Biney and Ibe indicate that this is still the situation five or six years after that survey was conducted, though the report from Zabi suggests that around Abidjan matters are improving. With little or no treatment to the effluents it would be surprising if toxic effects were not likely to be encountered and tests conducted by Ajao (1985) confirm that many of the effluents discharged from industrial sources in the Lagos area are toxic to mullet (<u>Mugil sp</u>) and hermit crabs (<u>Clibinarius africanus</u>).

The UNIDO study mentioned previously (UNIDO/UNEP, 1982) investigated the various sources of industrial effluent and estimated their probable pollutant inputs. For the purposes of the study the region was divided into 5 zones, Zone I - Senegal to Guinea Bissau, Zone II - Guinea to Liberia, Zone III - Côte d'Ivoire to Benin, Zone IV - Nigeria to Gabon and Zone V - Congo to Angola. Estimates of polluting loads were based on EPA guidelines on the expected pollutant load from a unit process of a similar nature operating in the USA. Where a comparison of estimated loads was made with the actual loads the agreement was not generally very good. Nevertheless, the tables of inputs are probably the best data available. They are included in this report as Tables 4 to 8. If nothing else they serve to show the types of industry present and where pollution abatement is likely to be most cost-effective. They also indicate the areas in which pollution problems are most likely to be acute. Although most of the organic load seems to be derived from municipal sewage, most of the industrial effluents are clearly amenable to conventional sewage treatment and combined treatment of effluents was recommended (UNIDO/UNEP, 1982).

An examination of the tables shows that Zone IV, in which about 75% of the region's industry is located, discharges more material than any of the other four zones. Of the total effluent load discharged by all 18 countries of the region about 43% of the BOD, 36% of the suspended solids, 83% of the oil and grease and 60% of the COD is discharged from Zone IV. Most of the rest of the contaminant inputs come from zones I and III in almost equal proportions, leaving very little input from zones II and V.

Table 4. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone I of the West and Central African Region (Tons per year)

| Type of industry | $BOD_5$ | SS | Oil and grease | COD | Ammonia nitrogen | Phenols | Total chromium | Fluoride | Cyanide | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum refining & handling | 116.1 | 74.2 | 44.1 | 331.1 | 25.0 | 0.6 | 1.5 | | | |
| Edible oils | 4 984.1 | 4 356.3 | 3 129.0 | 12 471.5 | | | | | | |
| Beer | 418.2 | 193.9 | | 459.2 | | | | | | |
| Soft drinks | 154.4 | 212.2 | | 387.1 | | | | | | |
| Soap & detergents | 63.7 | 108.5 | 7.7 | 159.3 | | | | | | |
| Fish & shrimps | | 2 338.4 | 557.0 | | | | | | | |
| Sugar | 779.8 | 962.2 | | 1 945.6 | | | | | | |
| Textiles | 230.0 | 587.8 | | 1 857.8 | | 4.1 | 4.1 | | | |
| Paint | 0.5 | 0.8 | | 1.3 | | | | | | |
| Rice | 2.8 | 1.6 | | 7.0 | | | | | | |
| Dairy products | 20.0 | 30.0 | | 51.2 | | | | | | |
| Fruits & vegetables | 27.5 | 33.9 | | 68.6 | | | | | | |
| Meat | 0.6 | 1.0 | 0.3 | 1.5 | | | | | | |
| Leather | 5 334.0 | 6 660.0 | 1 000.0 | 13 000.0 | | | 134.0 | | | |
| Fertilizer | | 381.6 | | | | | | 38.2 | | 114.6 |
| Asphalt | 0.7 | 0.6 | 0.2 | 4.1 | 0.4 | 0.1 | 0.1 | | | |
| Metal working & coating | 0.3 | 1.7 | 0.1 | 0.8 | 0.1 | 0.1 | | 0.7 | | |
| Total | 12 132.7 | 15 944.7 | 4 738.3 | 31 746.1 | 25.5 | 4.7 | 139.6 | 38.9 | | 114.6 |

Table 5. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone II of the West and Central African Region
(Tons per year)

| Type of industry | $BOD_5$ | SS | Oil and grease | COD | Ammonia nitrogen | Phenols | Total chromium | Fluoride | Cyanide | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum refining | 598.3 | 379.9 | 227.9 | 1 662.0 | 123.5 | 2.8 | 7.6 | | | |
| Edible oils | 515.9 | 451.1 | 323.9 | 1 290.4 | | | | | | |
| Beer | 1 704.5 | 792.3 | | 1 876.0 | | | | | | |
| Soft drinks | 192.2 | 264.3 | | 480.6 | | | | | | |
| Alcohol & blending of spirits | 0.4 | | | 1.0 | | | | | | |
| Soap & detergents | 84.1 | 143.5 | 10.1 | 211.1 | | | | | | |
| Fish & shrimps | | 490.8 | 125.3 | | | | | | | |
| Sugar | 68.8 | 14.4 | | 171.6 | | | | | | |
| Textiles | 10.2 | 26.1 | | 126.9 | | | | | | |
| Explosives | 1.0 | 20.5 | | 2.7 | | 0.2 | 0.2 | | | |
| Paint | 0.3 | 0.5 | | 0.8 | | | | | | |
| Flour | 3.7 | 3.3 | | 9.3 | | | | | | |
| Fruits & vegetables | 7.4 | 9.1 | | 18.4 | | | | | | |
| Total | 3 186.8 | 2 595.8 | 687.2 | 5 850.8 | 123.5 | 3.0 | 7.8 | | | |

