

AN OVERVIEW OF THE ENVIRONMENTAL IMPACT OF THE SHRIMP AND PRAWN INDUSTRY IN GHANA

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1. INTRODUCTION

The Ghana Export Promotion Council has prepared a Medium Term Plan for Non-Traditional Export Development for the period 1991-1995 which has been formulated with the objective of raising export revenues of Non-Traditional Exports (NTE) from US\$ 62 million to greater than US\$ 300 million by the terminal year of the plan ¹. The GEPC plan links in with USAID/Ghana which is developing a Trade and Investment Program (TIP) with the Government of Ghana so as to promote and increase investment, development and marketing in the NTE sector. The program is aimed at strengthening the policies and institutional framework needed to encourage private sector investment and export. It is also intended to improve the financing and incentives available to the private sector and to improve the capabilities and the capacities of individual firms and entrepreneurs to export ². The program includes U. S. dollar cash grants to the Government of Ghana for policy and regulatory reform, dollar financed technical assistance and training as well as cedi financed local activities. Shrimp, lobster and prawn have been identified as one of the NTE sectors that could benefit from the program, Table 1 gives the export projections for the sector to 1995.

Year	1991	1992	1993	1994	1995
Volume (metric tons)	230	338	615	862	1334
Revenue (US \$ '000s)	1500	2200	4000	5600	8670

Table 1. Projected export volumes and revenues from shrimps and lobsters ³.

In order to achieve the overall program aim of increasing exports of shrimp, lobster and prawn (product) several options are available; i) increase the amount of product that exporters catch, ii) increase the proportion of landed product exported, iii) increase the value of the exported product, iv) use aquaculture to produce more product.

As part of the final preparations for the TIP, USAID is required to prepare a short overview of the potential long-term environmental impacts related to the proposed project activities. This report presents an overview for the prawn and shrimp industry (Section 2.) and how the industry has had or will have impact on the environment (Section 3.). The actions required for the monitoring, evaluation and mitigation of any impacts that promotion of this sector would have on the environment are presented (Section 4.). A number of projects related to these actions and the information requirements needed for the sustainable development of the industry are outlined (Appendix C.).

2. THE SHRIMP AND PRAWN INDUSTRY IN GHANA

2.1. SHRIMP AND PRAWN HARVESTING

Shrimp, lobster and prawn are found in commercial quantities in Ghanaian waters (see Appendix B for list of species) and there has been a tenfold increase in the quantity of exports of these products, mainly shrimp and lobster, within the period 1986 (19 tons, US\$ 62,000) to 1991 (195 tons, US\$ 1,428,000). Shrimp and lobster make up 6.6% of the marine product exports. Production is mainly due to harvesting by industrial shrimpers and the artisanal canoe fisheries⁴. Prawns are caught by traps from estuaries and dams for local markets.

2.1.1. Industrial Harvesting of Shrimp

Commercial shrimping by specialised vessels started in Ghana in 1969 by two large (greater than 1000 hp) Italian ships, the *Sajpa Terza* and the *Oceania Rosa*. Operating off Cape Three Points and in the Keta-Ada area, they made shrimp catches of up to 1000 kg of tails a day. By September 1970 there were 18 shrimpers of varying horse power operating in Ghanaian waters⁵. In the period 1969 to 1975, an annual average catch of 720,000 kg shrimp was made. The highest recorded catch was in 1974 of 1,420,000 kg after which, in 1975, shrimp fishery operations on the Ghanaian shelf eventually ceased as catches fell below the threshold for the economic operation of the shrimpers.

In 1986 commercial shrimping resumed in Ghana when Kiku Company Ltd. imported two vessels. In 1988, Kiku Co. Ltd. imported another two vessels and in 1989 Kyerematen Foods Ltd. imported one vessel, since then another 5 vessels have started fishing in Ghanaian waters⁶. The Fisheries Department have set a limit of 10 vessels, as a result, Kiku Co. Ltd. has four more shrimpers operating off Benin which were refused licences to operate in Ghanaian waters. Table 2 presents data on the export performance of the top five exporters in 1991. The number of exporters in this sector was 44 in 1990, and this had increased to 83 by the end of 1991, most of these exporters operate at very low volumes usually in the order of kilograms rather than tons, and function by purchasing shrimps from the artisanal fishermen and then packaging them for export. An organisation to co-ordinate the marketing and export of shrimp and prawns has been set up recently (Ghana Lobsters and Shrimp Producers and Exporters Association) and has at present, about 60 members.

Exporter	Quantity (tons)	Value US \$
Kiku Co. Ltd.	77.828	672 245
Brigit Fisheries Ltd.	20.000	200 000
Mokoledzen Fisheries Co.	11.508	115 080
Unidentified Exporter	5.850	58 500
Seapro Ltd.	5.115	15 043

Table 2. Performance of the top five shrimp exporters⁷

2.1.2. Artisanal Harvesting of Shrimp

Artisanal shrimp fisheries operate in two forms in Ghana: lagoon fisheries and canoe fisheries. Ghana has over 50 coastal lagoons and many of these are highly productive⁸. Between the end of the 1960s and the early 1970s there was a lucrative shrimp fishery in the Anyanui estuary and in the Keta lagoon. This led to the establishment of a French owned shrimp canning factory Dzelukope⁹. The factory operated on inputs of shrimp and prawn supplied by the local fishermen. Changes in the hydrology of the lagoon and over-fishing eventually destroyed the industry. The canoe fishery is pluri-specific, using pelagic encircling gear (poli nets) and beach seines which capture shrimps really as a by-catch to the *Sardinella* and other fisheries. These are then sold to the exporters. Lobsters are caught mainly by bottom set nets, though there has been some training and trials in the use of lobster traps. Data on exports of lobster and artisanal landings of shrimp are given in Tables 3 and 4 respectively.

Exporter	Quantity (tons)	Value US \$
Amohware Co. Ltd.	3.705	43 611
Hentman-Gulf Ltd.	7.054	42 737
Kiku Co. Ltd.	6.768	40 608
Dotex Ent.	3.749	24 921
E.K.S. Foods Ltd.	1.956	17 713

Table 3. Performance of the top five lobster exporters in 1991¹⁰

Year	1984	1985	1986	1987	1988	1989
Catch (tons)	216	508	552	1602	1177	1152

Table 4. Landings of shrimp by the artisanal and inshore fleets 1984 to 1989¹¹

2.2. SHRIMP AND PRAWN AQUACULTURE

2.2.1. *Macrobrachium* projects

Much of the preliminary work on pond culture has been carried out on freshwater prawns. In 1984, a grow-out experiment using the exotic *Macrobrachium rosenbergii* was carried out on juveniles flown in from Sweden¹². The local species *M. vollehovenii* (Plate 1.) and *M. macrobracion* have undergone trials in ponds in the Ashanti region and also in the vicinity of the Weiija dam¹³. A number of project proposals have been prepared relating to prawn culture¹⁴, but none as yet has received the necessary funding for work to commence.

