CARICOM FISHERIES RESOURCE ASSESSMENT AND MANAGEMENT PROGRAMME

Shrimp/Groundfish Resource Assessment Unit[1]

Background Review and Subproject Initiation Mission Report for Shrimp and Groundfish Assessments (WBS - 420)

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INTRODUCTION

The Resource Assessment Subprojects of CFRAMP have as their objectives:-

I) the provision of basic information required for fishery management decision making;

ii) the development of the national and regional capability for ongoing acquisition and interpretation of fishery information, including the provision of fishery management advice (Subproject Initiation Mission Report for: Large Pelagics, Reef and Deep Slope Fishes Assessment, 1993).

The Shrimp and Groundfish RAU was established on November 1, 1994. During the period February - April, 1995, staff from the RAU visited participating countries (Belize, Guiana and Trinidad and Tobago), the non-CARICOM states (Brazil, French Guyana, Suriname and Venezuela)in the FAO/WECAFC Ad Hoc Shrimp Group for the Guiana-Brazil Shelf and the USA (National Marine Fishery Service, Miami and Texas, and the University of Miami). The purpose of the visits to the participating countries was to consult with Fisheries Divisions and other fisheries related agencies on the requirements for assessment of their shrimp and groundfish resources as well as to become familiar with the fisheries in these countries. The discussions with the participating countries addressed such areas as the status of the shrimp and groundfish fisheries; past and ongoing assessment activities; and management advice requirements for these fisheries.

The visits to the non-CARICOM states of the FAO/WECAFC Ad Hoc Shrimp Group was to determine the willingness of these states to collaborate with the RAU and Guyana and Trinidad and Tobago within the framework of the *Ad Hoc* Group mechanism or a modified version of it, if a meaningful programme were to be developed, as well as to become familiar with the intersessional activities of these states following the Third Workshop on the Biological and Economic Modeling of the Shrimp Resources of the Guiana-Brazil Shelf which was held in Suriname from June 22 - 25, 1992.

It should be noted that, at the request of CFRAMP, the FAO in the person of the Regional Fisheries Officer participated in the visits to the member states of the FAO/WECAFC *Ad Hoc* Shrimp Group.

The NMFS in Miami was included because of their historical links with the shrimp fisheries in the Guiana-Brazil shelf area, both in terms of research and with regard their connections with the American shrimp fleets operating in the region. The NMFS Laboratory in Texas is one of the

main shrimp resource assessment centers in the Americas. The opportunity was also taken to establish contact with Professor Nelson M. Ehrhardt of the Rosenthiel School of Marine Sciences of the University of Miami, who had helped to organize the first FAO/WECAFC Workshop on the Biological and Economic Modeling of the Shrimp Resources on the Guiana-Brazil Shelf in June, 1986 in Miami, and who was still interested in the assessment of these resources.

The main purpose of this report is to outline an approach to the Shrimp and Groundfish Assessment Subproject based on the findings of the consultation. This is done by presenting a summary country review and identification of needs and issues; description of the conceptual framework for shrimp and groundfish assessment; identification and description of the proposed stock assessment activities to be pursued in each country; description of proposed fishery assessment projects/activities which will be coordinated or undertaken by the RAU in order to address these needs. The activities leading up to the Subproject Specification Workshop and the Joint FAO/CARICOM Ad Hoc Shrimp Group Workshop and the Workshops themselves will be described.

PART I: REVIEWS

1. COUNTRY REVIEWS

1.1. Belize

1.1.1. Description of the Fishery

Export earnings from fish and fish products (lobster, conch, shrimp and fin-fish) account for just under 4% GNP. Fish is an important component of the national diet, especially in the coastal areas and in the main towns. The capture, processing and sale locally and overseas of fish and fish products, provide gainful employment for nearly 2,000 persons of whom over half belong to, or are employed by, organized and successful fishermen's cooperative societies (Robertson *et al.*, 1988).

The Belize Shrimp Fishery is made up of an industrial trawl fishery, a coastal artisanal fishery and shrimp culture. This Fishery is second in importance to the Lobster Fishery (Auil, 1993).