Table 6. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone III of the West and Central African Region (Tons per year)

| Type of industry | $BOD_5$ | SS | Oil and grease | COD | Ammonia nitrogen | Phenols | Total chromium | Fluoride | Cyanide | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum refining & handling | 537.0 | 341.2 | 204.5 | 1 496.3 | 111.4 | 2.6 | 6.8 | | | |
| Edible oils | 1 828.6 | 1 599.0 | 1 148.0 | 4 575.6 | | | | | | |
| Beer | 2 007.4 | 930.9 | | 2 204.2 | | | | | | |
| Soft drinks | 241.6 | 332.1 | | 605.9 | | | | | | |
| Alcohol & wine bottling | 187.2 | 257.4 | | 469.6 | | | | | | |
| Soap & detergents | 93.6 | 159.5 | 11.2 | 234.0 | | | | | | |
| Textiles | 684.5 | 1 752.2 | | 8 519.2 | | 12.1 | 12.1 | | | |
| Paint | 0.5 | 0.9 | | 1.5 | | | | | | |
| Flour | 57.7 | 51.3 | | 144.7 | | | | | | |
| Dairy products | 189.0 | 283.5 | | 483.0 | | | | | | |
| Fruits & vegetables | 82.1 | 101.3 | | 204.8 | | | | | | |
| Meat | 1.4 | 2.2 | 0.7 | 3.4 | | | | | | |
| Fertilizer | | 23 525.9 | 0.9 | | 6.3 | | | 2 330.8 | | 7 063.0 |
| Asphalt | 27.8 | 22.4 | 9.1 | 164.1 | 16.2 | 0.2 | 0.5 | | | |
| Steel | | 14.4 | 4.4 | | 36.6 | 0.6 | | | 9.0 | |
| Aluminium | | 1 874.4 | | | | | | 1 250.2 | | |
| Metal plating & coating | | 44.6 | | | | | 0.6 | 1.1 | | 2.2 |
| Cement | 1 355.0 | | | 3 400.3 | | | | | | |
| Coffee | 1 875.0 | 150.0 | | 4 686.0 | | | | | | |
| Cocoa products | 329.7 | 288.3 | 207.0 | 824.9 | | | | | | |
| Wood products (plywood, veneers, lumber | 13.2 | | | 33.2 | | 2.6 | | | | |
| Total | 9 511.3 | 31 731.5 | 1 585.8 | 28 050.7 | 170.5 | 18.1 | 20.0 | 3 582.1 | 9.0 | 7 065.2 |

Table 7. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone IV of the West and Central African Region
(Tons per year)

| Type of industry | $BOD_5$ | SS | Oil and grease | COD | Ammonia nitrogen | Phenols | Total chromium | Fluoride | Cyanide | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum refining & handling | 1 386.0 | 712.0 | 59 528.4 | 3 850.0 | 286.2 | 6.6 | 17.6 | | | |
| Edible oils | 698.0 | 610.4 | 438.2 | 1 745.6 | | | | | | |
| Beer | 5 371.3 | 2 490.8 | | 5 897.9 | | | | | | |
| Soft drinks | 726.8 | 998.9 | | 1 822.0 | | | | | | |
| Soap & detergents | 276.8 | 471.9 | 33.0 | 691.9 | | | | | | |
| Textiles | 5 428.6 | 16 426.1 | | 79 864.72 | 0.1 | 113.2 | | | | |
| Paint | 236.4 | 355.6 | | 592.0 | | | | | | |
| Dairy products | 0.2 | 0.3 | | 0.6 | | | | | | |
| Wood products (plywood, veneers, lumber) | 96.5 | 20.4 | | 242.0 | | 108.3 | | | | |
| Pulp & paper | 1 179.0 | 2 526.0 | | 2 949.0 | | | | | | |
| Alcohol & blending of spirits | 0.1 | 0.1 | | 0.2 | | | | | | |
| Tubes & tyres | | 1.7 | 0.4 | | | | | | | |
| Steel & fabrication | | 2.3 | | | | | 0.1 | 0.1 | | 0.1 |
| Fruits & vegetables | 25.7 | 31.7 | | 64.1 | | | | | | |
| Aluminium | | 500.0 | | | | | | 333.5 | | |
| Rubber | 4.5 | 7.3 | 1.9 | 91.3 | | | | | | |
| Batteries[a/] | 9.4 | 2340.0 | | 23.4 | | | | | | |
| Fishing | | 1 921.0 | 102.0 | | | | | | | |
| Flour | 60.0 | 60.0 | | 150.0 | | | | | | |
| Sugar | 158.1 | 33.1 | | 394.7 | | | | | | |
| Canned meat | 0.8 | 1.3 | 0.4 | 2.0 | | | | | | |
| Cement | 3 791.4 | | | 9 514.0 | | | | | | |
| Total | 20 449.6 | 29 510.9 | 60 104.3 | 107 895.4 | 286.3 | 228.1 | 130.8 | 333.6 | | 0.1 |

a/ 93.6 t/a of lead and cadmium are also discharged.

Table 8. Estimated mass of pollutants discharged to the ocean by industrial sectors in Zone V of the West and Central African Region
(Tons per year)

| Type of industry | $BOD_5$ | SS | Oil and grease | COD | Ammonia nitrogen | Phenols | Total chromium | Fluoride | Cyanide | Total phosphorus |
|---|---|---|---|---|---|---|---|---|---|---|
| Petroleum refining & handling | 342.1 | 238.0 | 4 948.6 | 1 165.3 | 61.1 | 1.8 | 4.8 | | | |
| Edible oils | 164.1 | 143.5 | 103.0 | 410.6 | | | | | | |
| Beer | 900.7 | 417.7 | | 989.0 | | | | | | |
| Soft drinks | 56.7 | 77.9 | | 141.8 | | | | | | |
| Soap & detergents | 5.9 | 10.1 | 0.7 | 14.7 | | | | | | |
| Fish & shrimps | | | | | | | | | | |
| Sugar | 77.4 | 16.2 | | 193.4 | | | | | | |
| Textiles | 144.7 | 369.8 | | 1 797.82 | 2.6 | 2.6 | | | | |
| Explosives | | | | | | | | | | |
| Paint | 0.1 | 0.1 | | 0.1 | | | | | | |
| Flour | 96.6 | 85.7 | | 242.1 | | | | | | |
| Dairy products | | | | | | | | | | |
| Wood products (plywood, veneers, lumber) | 198.4 | | | 496.1 | | 2.1 | | | | |
| Pulp & paper | | | | | | | | | | |
| Cement | | | | | | | | | | |
| Tubes & tyres | | 0.1 | 0.1 | | | | | | | |
| Steel | | 1.0 | 0.3 | | 2.4 | 0.1 | | | 0.5 | |
| Total | 1 986.6 | 1 359.9 | 5 052.6 | 5 450.8 | 63.5 | 6.5 | 7.4 | | 0.5 | |