2.2.2. *Penaeus* projects

There have been a few proposals for exotic shrimp culture in the coastal plain near the major rivers of Ghana ¹⁵. Most attention has been focused on the Black Tiger Shrimp *Peneaus monodon*. One venture, by the Ghana Prawn Company carried out growth trials at Ada on this species using imported post-larvae. Due to high local costs of pond construction, some proposals have suggested the use of existing storage reservoirs at salt works (Plate 2.) for the culture of *P. japonicus* which tolerates higher salinities than *P. monodon*. Interest in large-scale ventures by local/foreign investors is keen and in addition to the Ghana Prawn Co., which intends to develop 500 ha of pond area, the Managing Director of Kiku Co. Ltd. also wants to expand his operations into shrimp culture.

2.3. CONSTRAINTS ON THE INDUSTRY

The constraints on the industry must be considered as they have a bearing on the types of mitigating measures that could be used to reduce the impact this sector has on the environment.

2.3.1. Supply of the Resource, Preservation and Marketing

It is the smaller exporters who face most difficulties, none of these exporters have established their own means of supply and thus rely on fishermen whom they approach from beach to beach. This is especially true for the lobster exporters, who consequently are never sure of the volume available for shipment and cannot therefore advise buyers with any precision in terms of quantity ¹⁶. The fishing methods in use are for the most part outmoded and indiscriminate, hence catching individuals of all sizes ¹⁷. The craft used are also unsuitable for the deployment of modern gear. Most of the fishermen use empirical knowledge to locate fishing grounds and this can be very unreliable. Shrimp is a highly perishable product, weight loss and spoilage from inadequately preserved catch is very rapid. Most vessels have to take flake ice along with them when they go out to sea. This limits not only the length of time they can spend fishing, but also their choice of fishing ground as they are limited to the proximity of ice making facilities along the coast (Tema, Cape Coast and Sekondi). In the case of lobsters, there are very few lobster holding tanks along the shore, so they tend to be kept in floating cages out at sea. There is also a serious lack of cold stores at the minor fishing centres. The type of packaging used does not conform to any set standard and hence lowers the face value of the product. Due to the lack of processing capacity, most of the export is in the form of comparatively low value raw product.

2.3.2. Controls and Credit

Though there are regulations governing the gear used to catch of lobsters and shrimp, there is no effective way of enforcing these laws, and they are frequently ignored so that undersized product, especially in the case of lobster is often landed and sold. Large trawlers often operate illegally in the near shore area and interfere with the operations of the artisanal canoe fishery. A significant amount of product is lost by smuggling ¹⁸, either

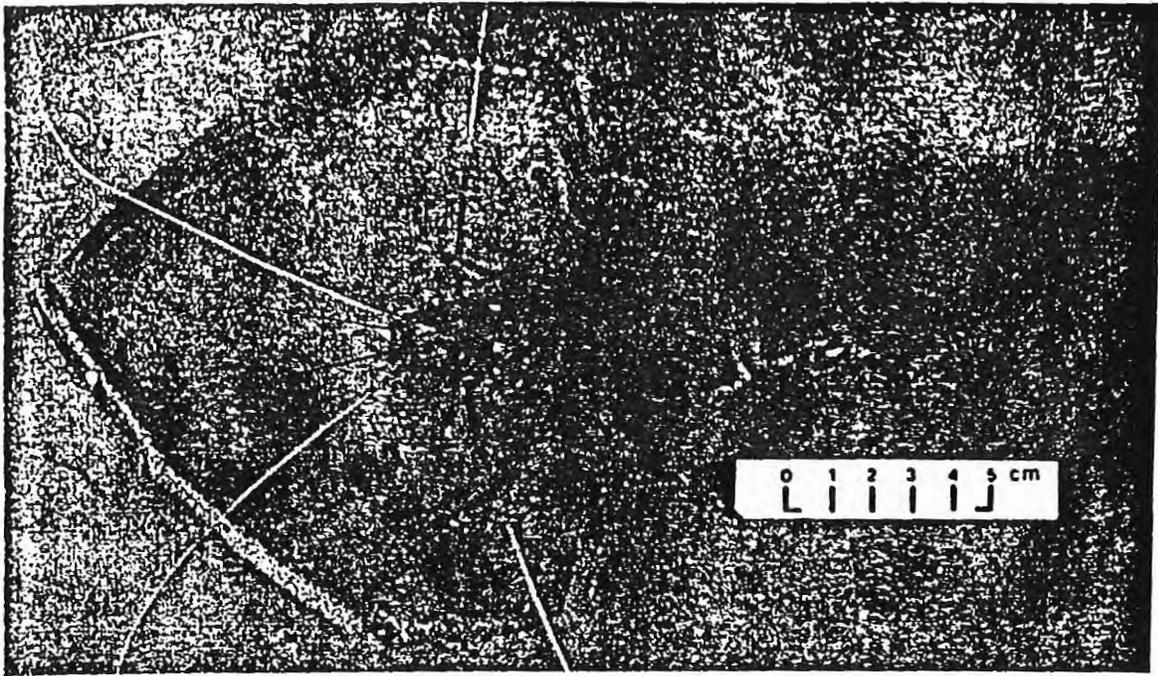


Plate 1. *Macrobranchium vollehovenii*, local species of freshwater prawn

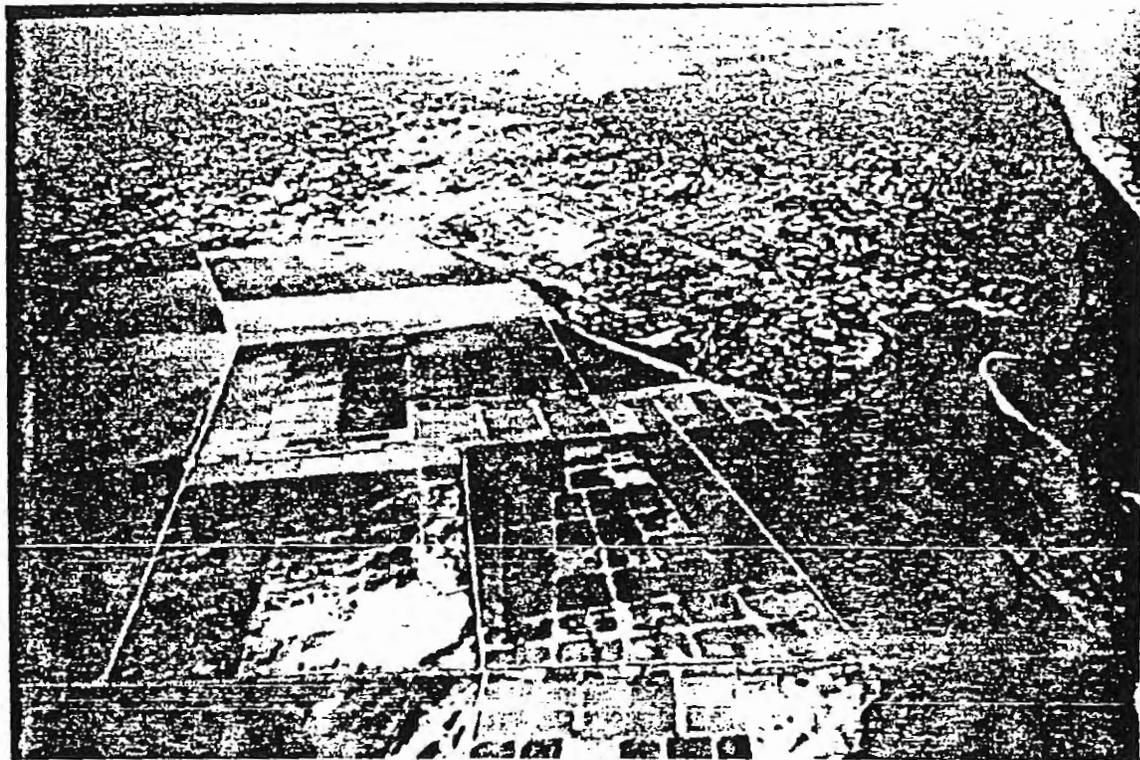


Plate 2. Panbros Salt works, a potential site for shrimp culture in storage reservoirs