Annual production and export earnings for the Shrimp/Trawl Fishery are set out in Table 1. With the exception of the first year of the Fishery, annual production of trawled shrimp for export averaged 245,000 lb/year. The values for earnings in the Table reflect the net value of exports following payment of the 5% tax/administrative fee (RDA Int. Inc., 1991).

Table 1. Annual Production and Export Earnings for Trawled Shrimp from Belize

	Economic Parameters		
Year	**Volume (lb)**	**Price (B$/lb)**	**Earnings (B$)**
1985	100,780	7.00	705,460
1986	235,952	10.00	2,359,520
1987	200,302	10.07	2,017,799
1988	249,650	9.24	2,307,689
1989	305,800	9.50	2,905,100
1990	233,750	9.49	2,217,162
Annual Average	221,039	9.22	2,085,455

SOURCE: RDA INT. INC., 1991

In 1984, the Trawl Fishery began on a commercial basis utilizing four industrial trawlers. During 1986, the Government of Belize as part of its fishery development policy, provided incentives to have more shrimp trawlers operate in Belize which led to a total fleet of eleven (Auil, 1993). The trawlers which were owned by Hondurans were operated through joint venture agreements with the local fishing cooperatives. The trawlers are the Gulf of Mexico type, 21 metres in length with double outrigger shrimp trawl nets. Shrimp are headed on board the vessels, but the sorting, packaging and marketing of all shrimp is done on land by the fishing cooperatives (Auil, 1993).

The main shrimp habitat and trawling areas are the soft sand-mud bottom of the Inner (or Main) Channel and Victoria Channel. The Inner Channel which is about 4 miles wide and 60 ft deep lies adjacent to the coastline with trawling concentrated between Colson Point and Placencia Point 32 miles to the South. At times, some trawling is carried out between Colson Point and Southern Grennels Channel to the north while transiting to or from Belize City or San Pedro for unloading the catch. Victoria Channel which is 8 miles long by 1 mile wide and mostly 120 ft deep lies seaward of the Inner Channel off the Placencia peninsula. The Victoria Channel represents less than 10% of the total area of the Inner Channel grounds, so less trawling occurs here (RDA Int. Inc., 1991). The trawlers utilize approximately 694 km^2 of fishing area.

There would appear to be very little documentation on the coastal artisanal shrimp fishery. In the Plan for the Development of a Comprehensive Data Collection System for the Shrimp Trawl Fishery in Belize (Auil, 1993), it is recommended that a frame survey be conducted in this

fishery to obtain information on number of fishermen, fishing grounds, landing sites, gears used, preliminary estimates of catch and effort, marketing, and value of products. The Draft Management Plan mentions that the artisanal capture fishery for shrimp is carried out in the coastal areas (Belize Dept. Of Fisheries, 1992), with Auil-Marshalleck (pers. Com., 1995) placing the activity on the coastline in certain areas of Belize City. The Fishery appears to be seasonal, possibly when the adults are inshore, and occurs around April - October, which coincides with the rainy season. The fishers target the white shrimp (*Penaeus schmitti*) and are known to take all sizes. The shrimp is sold primarily to restaurants (Auil-Marshalleck, pers. com, 1995).

In Belize, aquaculture activities has been mainly in the area of shrimp mariculture, which has focused on the culture of penaeids. The most widely cultured species has been *Penaeus vannamei*. In the past, *P. monodon*, *P. Stylirostris* and *P. schmitti* were cultured. *P.* schmitti was the only indigenous species among those cultured (Myvett, 1991). Other penaeids native to Belize are the pink shrimp (*P. duorarum*) and the brown shrimp (*P. aztectus*). The most abundant in the trawlable areas is *P. duorarum* (Myvett, 1991).

Since 1990, *P.* vannamei has been the only penaeid cultured in Belize. This is as a result of marketability, broader knowledge base, and longer experience in the culture history of this species in the region. Some farmers had indicated that they were interested in again culturing some of the above mentioned penaeids (Myvett, 1991).