Of the various industrial discharges in zone I most of the BOD load is derived from the edible oils and leather industries (41 and 44% respectively) which are also the source of most of the suspended solids load. In Zone II over 50% of the BOD load is from breweries, which also contribute the biggest single source of suspended solids. The edible oils industry accounts for almost half of the oil and grease, with petroleum refining adding a further third of the load and the fish and shrimp processing industries a further 18%. In Zone III the BOD comes mainly from the edible oils, brewing, cement and coffee industries in roughly equal proportions. Phosphate mining alone accounts for almost 75% of the suspended solids load and the edible oils industry accounts for a similar proportion of the oil and grease. In Zone IV the pattern of pollution sources is not dissimilar to that found in the other regions, except that the scale of inputs is larger and the petroleum industry accounts for almost all of the oil and grease input. In Zone V the brewing industry accounts for about 45% of the BOD load and the petroleum refining industry about 98% of the oil and grease. Suspended solids are discharged mainly by the petroleum, brewing and textile industry.

## 4.2 Development of coastal areas

A number of development activities are leading to major changes in coastal areas. The most obvious of these are the actual construction of towns with associated industries and the creation or extension of sea port areas. Although these are confined to a few locations they are frequently close to areas which are or could be exploited as tourist centres and there have been instances where hotels have been constructed and then affected by expanding towns or coastal erosion brought about by port developments (see section 4.4).

In some areas mangroves are being severely affected as they are continuously harvested for fuel-wood. Mangroves are also being affected by erosion, either directly or indirectly, by changes in salinity and through the construction of canals. These canals are intended for use as transport pathways. Their construction has the immediate side-effect of increasing suspended solids in the water which can lead to destruction of some benthic fauna. This is followed by more permanent damage as the hydrological regime and salt intrusion alters and the spoil banks impede land run-off.

## 4.3 Manipulation of hydrological cycles

Nearly all the main rivers of the WACAF region have been dammed in at least one location, most of them in the last twenty years or so [UNEP/UNESCO/UN(DIESA), 1985]. In some cases where large lakes have been formed, such as that created by the dam on the Volta river at Akosombo, the local climate has been changed (de Heer Amissah, 1969). The dam on the Volta river also eliminated the regular flooding in the wet season and as a consequence several lagoons, which used to be refilled in times of flood, have been lost.

A particular matter of concern in the region has been the effect on sediment transport to the sea. For example, in Nigeria there are now eleven River Basin Authorities manipulating hydrological cycles and it is estimated that the construction of their dams has resulted in a 70% loss of sediment catchment area, due to the effective entrapment of silt behind the dams (Leeming, 1985; Olofin, 1985). In some cases this loss of sediment input is blamed for coastal erosion which has occurred since the construction of some dams. A particularly serious case followed the damming of the River Volta with the partial disappearance of the town of Keta [UNEP/UNESCO/UN(DIESA), 1985] and it has been suggested that coastal erosion in nearby Benin and Togo can also be attributed to this. However, Abban (1986) has pointed out that the Volta river could never have replaced the amounts now being eroded. Similar problems have been reported in the Niger delta (McDowell et.al. 1983; Ibe and Antia, 1983).

The reduction of freshwater discharge in the lower estuarine reaches of rivers due to dam construction can also alter the extent of intrusion of the estuarine salt wedge inland. This can have important ecological effects on the flora and fauna of the coastal and nearshore zone. In the Niger delta, Ibe et.al. (1985) found that mangrove swamps and rain forests had been destroyed due to salt water intrusion. Ibe (Pers. Comm.) points out that the reduction in freshwater flow is accompanied by a reduction in inputs of nutrients to the coastal zone and this has led to a highly significant loss in local fish catches from some parts of the Nigerian coast. A further, more specific instance of this type of effect followed the impoundment of the Volta river. The alteration in the salt wedge intrusion resulted in the displacement seawards of the economically important bivalve Egeria radiata, by about 20 km (Ennin and de Graft-Johnson, 1977) in the first decade after completion of the dam. Breeding grounds now occur less than 10 km from the sea. Other effects include the seasonal spread of freshwater vegetation such as Vallisneria aethiopica, Potomogeton octamebers and Ceratophullum demersum, as well as the snail hosts of Schistosomiasis (Odei et.al., 1981).

A further feature of reduced freshwater flows is the extension of coastal sand spits, as has happened across the mouth of the Volta river. This does not however always occur and for example construction of the Cotonou dam in Benin has resulted in less erosion of the harbour area and reduced sedimentation on the coast [UNEP/UNESCO/UN(DIESA), 1985].

## 4.4 Other land-use practices

In addition to the impact man is having on freshwater flows through the construction of dams on rivers, use of the water for irrigation purposes is also affecting freshwater run-off to the sea. Agriculture is an important activity in all the countries of the WACAF region at both the subsistence and commercial level. In a few instances poor agricultural practices are leading to soil erosion but the main cause of this appears to be deforestation in the interests of exploiting timber resources, mainly for export.

An important anthropogenically induced alteration of land-use is brought about by reclamation of coastal marshland areas. In Nigeria alone, thousands of square kilometres of this type of natural habitat have been lost (Ibe, Pers. Comm.). For example, in 1984 extensive dredging of the Lagos estuary and deposition of the spoil in adjoining mangrove swamps led to high suspended solids in most of the embayments and severe damage to the oyster fishery.