by landing at foreign ports or by trans-shipment of catch to foreign vessels out at sea. Lobster are also carried overland as undeclared or under declared exports. The fishing industry as a whole has suffered from inadequate credit facilities and investment, but the losses accrued by financial institutions in loans for fish farming during the mid 1980s has made credit for aquaculture ventures even more very difficult to come by. Despite all these constraints it must be remembered that the volume of exports and the number of exporters has been increasing steadily each year.

3. ENVIRONMENTAL CONSIDERATIONS AND DATA GAPS

3.1 IMPACT OF PROJECT ACTIVITIES ON THE ENVIRONMENT

3.1.1. Harvesting

Resource base

The primary impact project activities could have is the depletion of the resource base due to over-exploitation. This has happened twice before, once when the marine shrimp fishery collapsed in 1975 and again with the loss of the artisanal Keta lagoon fishery. This danger is a very real one and is compounded by the fishing gears used which are not very size selective. The artisanal canoe fishermen and small two/four man beach seines catch young shrimp when they are migrating either along the coast or moving from the nurseries toward the open sea. One effect of these small scale fisheries is that they reduce the stock in the sea, and with respect to the breeding cycle of the shrimp, they play a more significant role than the offshore fishery¹⁹. It has been estimated that in the neighbouring Cote d'Ivoire, 55% of the shrimp are caught as sub-adults before they can migrate out to sea²⁰. The actual amount of shrimp caught by artisanal fishermen needs to be more accurately measured.

The commercial shrimpers have a different effect on the shrimp stocks, they tend to catch more shrimps of the 1+ cohort, and due to the large demand for the product shrimpers tend to concentrate in a few fishing grounds thus increasing the danger of over fishing. The present estimated total area of the main shrimp grounds²¹ in Ghanaian waters between the depths of 24-45 metres is approximately 520 km², comprising 310 km² in the Axim to Cape Three Points area and 210 km² off the coast in the Keta-Ada area (Fig. 1.) .

By-catch

The problems of by-catch and by-catch discard is not a problem for the unspecialised small scale artisanal canoe fishery (Plate 3). The only fish not taken are those which are poisonous or distasteful, although these are sometimes collected for medicine²². In the case of the commercial shrimpers the volume of by-catch can be considerably larger than the shrimp catch. As the shrimp is worth more than the by-catch and freezing and storage facilities are limited, the fish actually landed by shrimpers consist of specimens of a certain commercial value taken during the final days of a trip. Recent observations on board two

shrimping vessels operating in Ghanaian waters indicate that the shrimp to by-catch ratio varied from as low as 1:8-9 to as high as 1:0.4-0.5, it was also noted that between 6 and 44% of the by-catch was discarded at sea, mainly made up of undersized shrimp and fish ²³. A major data gap exists concerning quantities of commercial by-catch.

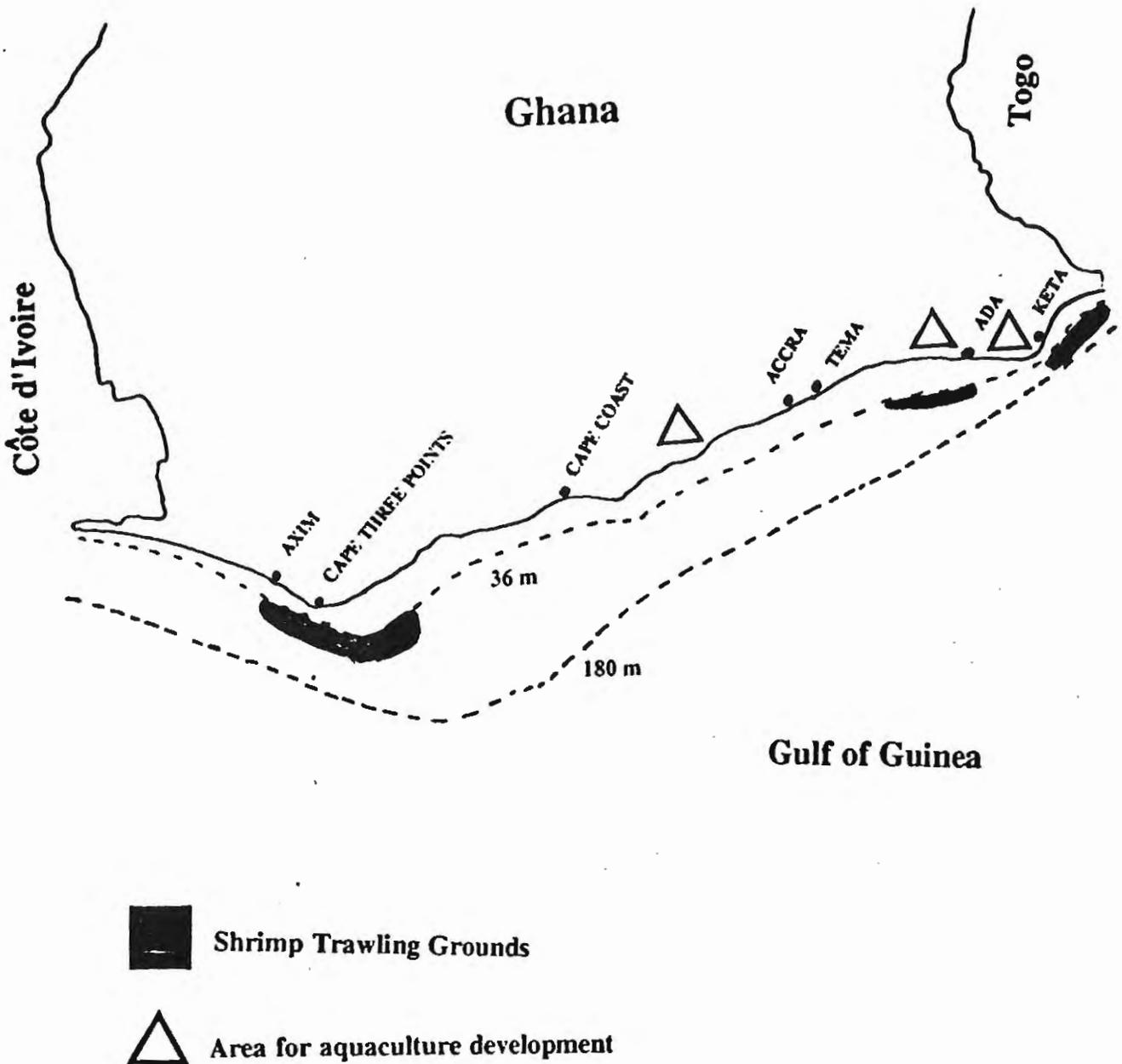


Figure 1. Main shrimping areas and identified sites for shrimp aquaculture in Ghana