The Fisheries Department has established a hatchery with the aim of culturing *Penaeus schmitti*. However, at present, this hatchery is not in operation as sourcing gravid females has proven to be a problem. Technicians have even gone on shrimp trawlers in an effort to obtain females, with little success. As such, the interactions between the industrial trawl fishery and shrimp culture may be limited as the trawlers target the pink shrimp (*P. duorarum*) and the aquaculture industry targets the white shrimp (*P. schmitti*) (Auil-Marshalleck, pers. com., 1995).

At the end of 1991, there were four operational shrimp farms in Belize, with a total of 1008 acres of constructed ponds. There were 533 acres of operational ponds. The shrimp culture operations ranged from semi-intensive to intensive. In 1991, 345,365 lb of shrimp tails were exported (Myvett, 1991).

1.1.2. Assessment and Management

Very little research has been done on the shrimp fishery in Belize. One notable work was done in 1990 by RDA International, Inc. This firm was contracted by USAID - Belize to conduct a study to assess the ecological and economic impacts of shrimp trawling in Belize. The study carried out onboard observation and sampling of the catch to assess species composition, relative abundance

and possible impacts of by-catch. Also, it carried out an assessment of beach, mangrove and reef habitats near the shrimp grounds to determine if they were being adversely impacted by shrimp trawling operations.

The results from the study led to the following conclusions:

1) A catch ratio for shrimp:by-catch of 1:7.3 was found for the study at Belize, which was basically consistent with that from shrimp trawl fisheries elsewhere.

2) The high tonnage of finfish by-catch most likely represented a significant portion of potential artisanal fish production.

3) The two most common families of by-catch were juveniles of shad and snapper. These juveniles had essentially no market value at their present trawl caught size, but would have substantial value at maturity.

4) Results of the assessment indicated that turtle by-catch in shrimp trawls were low in Belize.

5) Essentially all the discarded by-catch was reincorporated into the food chain through consumption by fish, birds and benthic carnivores.

6) Evidence in the assessed by-catch, such as the predominance of pre-spawned juveniles, decreased in CPUE over time, and the considerable volume of fish taken, suggested that the shrimp industry was negatively impacting certain finfish stocks in the trawling grounds.

7) It was not known whether stock sizes of commercial fish have been significantly reduced since trawling began in 1985.

8) While CPUE for shrimp was similar for both channels, by-catch was significantly less from the deeper and more seaward Victoria Channel for most common fish families.

9) Even though the catch (CPUE) of shrimp and by-catch increased immediately following the mid-season closure, both the fall and winter periods were characterized by substantial decreases in CPUE.

10) Considering these decreases in CPUE in the fall and winter, it may be unprofitable to trawl for more than two continuous months at a time.

11) The shrimp industry benefitted the Government of Belize economically through foreign exchange and export tax earnings for shrimp sold internationally, and from employment of

Belizeans locally. Such benefits should be weighed against the benefits of competing economies such as marine recreational tourism and local fisheries.

12) The ecological assessment of reefs, mangroves and beaches revealed no major or consistent differences in condition between treatment sites near to the trawling grounds and control sites distant from direct effects of the shrimp trawlers (RDA Int., Inc. 1991).

The Report also suggested that the Government Of Belize take a clear policy decision to manage the shrimp resource to produce Optimum Sustainable Yield (OSY). Such a decision would have required several actions by the Government for the policy to be successful. Some of the suggested actions were:

1) A complete resource evaluation, including study of the biological aspects of shrimp, to provide the baseline information necessary to measure the health of the resource.

2) Government regulation of levels of catch, gear restrictions, fishing seasons, and closed areas as necessary to provide protection to the resource.

In terms of areal regulation, it was suggested that fishing effort be encouraged in Victoria Channel rather than in the Inner Channel as shrimp CPUE was equally productive and by-catch CPUE was less in the Victoria Channel. It was proposed that alternate areas of the Inner Channel be established as seasonal nursery grounds which might improve the catch rate of shrimp and enhance reproductive success of species common in the by-catch.