A further feature of man's activities is the development of port facilities. In some cases the construction of these, especially jetties and breakwaters, has interrupted long-shore drift patterns and caused striking coastal erosion problems. For example, at Lagos in Nigeria, Victoria Beach has been eroded 2 km inland since the breakwaters were complete in 1912 (Ibe, 1985). Equally striking is the erosion of 0.5 km at Escravos (also in Nigeria) since breakwaters were completed in 1964 (Ibe, 1986). Similar problems were created at the Port of Abidjan when the Canal de Vridi was opened in 1950; since then the beach has eroded to the east of the canal and a road has been cut through. An extensive review of these and similar problems has been published by UNEP following investigations carried out by a team of experts in cooperation with UN and UNESCO [UNEP/UNESCO/UN(DIESA), 1985]. In a further review of the subject Abban (1986) reports that serious erosion occurs in Benin, Togo, Sierra Leone, Liberia and Gambia.

## 4.5 Disposal of contaminated sediments, mine tailings and industrial solid wastes

Although some dredging of navigation channels and port areas is necessary, the disposal of the dredge spoil is not considered to present much of a problem in terms of its contaminant load (Biney, Pers. Comm.). A report by UNEP and UNESCO experts on coastal erosion problems [UNEP/UNESCO/UN(DIESA), 1985] suggests that the majority of the material which has to be removed by dredging, arises as a consequence of long-shore transport of sands. Consequently contamination is unlikely to present much of a problem.

The offshore exploitation of oil deposits does lead to the disposal of drill cuttings from the drilling platforms. These are contaminated by drilling mud which it is not possible to remove completely and as a result a variety of chemicals present in the drill mud is discharged with the cuttings. It is therefore possible that, in addition to blanketing the bottom fauna in the immediate vicinity of the platforms, some toxic effects may also occur. However, detailed investigations of the impact of this type of activity in the North Sea (Bedborough et. al 1987) indicate that even when oil-based drilling muds are used, the scale of any such effects would be small and is restricted to the zone close to and downstream of the platform.

Along the Gulf of Guinea many countries have rich mineral deposits and these lead to large quantities of suspended solids being released into coastal waters. The most seriously affected countries are Côte d'Ivoire, Ghana, Togo, Benin and Nigeria where the major source of suspended solids is phosphate ore mining, which introduces both potassium and fluoride [UN(DIESA)/UNEP, 1984]. Mining operations also take place inland and for example in Ghana mining for gold, manganese and diamonds more than 50 km inland leads to the estuaries of the rivers Pra and Ankobra having high turbidities. Diamonds are also mined, either close to the coast or dredged from beaches and coastal waters in Angola, Zaire and Namibia. Uranium is also mined in Namibia. In most cases the washings from the mining operations are discharged directly into the sea.

Ibe (Pers. Comm.) mentions that in the equatorial region especially, large quantities of saw dust from the forestry industry, are discarded into coastal waters. In some areas this had led to marked changes in the physical and chemical nature of the sea bed and consequently the structure of benthic populations has been altered.

Many other industries discharge solid matter in their effluents; in particular the discharge of organic solids from the food processing and brewing industries seem to merit particular concern (UNIDO/UNEP, 1982). They are liable to cause suppression of dissolved oxygen levels in the waters to which they are discharged and can cause anoxic conditions on the sea bed. This need not be allowed to occur as the technology for treating these types of wastes already exists and its applicability has been tested under local conditions. For example, Edewor (1986) has demonstrated that palm oil mill effluent can be treated economically and would yield saleable products with an overall pay-back time of 2 to 6 years depending on the process adopted.

## 4.6 Disposal of solid matter (litter)

In the same way that there are few proper facilities to dispose of sewage in many of the coastal communities, arrangements for the collection of household rubbish are limited or non-existent. As a result many of the population of these areas use the estuarine and coastal waters or the beaches as places to dump their rubbish. Some of this rubbish accumulates on the beaches and the scale of the problem is highly positively correlated with location population density (Biney, Pers. Comm.). The most commonly encountered forms of litter are plastic wares, metal cans and the less readily degraded portions of household and industrial refuse. Biney (1982) measured accumulations of plastic wares of up to 200 g $m^{-2}$ in some of the worst affected areas near coastal settlements.

In addition to the problem of household and industrial litter, Biney (Pers. Comm.) mentions that charcoal occurs fairly uniformly along the coast and that logs from the timber industry remain a problem, as was reported in the UNIDO survey (UNIDO/UNEP, 1982). He also mentions that in some areas the number of fishing vessels wrecked or abandoned present particular problems, near Tema, for example, there may be as many as 5 per kilometer.

## 4.7 Marine transport of oil and other hazardous substances

The WACAF region exports oil to Europe and America. The coastline lies to the east and is downwind of the main route of oil transport from the Middle-East to Europe. The total volume transported annually along the Gulf of Guinea has been estimated to be 706 x $10^6$ tonnes

(IMCO/UNEP, 1982). However, the sea lanes are very wide and the number of accidents involving tankers has been low compared to elsewhere in the world, with only three major accidents up to 1981 (see section 5.5). Early reports (Portmann, 1978) suggested that the discharge of tank washings from offshore traffic was a major source of oil on beaches but it is now apparent [UN(DIESA)/UNEP, 1984, plus Personal Communications from Bieny and Ibe] that much of the oil found on beaches arises as a result of spills or tank washings discharged from tankers visiting ports in the region, although other sources are also important. The investigations of pollution in the Ebrie lagoon (Ivory Coast) by Marchand and Martin (1985) produced a wide range of concentrations of total hydrocarbons in the lagoon sediments (100-2400 mg/kg). The highest concentrations were associated not with shipping but with industrial and domestic sewage discharges. However, a spill of 400 tonnes of oil at a refinery in 1981 was still clearly detectable at the time of their survey (1983).

None of the three correspondents reported any incidents involving transport of substances other than oil by sea, although a wide variety of chemicals are known to be transported to an from the ports in the region.