Biodiversity

The methods of capture presently in use have implications on the biodiversity of demersal species on the near shore continental shelf. This is true not only of the fish species but for all the invertebrate species that colonise the sea bed. The operation of the fish gear disturbs the benthos, but as so little is known about this community on the Ghanaian continental shelf, there can be no firm conclusion on such effects. In the Gulf of Mexico, marine turtles are often caught in shrimping trawls and as a result, nets have been designed with turtle exclusion devices (Fig. 2.). These do not affect the catch of shrimp and indeed if properly deployed can increase gear efficiency²⁴. Marine turtle populations are threatened in Ghana, and are protected by law, however there is no information available on trapping of turtles by shrimpers and indeed all trawlers.

Processing

The current levels of exploitation and methods of processing do not, at present, have any meaningful impact on the environment. The commercial shrimping vessels sort and freeze their catch out at sea, the large shrimps are landed frozen and packed and exported in this state. The smaller shrimps brought back are defrosted, beheaded and exported as tails only. The heads are then sold to poultry farmers for feed. Apart from the melt water, which is of low volume, a minor cause for concern is the packing material (Polystyrene/Styrofoam) which is regarded as being detrimental to the environment. Processing of the artisanal catch is often very poor (Plate 4). Traditionally shrimp is usually dried or smoked by wood fires - this is a minor concern as the amounts of fuel wood used are insignificant when compared to the amounts used for the main fish catch.

3.1.2. Aquaculture

Though there are no fish farms currently operational in this sector, interest is great and it is only a matter of time before the first large scale shrimp farm begins to operate in the country. The potential environmental problems that may arise depend very much on the scale of operations, the species used and the level of management.

Habitat destruction and biodiversity loss

The major environmental problem in shrimp farming is the destruction of coastal wetland habitat. The areas that are targeted first are salt marshes and mangroves (Plate 5). A farm of 500 ha. water area, requires an additional quantity of land to provide for pond bunds, access roads and buildings. The coastal wetlands harbour large numbers of birds and other vertebrates. Mangroves and lagoons act as an important breeding area for many species of commercially valuable fish, including shrimp and prawn. Large data gaps exist in the knowledge of coastal ecosystem functioning in Ghana, great care must therefore be taken in site selection. It must be noted that the two areas most favoured as sites for shrimp culture (Keta lagoon and Songor lagoon) hold internationally significant populations of waders²⁵.

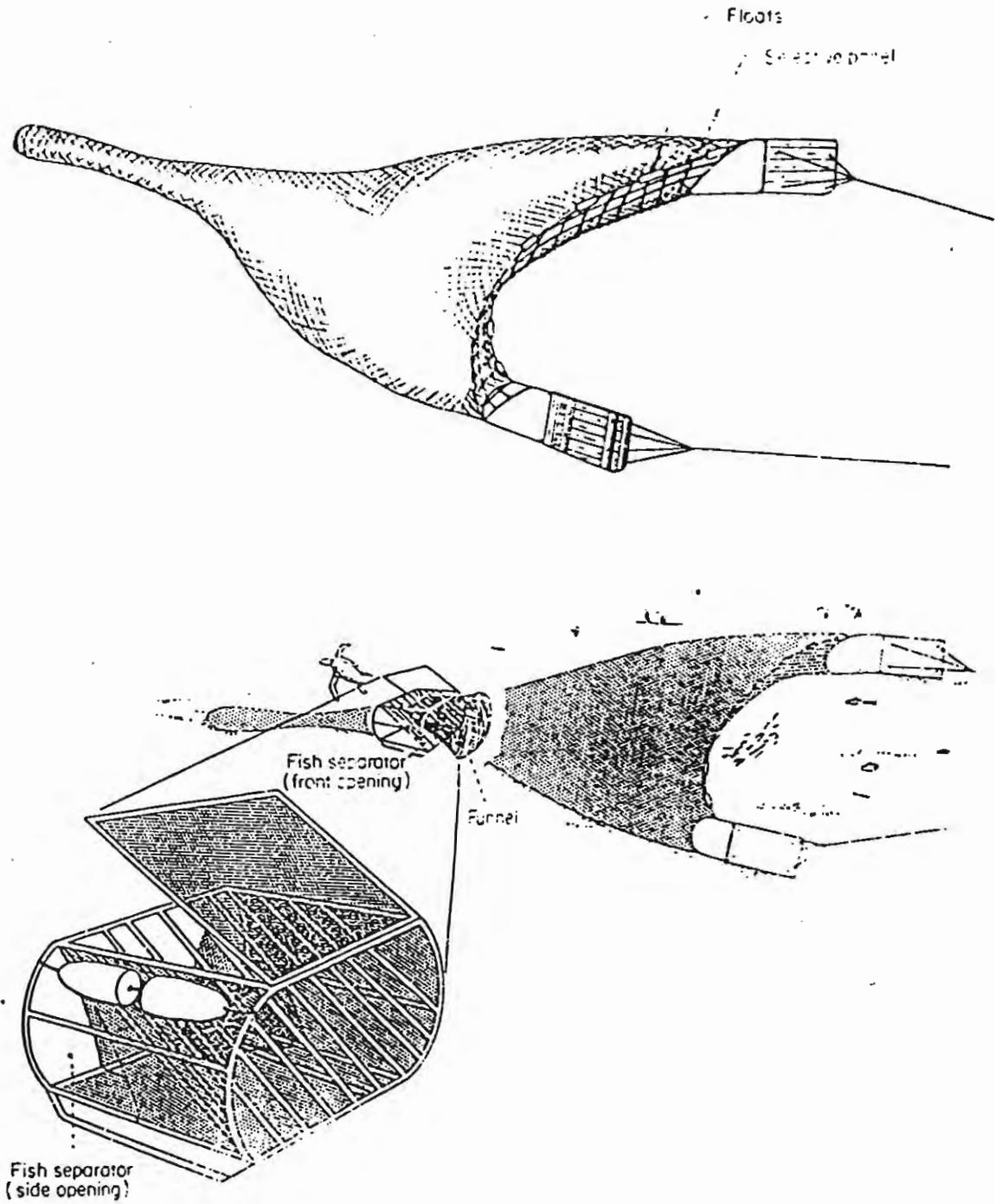


Figure 2. Selective trawls fitted with Marine Turtle excluder devices



Plate 3. Landing of beach seine of the coast near the Songor lagoon



Plate 4. Handling of product at a landing site by the artisanal sector

Water abstraction and effluents

Ponds require large amounts of water for the maintenance of water levels due to losses caused by seepage, evaporation and the need to exchange water to maintain water quality. This requirement could lead to conflicts with other water users in times of low river flow. The water from ponds, when drained for harvest, is high in nutrients and chemicals and if discharged untreated into other water bodies can cause eutrophication problems. This problem is also associated with high volume processing plants.

Exotic introductions and disease

As there is a lack of knowledge on the biology and physiology of local species of shrimp and prawn, any venture in the near future will depend on an imported exotic species. Though sites for hatcheries for these exotic species have been identified in the Central region, hatchery development is likely to be in the second phase of any venture. Shrimp and prawn farmed under intensive systems (up to 50 per m²) are very susceptible to disease. The importation of diseases with foreign post-larvae, and the possible escape into the wild, of both disease and the exotic species itself could have serious and negative effects on indigenous species and coastal communities.

3.2. SOCIO-ECONOMIC IMPLICATIONS

In other Third World countries, the crustacean shellfish industry has proved to be very profitable for certain groups of people. It is important to ask certain questions relating to equity. Who is going to benefit from the development of the industry? How will these benefits be distributed within the population? Within the artisanal fishery, the population sector at risk are the women who traditionally purchase catch direct from the fishermen. The export of shrimp and lobster is dominated by men who by purchasing shrimp at the beach deprive these women of high value product. There is a need to assess the contribution made by the sale of shrimp and prawn to the income of these women.

Large scale aquaculture ventures are usually owned and run by local elites who have access to sufficient knowledge and capital. These elites also have political influence which sometimes make it possible for them to displace communities, who live on the land and use its resources, but have no formal title or property rights. In many cases the land that is to be used for the project is valued to small communities who have no clear idea of how the project will affect them, and traditional methods of resource control which have no legal basis are brushed aside (Plate 5). The situation would be more positive if there was a guarantee that displaced people were absorbed by the new industry. The experience in other countries such as the Philippines shows that this is not the case. The problem that arose between the large scale salt companies and the people of the Songor lagoon is a recent and local case in point. The groups at risk are the subsistence fishermen in the coastal lagoons and data on the magnitude and value of this fishery need to be collected.