## 4.8 Exploitation of non-living marine resources

The activitiy of highest economic value in this context is oil. Most of the countries have now been shown to have exploitable oil reserves, although the main exploitation at present takes place in the sector between Nigeria and Gabon. A report produced by IMO on behalf of UNEP in 1982 (IMCO/UNEP, 1982) identified a wide range of potential problems which could arise as a consequence of oil production but presented little by way of evidence of actual effects, other than those caused by chronic low level releases or the occasional small spills. This is not to say that these are not locally significant. For example, Table 9 shows the history of spillages in Nigeria alone from 1976 to 1983 and in some years the losses were obviously large. Nwankwo and Ifeadi (1985) report that well blow-outs are no longer merely a theoretical possibility (there have been at least three). Oil is discharged in production water effluents and this too contributes to the input of oil. Data from Nwanko and Ifeadi (1985) suggest that during 1983 this amounted to about 64000 tonnes from the eleven fields operated by one company in the Nigerian sector. Ajao et.al. (1983) have shown that these effluents can be toxic to marine fish species such as mullet (*Mugil sp*).

Table 9. (After Nwankwo and Ifeadi, 1985)
Yearly distribution of oil spills (1976-1983)

| No. | Year | No. of spills | New volume spilt |
|---|---|---|---|
| 1 | 1976 | 128 | 20,023 |
| 2 | 1977 | 104 | 31,144 |
| 3 | 1978 | 154 | 97,250 |
| 4 | 1979 | 157 | 630,405 |
| 5 | 1980 | 241 | 558,053 |
| 6 | 1981 | 233 | 22,840 |
| 7 | 1982 | 213 | 33,612 |
| 8 | 1983 | 130 | 32,467 |
| Total | | 1,360 | 1,464,131 |

The region also has vast beach and offshore sand and gravel deposits some of which are being exploited for construction and land reclamation purposes. Whilst Biney (Pers. Comm.) reports that the exploitation of beach sands has not thus far caused many serious effects, in some areas dredging of offshore deposits is known to have caused erosion. For example, extraction of sand near Freetown in Sierra Leone caused coastal erosion [UNEP/UNESCO/UN(DIESA), 1985] but the same report also indicates that this is not always the case and illustrates this by pointing out that at Lome in Togo 20000 $m^3$ of sand dredged from the beach west of the harbour has had no impact because the area from which the sand was dredged was a deposition zone.

### 4.9 Exploitation of living marine resources

The total annual catch of fish in the region is estimated to be about 2.6 x $10^6$ t/yr (FAO, 1987) and Biney (Pers. Comm.) reports that about 10% of the coastal population engages in some form of fishing activity. At least 30% is canoe fishing, but larger fishing trawlers account for the bulk of the remaining catch. None of the local correspondents reported any serious impact on resources from the present methods of fishing, although Ibe pointed out that lack of enforceable mesh regulations has caused some alterations in ecological balance. The industry was not singled out by any of the local correspondents as being a major source of pollution. Nor is it so pin-pointed by any of the expert missions to the area. However, Ibe did report that the industry is responsible for the introduction of litter to the near-shore waters and beaches and in at least one other country (Republic of Gambia) wastes from fish processing cause local problems.

## 5. BIOLOGICAL EFFECTS

### 5.1 Eutrophication and associated phenomena

Agriculture is important to the lives of virtually all the peoples of the West and Central Africa (WACAF) region [UN(DIESA)/UNEP, 1984] either as a means of earning a living or supplementing it or simply through subsistence farming. Most of the countries are actively seeking ways to increase their agricultural output, partly to increase yields of cash crops, but also to improve the food supply to their own peoples. As part of this drive inorganic fertilisers, especially those based on nitrogen and phosphorus, are being used on an increasing scale. Some are produced locally and almost all this production is used in the region; local production is supplemented by imports but there do not appear to be any accurate data for these. Local production facilities include Senegal 110,000 t/yr, Côte d'Ivoire 85,000 t/yr, Togo 7 million tons of products and Congo 300,000 t/yr of potash based fertilisers.

These quantities of fertilisers are not thought likely to lead to eutrophication problems in marine waters (UNEP, 1984) and data for concentrations of nutrients in nearshore waters (e.g. Biney, 1984b) in the region off Greater Accra tend to support this, being similar (0.014 mg $l^{-1}$ P and 0.52 mg $l^{-1}$ N) to values for the world-wide seas (Liss, 1976). In the open surface waters of the Gulf of Guinea, levels are even lower e.g. 0.008 mg $l^{-1}$ P (UNEP, 1984). However, Ibe (Pers. Comm.) points out that in some lagoon areas the input of nutrients via sewage is extremely high and together with the land-use of fertilisers could cause eutrophication problems. Okonya et.al. (1985) have in fact suggested that this was the cause of some fish kills off the Nigerian Coast.

### 5.2 Public health effects

Reference has already been made both above and in section 3.1.4 of the high risk of infection of consumers through the consumption of shellfish taken from waters which are heavily contaminated by sewage. There does not appear to be any statistics of such disease incidence and it is likely that the infrastructure for their collection, in isolation from other causes of the same diseases, is not adequate to permit their production. However, it seems highly likely that diseases are transmitted by this route. It also seems likely that diseases are contracted through direct water contact in some of the waters that are most highly contaminated with sewage.

Clearly there is a need for marked improvements in the arrangements for sewage disposal in many areas within the region. Although the UNEP report (UNIDO/UNEP, 1982) suggested the installation of conventional sewage treatment (see section 4.1.2) it is questionable whether this would consistently achieve the desired results over the longer term and such works would certainly be costly to construct, operate and maintain even if the necessary skilled operators could be made available. It might be more appropriate to make use of land-intensive but low-energy treatment facilities such as lagoons and marshland irrigation wherever space is adequate. In areas of high temperatures and sunlight such facilities can be highly reliable and efficient solutions to a problem which most of the correspondents admit is probably growing rapidly with increased urbanisation.