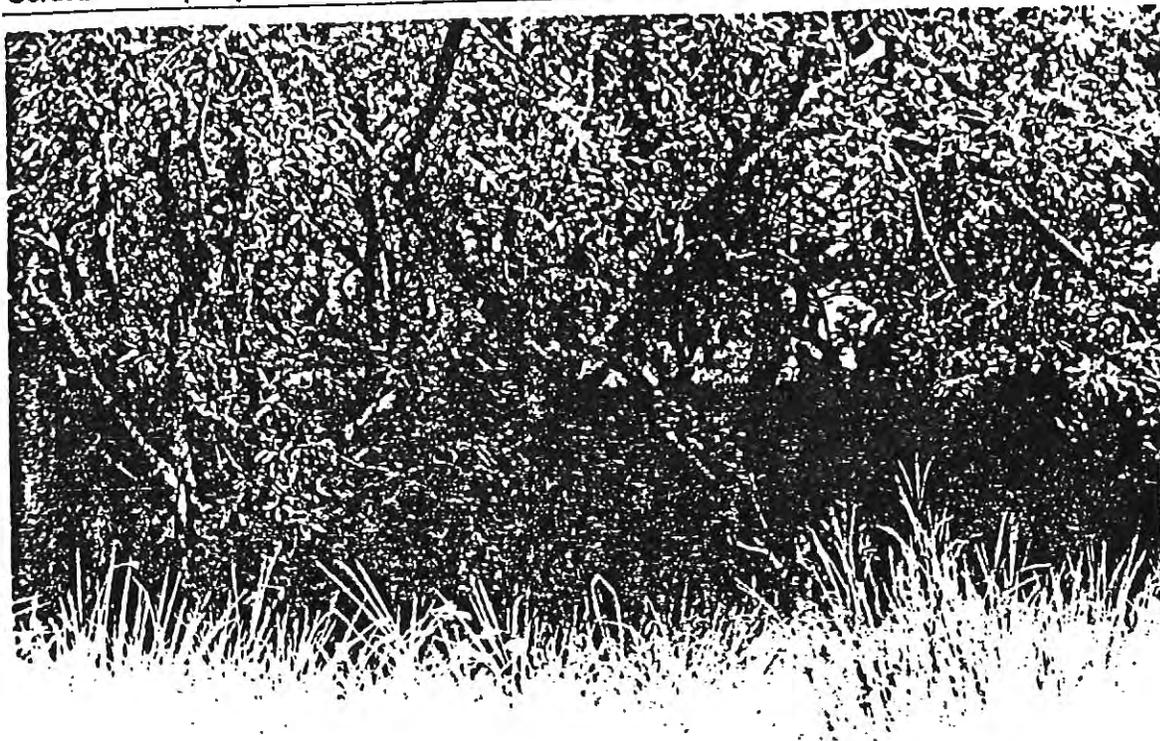


Plate 5. Mangrove thicket near Ada in an area earmarked for shrimp farms

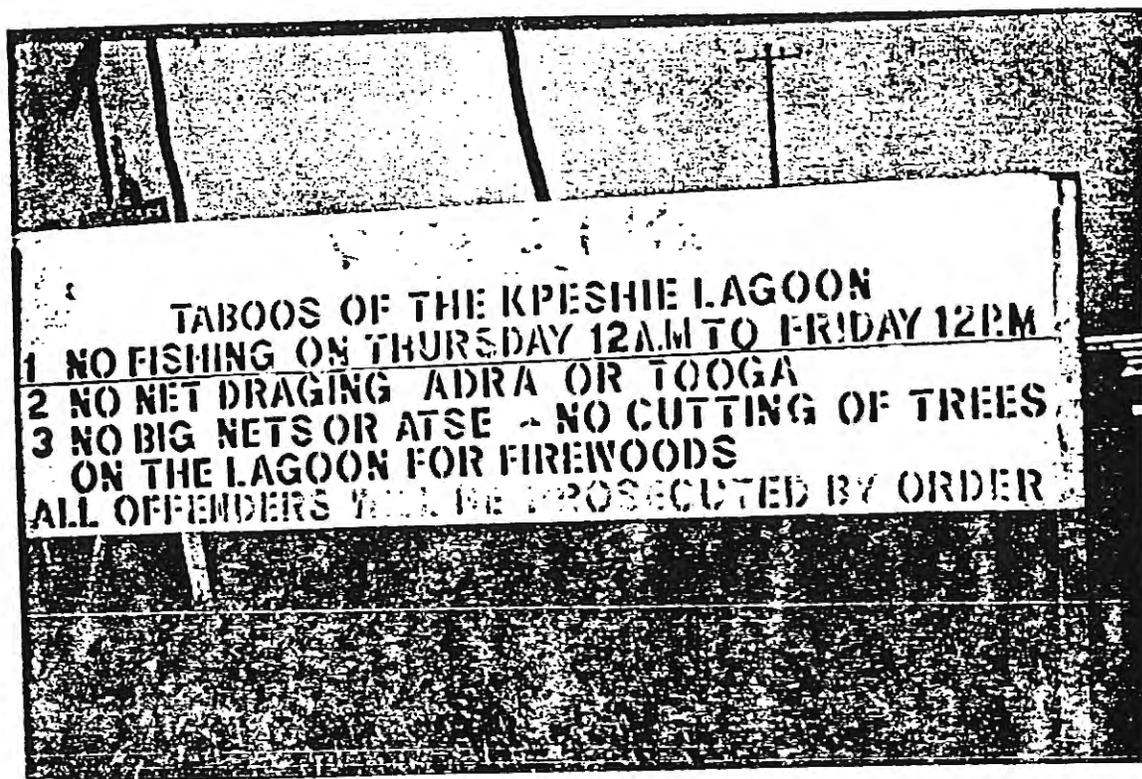


Plate 6. Local controls of resource use in a coastal lagoon in Ghana

3.3. IMPACT OF OTHER DEVELOPMENT ACTIVITIES ON THE INDUSTRY

3.3.1. Dam construction and operation

The collapse of the Keta lagoon shrimp industry has been attributed to the damming of the Volta river, which caused changes in the hydrology in the Lower Volta and the Ada estuary. This can not be proved due to lack of knowledge of conditions in this area before the dam was formed. It is true to say, however that the regularised flows have removed any seasonality in salinity and water level that could have acted as an environmental trigger for the shrimps. As shrimps require brackish water conditions to breed, retention of water by dams inland can have profound effects on recruitment to the marine standing stock as a result of changes in the salinity regime in the estuaries and lagoons.

3.3.2. Coastal protection works

There are a number of sites along the coast of Ghana where there is rapid erosion of land. The Keta area has suffered in this respect for years. In order to safeguard life and property a number of sea defence schemes have been put in action ²⁶. At present there has been limited success, so that increasingly ambitious projects are being suggested. Given that the shrimps use the interface between land, sea and freshwater to breed, it is possible that some of these schemes may destroy the fishery.

3.3.3. Agrochemicals, Eutrophication and Sediments

Two of the projects under TIP are geared at increasing exports in agricultural ²⁷ sectors. Activities in these sectors have implications on the shrimp and prawn sector. The increased and indiscriminate use of pesticides such as herbicides and insecticides can have lasting and significant effects on water quality in both rivers and the coastal lagoons. Poor farming practices and the rampant cutting of timber and fuel woods (eg mangroves in coastal wetlands Plate 7) has increased rates of soil erosion in many river catchments, not only destroying valuable top soil, but increasing the sediment load of the rivers that feed the various lagoons bringing the danger of their silting up. Fertiliser runoff can cause eutrophication of the lagoons and in extreme cases completely wipe out all but a very few specialised form of life ²⁸.

3.3.4. Industry

Industrial effluents and Pollution incidents

The effluents from gold mining and processing in the west of the country enter the river Ankobra and reach the sea in the area of the main shrimping grounds. These effluents contain arsenic and cyanide as well as quantities of suspended solids. The occurrence of tar balls (Plate 8) along the beach arising from oil spillage out at sea are a cause for concern as well as are inland spillage's such as the Akosombo Textile Ltd. spill which polluted the Volta river.

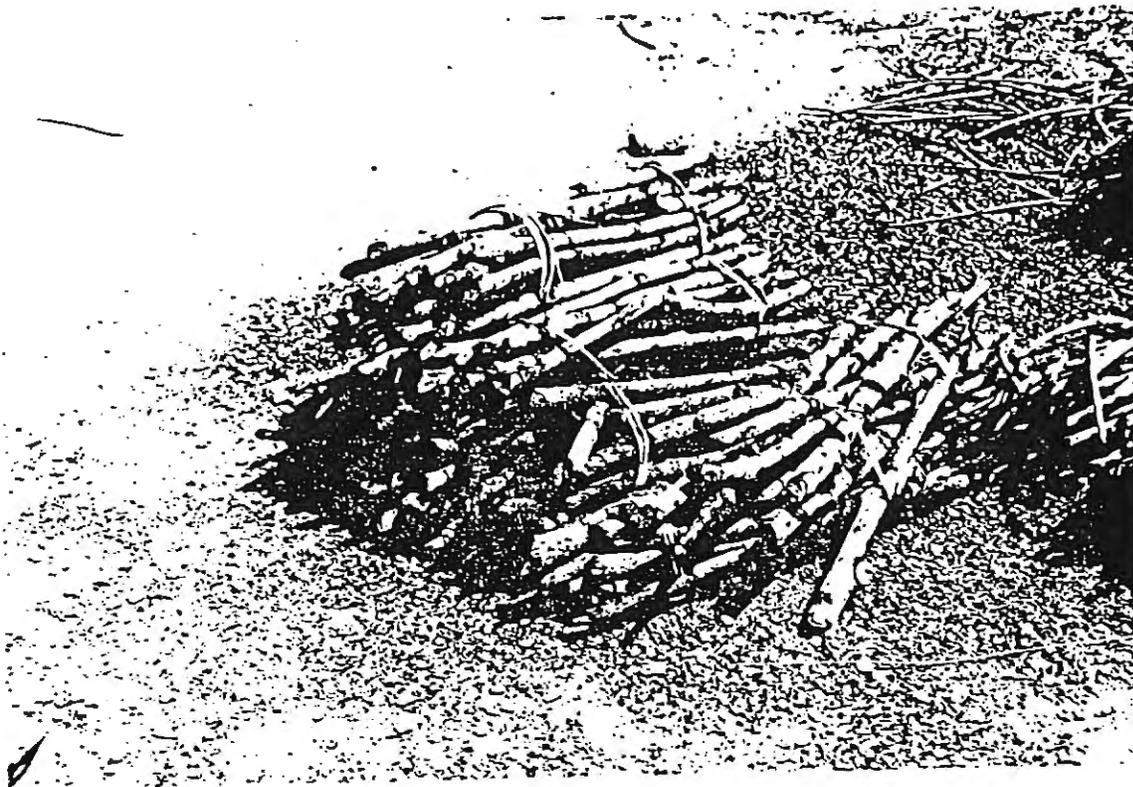


Plate 7. Pile of mangrove cut as fuel wood displayed by the Keta road



Plate 8. Tar balls on the beach near the mouth of the River Volta

Salt Mining

Under the TIP, increase in exports of salt²⁹ has been identified as a program activity. This activity, to be carried out at Songor lagoon is not incompatible with the activities in the prawn and shrimp sector. The dual use of primary concentration reservoirs for salt and shrimp production is feasible, even the more saline pans could be used for the production of brine shrimp which is required as feed for the young stages of shrimp. However the design and layout of the salt pan complex could also be done in such a fashion that it would reduce the value of the area to fisheries.

3.3.4. Human Settlement

Sanitation

The coastal plain of Ghana is the most densely populated area of the country, and the disposal of human wastes has become a critical issue especially around urban centres such as Accra and Tema. Some of the coastal lagoons have become recipients of sewage (eg. Korle, Sakumo) and are grossly polluted or hypertrophic. The effect this situation has on the shrimp population is bound to be negative. The Government of Ghana is aware of the problem and is exploring ways in which the situation can be improved. Unfortunately some of the proposed solutions involve the dumping/piping of sewage into the sea. In a worst case scenario, this could have direct effects on the stocks of shrimp and lobster out at sea and also their acceptability on the world market if they were to become contaminated by coliform bacteria from the sewage plume.

4. ENVIRONMENTALLY SOUND DEVELOPMENT OF THE INDUSTRY

4.1. POLICY LEVEL

4.1.1. Legislation and Enforcement

The requirements for development of shrimp and prawn as an export have been described elsewhere^{30, 31, 32}. The growth of this sector can only succeed if the activities are sustainable in the long term. The immediate concern of the government and of the industry should be the mitigation of environmental damage so as to protect stocks. The Environmental Protection Council³³ has prepared a National Environmental Policy (NEP) document which presents all the required actions. These include restructuring of the EPC, a revised conservation policy, legislation for coastal zone management and the establishment of a water resources commission. There is a need for the actions under the NEP to be implemented swiftly. The fish stocks are protected by the Fisheries Decree (1972) and Fisheries (Amended) Regulations of 1984. Ghana is also signatory to the Ramsar Convention which places an obligation to protect wetlands especially those of importance to birds. Though there are no legal instruments specifically controlling the discharge of sewage and effluents into the marine environment and the abstraction of water from the environment³⁴ - the overall legal policy agenda for the environment is being sufficiently addressed by government. The problem is

legal instruments specifically controlling the discharge of sewage and effluents into the marine environment and the abstraction of water from the environment³⁴ - the overall legal policy agenda for the environment is being sufficiently addressed by government. The problem is with the observance and enforcement of the laws/regulations. This can only be addressed by institutional strengthening and education of the concerned groups. New laws and regulations, for example - on minimum exportable sizes of lobster, will only serve to drive the illegal trade further underground.

4.2. STATUS OF THE RESOURCE/ENVIRONMENTAL CARRYING CAPACITY

The Fishery Department, has rightly been very cautious in allowing vessels to operate in the sector. This is because of lack of knowledge on the available stocks. Following their recommendations³⁵ the number of vessels should not exceed ten, until stock assessment data indicate a review of fleet size. It must also be pointed out that such a study may result in a recommendation that the current fleet size should be reduced. The gear used by the shrimpers should be standardised and mesh regulations strictly enforced. The recommendation that areas around estuaries and lagoon entrances should be adopted, as should the recommendation on a closed season (February to March and August to October).

There is a need to have greater protection and management of coastal habitats so as to conserve their productivity and value to coastal communities. The EPC has commissioned the preparation of a Coastal Zone Indicative Management Plan, which assesses the policies and presents in detail the actions that must be implemented so as to preserve the environmental carrying capacity of the area.

4.3. INSTITUTIONAL ISSUES/ENVIRONMENTAL POLICY REFORM

4.3.1. Institutional linkages

At present there are six main groups of organisations interested in the shrimp sector and there is an urgent for the establishment of some sort of formal dialogue between them so that exchange of views can take place and possible conflicts can be resolved as early as possible within any planning or implementation activity. The governmental bodies are the Ghana Export Promotion Council, The Fisheries Department of the Ministry of Agriculture and The Environmental Protection Council. The non-governmental organisations are the association of exporters, the canoe fishermen association, and local environmental pressure groups. There will have to be greater co-operation and communication between all these organisations. Either the EPC or the GEPC could set up a committee to act as a forum for the sector, this would be in addition to the Annual Environment Conference/Workshop suggested in the IEE to review TIP impacts and will thus provide a mechanism for feedback to government for Environmental Policy Reform.

4.3.2. Institutional strengthening

A primary requirement for the success of the TIP program is the training of manpower. The twenty projects outlined in Appendix C should be linked to the development of local skills in environmental monitoring and fishery biology. This training must be carried out at all levels and with the following target groups; Fishermen, Exporters, Fisheries Department, Environmental Protection Council and the University of Ghana. It is expected that USAID will identify American institutions to which local institutions can be affiliated for staff training using the projects given. This may be in the form of staff exchange visits, short courses run both here and in America as well as higher degrees for professional staff. The information generated by the projects and the manpower development will improve the predictive and analytic capabilities in the sector.

4.4 MONITORING PROGRAM AND INDICATORS

The IEE suggests the use of an Environmental Monitoring, Evaluation and Mitigation Plan (EMEMP) to control the direction of the TIP program. The projects presented in Appendix C should address this issue, within these projects there are a number of key environmental indicators that will be monitored. These are, (project numbers in bold):

Coastal Processes **2.1.**,

Sediment Budgets; river sediment loading, long shore drift
Beach profiles

Marine Fishery Resources **1.1., 1.2., 1.3., 1.5, 1.7, 1.8.**

Size spectra of shrimps, lobster and prawns
Biomass of landed product
Movement/migration of stocks
By-catch

Coastal Ecosystems **1.5, 1.7., 1.8., 2.1., 2.2., 2.3., 2.4.**

(Lagoons, Estuaries, Salt marshes, Wetlands and Mangroves)

Hydrology; water budgets, sediment transport

Limnology; pH, colour and transparency, salinity, dissolved gases, sediments, ionic proportions, nutrients, Biological Oxygen Demand

Ecology of major groups: algae, macrophytes, zooplankton, benthos, fish, amphibians and reptiles, birds and mammals

Pollution **2.1., 2.3., 2.5.**

Petrochemicals; tarballs, oil slicks

Organochlorides; pesticides, industrial wastes

Heavy metals and traces elements

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**APPENDIX B.: COMMERCIAL SHRIMP, LOBSTER AND PRAWN SPECIES FOUND IN
GHANA (from Ofori-Adu, 1988 and Gordon, 1989)**

PENAEIDAE (Marine shrimps)

1. *Penaeus notialis*
Penaeus duorarum
Penaeus brasiliensis
Pink Shrimp
2. *Penaeus kerathurus*
Penaeus trisulcatus
Penaeus caramote
Caramote prawn
3. *Parapenaeus longirostris*
Deep-water rose shrimp
4. *Parapenaopsis atlantica*
Guinea/Tiger shrimp

PALINURIDAE (Craw fishes/Lobsters)

Panulirus regius
Panulirus rissoni
Royal spiny lobster

SCYLLARIDAE (Squat lobsters)

Scyllarides herklotsii
Red Locust lobster

SOLENOCERIDAE (Solenocerid shrimps)

Solenocera africana
Solenocera membranacea
African mud shrimp

PALAEEMONIDAE

Nematopalaemon hastatus
Estuarine prawn
Macrobranchium vollenhovenii
Macrobranchium macrobracion
Brackish water prawn

APPENDIX C. RESEARCH NEEDS AND PROJECT OUTLINES

The following briefly summarises the information requirements and projects for environmental monitoring and mitigation that would need external assistance along with independent action by the Government of Ghana for the sustainable development of the shrimp, lobster and prawn export sector. "University of Ghana" listed below represents the Volta Basin Research Project, and the Departments of Zoology/ Fisheries and Oceanography.