## 5.3 Long-term impacts

There have been few long-term systematic studies which could yield information of this type relative to the area. There have however, been a number of changes which are attributed to pollution. For example, it seems to be generally accepted that the virtual loss of the fishery in Korle lagoon, Accra (Ghana) has been caused by the continued discharge of domestic and industrial wastes (Biney, Pers. Comm.). Similarly, Ajao (1986) reported that a decrease had occurred in the number of species and individuals of polychaetes, nematodes and crustaceans due to the long-term discharge of domestic and industrial wastes into the Lagos lagoon. In the same area, Dambo (1985) attributed the absence, from parts of the lagoon, of *Pachymelania aurita* and *Tympanotanus fuscatus* to higher than normal levels of organic materials and sawdust.

## 5.4 Damaged habitats and resources and their potential for recovery and rehabilitation

Fishing is important, at least at a local level, in most countries in the region and is a source of export earnings in several. For example, Senegal landed over 300,000 tonnes of marine fish in 1980 (FAO, 1981) of which a substantial part was shrimp, over 70% of which was exported. Benin has one of the smaller recorded catches, only 4,800 tonnes in 1980 (FAO, 1981) but it is likely that a substantial part of the small-fish catch in lagoons, caught in extensive wicker cages and traps, is not recorded. There are numerous instances where lagoon based fisheries have been affected by man's activities and the potential for further damage to these highly productive areas seems to be very real.

Apart from the direct effect of pollution in altering habitats and depleting numbers, the impact on the quality, particularly microbiological quality of molluscan species, brought about by sewage pollution, should not be ignored. The lagoon areas of countries like Senegal, Sierra Leone and Nigeria are used for exploitation of edible molluscs such as *Crassostrea gasar* and *Perna perna* and where these are harvested from waters contaminated by sewage, infection of consumers of diseases such as typhoid, cholera, and hepatitis is almost inevitable.

There are a number of aquaculture ventures in the region [UN(DIESA)/UNEP, 1984] all of them in lagoon or delta regions. These are obviously potentially at risk from sewage or industrial pollution either directly through damage to their stocks or indirectly through adverse effects on the quality of their products.

According to the regional correspondents, the general trend has been one of gradual deterioration in environmental quality, with the emphasis on development. They report also that little attention has usually been paid to the possibility that serious pollution problems might arise if effluents continue to be discharged in ever increasing amounts without treatment. Only very recently have control measures been introduced and generally it is too early to assess their impact. However, on the basis of observations after the Funiwa 5 oil well blow-out, it appears the flora and fauna of the region do have a potential for recovery if given the opportunity. Ekekwe (1981) recorded that sixteen months after the blow-out the flora was beginning to recover, crab populations had recovered well and juvenile oysters and periwinkles were recolonising the area. This is confirmed by observations carried out over several years in the Ebrie lagoon, where, following pollution control measures, the benthic populations are showing clear signs of recovery, with new species being recorded in successive surveys in four of the five areas studied (Glemarec et. al, 1980).

### 5.5 Accidents and episodic events

Predictions have been made (IMCO/UNEP, 1982) of the likelihood of oil spills based on the number of oil production and port facilities and the number of ships operating through the region. These showed that at any time there could be up to 126 tankers of >200,000 t dead weight and 400 tankers averaging 60,000 t dead weight with up to 50% of these being full. The estimates suggested 1.5 spills each year of 1,000 tonnes within 50 miles of land and 0.26 spills each year of 334 tonnes further than 50 miles from land. In fact, between 1975 and 1980 there were ten shipping accidents, including the suspicious loss of the "fully-laden" Salem in 1980. As previously mentioned there have been at least three oil well blow-outs (UNEP, 1984) including the Funiwa 5 blow-out in 1980 which spilt over 400,000 barrels of oil into the coastal waters of Rivers State, Nigeria. This caused mortalities of crabs, oysters and winkles in the short-term (Ekekwe, 1983) and has subsequently reduced both the size and numbers of winkles. The oyster stocks have still not returned to pre-spill levels, perhaps because of loss of habitat due to the killing of some mangrove areas (Ibe, Pers. Comm.).

The WACAF area is generally considered unlikely to be subject to major volcanic eruptions, earthquakes etc., although from time to time these do occur. Adams and Anbrasseys (1986) found 200 such records, 120 of which they were able to authenticate. In recent years there have been earthquakes in Guinea (1983) and coastal Nigeria (1984) and the very recent gas eruption in Cameroon (1986). The possibility of a major natural disaster affecting coastal resources cannot therefore be ruled out.

The area is, like most of the rest of the world, subject to storms and these can have locally spectacular effects on sandy coastlines, albeit of a lesser overall scale than an earthquake. One such instance is recorded in the report on coastal erosion [UNEP/UNESCO/UN(DIESA), 1985] where in the course of a single July storm up to 20 metres of shoreline was washed away in the Port Bonet region of Abidjan, Côte d'Ivoire.

## 6. PREVENTION AND CONTROL STRATEGIES

The extent to which countries in the area have marine pollution and control strategies actually in place and operating successfully seems to differ markedly. The existence of the WACAF projects has probably helped and at least one respondant made specific reference to the fact that data relevant to control of oil pollution would not exist if it were not for the project.

Regrettably, it has to be stated that although statements have been made by most countries' politicians as to their readiness to combat marine pollution, in many cases these statements have not been backed by action to implement those statements. Since in many countries the public is either unaware of the problem or how to deal with it and there is a lack of suitably trained personnel even in the better equipped countries, it seems likely to be some time before effective action is being taken in all countries.

The above does not necessarily mean no action is being taken. In Nigeria for example, a good system has been established for combatting oil spills which involves all the operators working together. Oil pollution is rigorously restricted by a national body and the controls are reasonably effectively enforced. Similarly, in Ghana an Environmental Protection Council (EPC) has been established with a responsibility for conducting pollution control activities. Its powers have recently been strengthened to enable it to tackle existing practices as well as new industries and to require improved or new effluent treatment in both sets of circumstances. This EPC is proving to be reasonably effective in its tasks. In Côte d'Ivoire the Ministry of Industry is responsible for protecting the environment and can restrict industrial discharges. A monitoring system has also been established but it is too early to assess how effective these procedures actually are.