1. Project area Evaluation of the Resource Base

1.1. Project Title: Stock Assessment of Shrimp, Lobster and Prawn in Ghana

Implementing Agency: Fisheries Department (MoA); Universities of Ghana and Rhode Island

Immediate Objective: Develop realistic projections of the maximum sustainable yield of shrimp, and lobster, linkage with the FAO/CECAF decapod survey

Inputs/Time frame: US \$ 300,000 3-4 years

1.2. Project Title: Artisanal landings of shrimp and prawn in Ghana

Implementing Agency: Fisheries Department (MoA); Universities of Ghana and Rhode Island

Immediate Objective: Assessment of the species, quantity, sizes and quality of shrimp landed by canoe fishermen, as well as where they are landed.

Inputs/Time frame: US \$ 80,000 3 years

1.3. Project Title: By-catch of trawlers operating in Ghanaian waters

Implementing Agency: Fisheries Department (MoA); Universities of Ghana and Rhode Island

Immediate Objective: Assess the quantities of by-catch, especially turtles and marine mammals caught by trawlers off the coast of Ghana.

Inputs/Time frame: US \$ 20,000 3 years

1.4. Project Title: Gear development for shrimp and lobster

Implementing Agency: Fisheries Department (MoA), GEPC, EPC and University of Ghana

Immediate Objective: To improve the selectivity of fishing methods used so as to avoid non-target species.

Inputs/Time frame: US \$ 40,000 2 years

1.5. Project Title: The biology and ecology of penaeid shrimps in Ghana

Implementing Agency: University of Ghana

Immediate Objective: To determine the breeding requirements, population and migration patterns of shrimps.

Inputs/Time frame: US \$ 40,000 4 years

1.6. Project Title: Culture and economic potential of penaeid shrimps in Ghana

Implementing Agency: University of Ghana

Immediate Objective: To investigate the feasibility of developing shrimp culture in Ghana and the suitability of the local species.

Inputs/Time frame: US \$ 50,000 3 years

1.7. Project Title: Biology and ecology of freshwater prawns

Implementing Agency: University of Ghana

Immediate Objective: To determine the breeding requirements, population and migration patterns of prawns.

Inputs/Time frame: US \$ 40,000 4 years

1.8. Project Title: Biology and ecology of palinurid lobsters

Implementing Agency: University of Ghana, Fisheries Department (MoA)

Immediate Objective: To determine the breeding requirements, population and migration patterns of lobsters.

Inputs/Time frame: US \$ 80,000 4 years

1.9. Project Title: Design of low-cost iceboxes for shrimp transport using local materials

Implementing Agency: University of Ghana, Fisheries Department (MoA)

Immediate Objective: To design and construct a simple, cheap and efficient cold box for use by fishermen in their canoes, the small scale exporters and researchers.

Inputs/Time frame: US \$ 15,000 0.5 years

2. Project area Environmental Monitoring

2.1. Project Title: Limnology of Ghanaian Estuaries

Implementing Agency: University of Ghana, EPC

Immediate Objective: To assess the quality of estuarine waters to determine rates of eutrophication, pollution and sediment transport.

Inputs/Time frame: US \$ 200,000 3 years

2.2. Project Title: Biodiversity of the coastal lagoons of Ghana

Implementing Agency: University of Ghana, Save the Seashore Bird Project - Ghana, EPC

Immediate Objective: To prepare baseline faunal lists of species using coastal lagoons

Inputs/Time frame: US \$ 150,000 3 years

2.3. Project Title: Ecology of the coastal lagoons of Ghana

Implementing Agency: University of Ghana, University of Cape Coast

Immediate Objective: To examine the functional links between lagoons and their fauna.

Inputs/Time frame: US \$ 150,000 3 years

2.4. Project Title: Comparative studies on the marine benthos in trawled and non-trawled areas of the continental shelf

Implementing Agency: University of Ghana, Fisheries Department (MoA)

Immediate Objective: To assess the effects of trawling on benthos

Inputs/Time frame: US \$ 150,000 4 years

2.5. Project Title: Ecotoxicology of shrimps and prawns

Implementing Agency: University of Ghana, EPC

Immediate Objective: To assess the effects of pollutants found in Ghanaian waters on the biology, physiology and ecology of shrimp and prawn.

Inputs/Time frame: US \$ 100,00 3 years

3. Project area Mitigation measures and Human Issues

3.1. Project Title: Mangrove rehabilitation and restoration

Implementing Agency: Forestry Department, Botany Department (UG), EPC

Immediate Objective: To replant mangrove or its equivalent in deforested areas

Inputs/Time frame: US \$ 200,000 3 years

3.2. Project Title: Reintroduction of penaeid shrimp to the Keta lagoon

Implementing Agency: National Service Scheme

Immediate Objective: To attempt to establish breeding populations of shrimp in areas of the Keta lagoon where brackish water conditions have been recreated as a result of the dredging of the Volta mouth.

Inputs/Time frame: US \$ 75,000 4 years

3.3. Project Title: Role of Women in the processing and marketing of shellfish

Implementing Agency: National Council for Women and Development, Fisheries Department (MoA), Department of Food Science (UG), Institute of Statistical, Social and Economic Research (ISSER) (UG)

Immediate Objective: To quantify the role women play in the marketing of shrimp and to assess their methods of handling and processing.

Inputs/Time frame: US \$ 45,000 2 years

3.4. Project Title: Economic assessment of the value of lagoon fisheries

Implementing Agency: University of Ghana, ISSER (UG), Fisheries Department (MoA)

Immediate Objective: To measure incomes derived from lagoon fisheries and to estimate loss in means if local people were deprived of them.

Inputs/Time frame: US \$ 55,000 2 years

3.5. Project Title: Education program for fishermen/ exporters in the shrimp/lobster sector

Implementing Agency: Fisheries Department (MoA), Institute of Adult Education (UG), GEPC, EPC

Immediate Objective : To devise and administer an environmental education package so as to change attitudes and behaviour patterns on fishing in an environmentally damaging fashion. This would include a Newsletter for the Exporters

Inputs/Time frame : US \$ 250,000 4 years

3.6. Project Title: Assessment of traditional strategies for coastal resource protection

Implementing Agency: Institute of African Studies (UG), University of Ghana

Immediate Objective: To establish the effectiveness of local methods of resource protection, and how they can be strengthened by modern legislation.

Inputs/Time frame: US \$ 100,000 2 years

3.7. Project Title: Committee for the sustainable development of the shrimp industry

Implementing Agency: GEPC, EPC

Immediate Objective: To make provision for quarterly meetings by the identified groups in the sector in order to discuss issues and resolve possible conflicts

Inputs/Time frame: US \$ 20,000 5 years

3.8. Project Title: Annual Environmental Conference/Workshop

Implementing Agency: EPC

Immediate Objective: Provision of an open forum to conduct a yearly review of activities under the TIP program in order to assess changes that may need to be made to policy as results from the research projects.

Inputs/Time frame: US \$ 12,000 for each year of program operation