Thus the overall impression is one of slowly developing environmental awareness and the establishment of regulations to permit pollution controls. The extent to which these are proving effective is more variable but in many cases it is fairly clear that more resources need to be deployed and a real willingness to act must be demonstrated by governments in the area even if this may initially be seen as inhibiting development.

# 7. TRENDS AND FORECAST

## 7.1 Pollution

The impression gained from the various national reports concerning the state of oil pollution in the area, viz that it has certainly not worsened in recent years and might perhaps have improved somewhat, is supported by one report from Nigeria (Ibe) who stated that the situation has definitely improved. Only one response (Republic of the Congo) suggested that the situation was getting worse, and in this case it was due to the development of the offshore oil industry. In the context of more general pollution from industry and domestic sewage discharges the general impression from all the national correspondents is one of a progressive worsening in pollution impact and a belief that this is likely to continue. Almost all of the respondants admit to their assessments being largely subjective, either because of a total lack of quantitative data or a lack of an adequate time series of data. However, since at least until very recently most countries had only very limited policies and facilities for pollution control, such assessments are probably accurate, given the rate of development of industry and the associated population increase in coastal areas.

Most of the forecasts for future trends are rather pessimistic and it seems that these are based on two perceptions of the situation. Either development is being given priority by the politicians at the expense of pollution control or the rate of development is such that the existing pollution control facilities and monitoring arrangements simply cannot keep pace. Several of the national respondants also point out that there is a lack of public appreciation of the actual or potential dangers which means that there is little local public pressure to remedy the situation.

On the basis of the information on inputs the contaminant most likely to give rise to problems in the WACAF area is sewage; both because of its content of pathogenic organisms and because of the oxygen demand it imposes on the environment to which it is discharged. In addition, the input of nutrients via this route may give rise to increased phytoplankton production in the areas most affected (see section 5.1). Oil is a commonly encountered pollutant in the region and its impact on the tourist potential of beach areas can be serious. There are, however, few reports of oil causing damage to marine living resources in the area.

Apart from these substances, Ibe (Pers. Comm.) suggests that phenols and fluorides might give rise to problems where they are discharged, but the two reviews of inputs (UNEP, 1982a and 1984a) suggest that the number of sources of these substances is limited. Whitehead (1985) has suggested that the wide-scale use of chlorophoxim in the Onchocerciasis control programme may lead to pollution due to its effect on fish (Antwi, 1985). For similar reasons deltamethrin may also merit investigation as to its potential to cause adverse environmental effects.

### 7.2 Climate

As with data on contaminants in the environment there appear to be few really long-term records of such climatic parameters as rainfall and temperature. Perhaps one of the longest records exists for Ghana where there are data for the total annual rainfall in Takoradi and Accra over a period of 50 years. These show marked annual variations but little evidence of an overall trend, although there may be a slight indication of an overall increase up to about the mid 1960s followed by an overall decline to the present time. In Côte d'Ivoire, records are apparently available only from 1975 but these too show some signs of there being a slight decrease in rainfall. In the Republic of Gambia the recent long drought was followed by double the normal average rainfall and the respondant for that country reported that both winter and summer temperatures had been higher than normal in the last two years. No obvious trend was reported to be detectable in Nigeria and in the Congo the records span only 20 years and have not been assessed in this context.

Some local climatic changes have been reported as a direct result of man's activities e.g. those associated with the creation of the lake at Akosombo on the Volta river (de Heer Amissah, 1969). It also seems possible that deforestation by the exploitation of natural timber reserves may have locally significant effects on rainfall.

There appear to be no records of sea level changes, though there are many reports of coastal erosion and changes in sea water intrusion up estuaries as a result of restrictions in river flows through dams.

Similarly, there appears to be no information on carbon cycle changes, though again productivity in some coastal lagoons at least must have increased. Conversely, off at least some major river estuaries it may have declined as a consequence of reduced river flows.

## 8. ECONOMICS

No data on this subject were provided by the national contacts. It would appear, however, that there is a fear pollution control might impose a burden on industry that might inhibit development. This need not be the case as treatment processes are available which can be made to pay for themselves by yielding usable products (see e.g. section 4.5). Similarly, sewage treatment need not be complex and expensive if methods appropriate to the area are employed (see section 5.2). If, as an alternative, long sea outfalls are used it is important that these are properly sited in relation to sea bed profiles and residual and wind driven current regimes. At least one national contact suggested that this is not obviously assured in all cases.

There is clearly ample opportunity for a conflict of interests to arise. An eagerness to develop the countries' resources and to introduce industry, with the jobs and economic benefits it brings, can cause attitudes to pollution controls to be somewhat relaxed for fear that industry will not be attracted to the area. People will be attracted to the towns as a result of the availability of jobs and unless adequate advance planning is exercised almost inevitably waste disposal facilities for sewage and general urban refuse will not keep up. Pollution of the coastal waters will result and public health may suffer directly as a consequence, with attendant costs.

Many countries of the region have a potential for tourism and in most cases this has only partially been realised. The tourists are attracted mainly by the climate and by expectation of unspoilt beaches. They will soon be deterred if they find industrial or sewage pollution near their hotels or litter and oil on the beaches. There will be a loss of income to the country concerned as a result, either actual or potential depending upon the state of development of the tourist industry.

In addition to the adverse effects on human health that may be caused by sewage pollution of marine resources, especially of molluscs, pollution may cause direct adverse effects on fisheries resources. The WACAF area roughly coincides with that supervised by the FAO Fishery Committee for the Eastern Central Atlantic (CECAF) and this area produces a not insignificant contribution to the world fishery landings. Out of a total marine catch of 73 million tonnes in 1984 the CECAF region yielded a recorded 2.6 million tons. This is almost certainly an underestimate of the landings since many of the coastal and lagoon fishery catches will not be recorded at all. It is these catches which are probably most vulnerable to pollution. The FAO Review of the State of World Fishery Resources (FAO, 1987) makes several references to marked fluctuations in catches from year to year. Most of these changes seem to be the result of fishing practices but in one instance - reductions in stock of bonga in the Iby Lagoon in Côte d'Ivoire at least part of the cause was attributed to reduced fresh water inputs to the lagoon (as a result of man's activities).

Since the value of industrial development, tourism and fisheries as well as the cost of damage to human health, are all characteristics of the individual country, calculations on a common base do not seem very meaningful. The important feature should be a balance of the relative interests. It is, however, worth bearing in mind that although the environment does have a capacity to recover, recovery can be slow and rectification of problems by installation of waste treatment plant and/or better sewerage and industrial effluent disposal systems is usually much more costly than installation at the time of initial construction.

## 9. SUMMARY

The West and Central Africa Regional Sea area stretches from approximately 16°N to 18°S. It has a coastline of some 8,000 kilometres. It is a region characterised by marked diversity. The climate ranges from desert in the north - the Sahara - through a humid tropical belt, which contains two of Africa's largest rivers, the Niger and Congo-Zaire, to desert again in the south - the Kalahari. The coastal regions show equal diversity, ranging from dunes through marshy delta lands and mangroves to Rias with steep cliffs. The continental shelf also varies markedly in width from some 70 kilometres or so in the Gulf of Guinea to about four kilometres off Angola and Zaire. Even the countries that make up the region differ markedly, from small island states like Sao Tome and Principe to large mainland countries like Nigeria and Senegal. While all are classified as developing countries, their state of development differs. Some have economies based essentially on handicraft and subsistence farming, whereas others have quite well developed industries.

Although the coastline is generally quite sparsely populated and the majority of the total population live away from the coast, most of the national capitals are situated on or very near to the coast. Consequently, the coast features some very densely populated areas. Two examples are Lagos with upwards of eight million people and 85 per cent of Nigeria's industry, and Accra-Tema with 60 per cent of Ghana's industry.

In common with many other regions, developing and developed, one of the major difficulties is a lack of good data on the sources, nature and content of inputs from towns, rivers, industry and shipping to the coastal waters of the area. The situation is compounded by the absence of an adequate database on the quality of coastal and offshore waters in the area. This is gradually being improved, but the availability of the data to organisations outside the laboratories that collect them is somewhat restricted. Despite these difficulties a moderately comprehensive, if somewhat general, picture of the marine and coastal environmental problems has been drawn, thanks mainly to substantial contributions by a few workers in the area and a number of reports on missions conducted with the help of FAO, UNEP and other UN agencies.

There appear to be two major problems that affect the region in a fairly general sense and others that are more local in impact. The most important, since it can potentially affect the health of the human population, is pollution of coastal waters and especially coastal lagoons by sewage. For example, over a period of three months in 1974 in Lagos, Nigeria, an estimated 7.5 million litres of untreated sewage was dumped into the lagoon at Iddo, this is aggravated by the fact that the beaches and open water courses are used as toilets. Of 16 coastal lagoons studied in Ghana, 12 were found to be polluted, two of them grossly so. In the early 1970s, in Abidjan, Côte d'Ivoire, the volume of domestic sewage discharged each year into Ebrie Lagoon was equivalent to about 18 per cent of the total lagoon volume.

In 1988 the situation seems to be no better. This is causing several organic enrichment in some areas with attendant deoxygenation, either as a direct result of adding organic matter or through the promotion of algal blooms that eventually collapse and decay. This in turn affects the availability of fish that have traditionally been caught for food in the areas affected. The pathogenic organisms, that are a component of all sewage effluents, are liable to infect those who come in contact with the contaminated waters and especially those who eat molluscan shellfish collected from other than lightly contaminated areas.

The second most common problem is probably coastal erosion aggravated by man-made alterations to lagoon channels and the construction of port facilities. For example, in Lagos, Nigeria, Victoria beach has eroded two kilometres and Escravos beach has eroded 0.5 km since breakwaters were constructed. Similar problems were created at the Port of Abidjan, Côte d'Ivoire, where the beach has eroded to the East and a road was cut through after the Canal de Vridi was opened in 1950. Serious erosion has also been reported for Benin, Gambia, Liberia, Sierra Leone and Togo. Changes to coastal areas are also being brought about by mining and especially by damming of rivers for irrigation and hydro-electric purposes. These restrict inputs of both suspended solids and nutrients to the coastal waters. Further changes are caused by the development of more intensive methods of agriculture and by deforestation for commercial timber and domestic firewood purposes.

In some areas oil pollution of beaches is also causing problems, especially in areas of local and international tourist interest. Originally, this was thought to come mainly from offshore tanker traffic between the Middle East oil fields and Europe, but it is now apparent that much is derived from local tanker traffic and from small spills and chronic losses from the oil exploitation activities in the area and the local port and refining facilties. Ghana's only oil refinery, for example, discharges a completely untreated effluent with an oil content of between 0.4 and 1.0 mg $l^{-1}$. Inshore and lagoon waters are also contaminated, for instance, concentrations of 10 - 65 mg $l^{-1}$ and 0.2 - 17.6 mg $l^{-1}$ were found in the Niger Delta and Lagos lagoon respectively. On some Ghanaian beaches 30 grammes of tar balls per square metre were found and 11.6 to 96.2 mg of tar balls per square metre were measured on Nigeria's Badagry beach.

Where industry has been promoted, very often it has been allowed to develop with no, or only very limited requirements for treatment of the effluents. Consequently, in areas that are heavily industrialised, pollution is apparent. This appears to be most serious in the context of organic enrichment of coastal waters with restricted circulation, especially in lagoons. There is at present little evidence of pollution being caused by persistent substances; where this does occur it is usually on a very limited scale.

Action to curb pollution both from existing and future activities has been promised in most countries and some measure of success does seem to be achieved by a few. However, it is clear that much greater efforts have to be made. This will mean more resources being devoted to monitoring and policing activities and a realization, both by the public and the national administrations, that pollution does not go away simply because a promise has been made or a law has been passed with the intention of improving matters. If a truly co-ordinated and unified level of effort were applied throughout the area, this greater attention to pollution prevention would certainly not inhibit developments as is occasionally claimed.

## 10. REFERENCES


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