Seasonal regulation could be used to achieve two objectives. First, to protect juvenile and breeding stocks of either the target species or of by-catch. The other, to use seasons to limit harvest of the target species or by-catch through limiting fishing effort. A 45 day year-end closure was reportedly established for two reasons: 1) Shrimp CPUE and size declined during the first half of the season to a level where continued fishing was not economical; and 2) Honduran crews on the shrimp boats prefer to spend the Christmas and New Year's holiday at home.

3) Development of government capability to enforce fisheries regulations.

Following a CFRAMP sponsored attachment to the Fisheries Departments of Trinidad and Tobago and Guyana to observe their operations in relation to the management of their shrimp fisheries, Stephanie Auil, Fisheries Research Officer of the Ministry of Agriculture and Fisheries, Belize, prepared a "Plan for the Development of a Comprehensive Data Collection System for the Shrimp Trawl Fishery in Belize" (Auil, 1993). The plan sought to develop a programme of data collection for catch and effort data, biological data and economic data for shrimp and by-catch. The approach, spread over a three year period, would be to collect historical data on

catches and values from the fishermen's cooperatives as well as to introduce a data collection system using log books for vessels and fishermen's cooperatives/processing plants. The vessel logs would be aimed at obtaining catch and effort data on shrimp and by-catch while the processing plant logs would be aimed at obtaining data on landings by commercial size categories and values. Also, biological data would be collected by way of an observer system on board vessels and a sampling system in the plants. These systems would provide data for stock assessment and economic analyses which would yield information for the fisheries management decision making process. Later, a data collection system would have had to be developed for the artisanal coastal shrimp fishery (Aùil, 1993).

The draft Plan for Managing the Marine Fisheries of Belize (Belize Dept. of Fisheries, 1992), under the section Management Plan for Shrimp indicated that there were in place regulations for a closed season, April 15 - August 14 as well as provision for joint venture agreements between foreign vessel owners and local fishermen's cooperatives, with a limit on the number of foreign crew.

The management option considered were phasing out of foreign trawlers; establishing "no-trawling" zones or closed areas near shorelines and reefs; and establishment of quotas. All with the view to putting in place habitat protection measures to prevent undue loss of nursery grounds and to ensuring the development of a sustainable fishery (Belize Dept. of Fisheries, 1992).

At present, the trawling fleet consists of six vessels. The closed season regulation is still being applied.

Most of the conclusions and recommendations of the RDA Int., Inc. report are still valid as Belize was still concerned with the long term sustainability of the resource and the profitability of the fishing fleet, and its impact on the local economy. They are also concerned with the impact of the shrimp trawlers on the recruitment to the fishery (e.g. snappers) of other valuable fish species and on the marine habitat.

1.1.3. Country issues and requests

Belize would like to have a project that would provide stock assessment information on shrimp as well as on the secondary fish stocks e.g.. finfish by-catch. The project should include determination of the shrimp and fish species being harvested, especially shrimp as some doubt was expressed about the identification of the species being landed; collection of catch and effort data for analysis; collection of biological data for analysis; and the collection of social and economic data for analysis.

In this regard, the data collection system proposed by Auil in 1993, may still be valid, with some

modifications. However, it should be noted that the social data or information would have to be generated in collaboration with the Community Participation Subproject.

1.2. Trinidad and Tobago

1.2.1. Description of the Fishery

The dominance of the oil and petrochemical industries in the economy means that other sectors which are important to the country appear to be extremely small. The contribution of the Fisheries Sector to the GDP is about 0.3%. When all the ancillary activities associated with the catching of fish are taken into account, it would be less than 1%. However, the contribution of fisheries, excluding the ancillary activities, can be put into some perspective by the recognition that the marine fisheries alone accounts for some 13% of the agriculture input to the GDP (Draft Policy Direction for Marine Fisheries of Trinidad and Tobago in the 1990's, 1994).

In like manner, the importance of oil in foreign exchange earnings dwarfs that of fish, with the earnings of fish and fish products being about 0.3% of those of oil and petroleum. However, foreign exchange earnings of fish and fish products in recent years have been at about the same level as the cost of imports. From this view, it could be claimed that the sector has made a contribution to food security (Draft Policy Directions for Marine Fisheries of Trinidad and Tobago in the 1990's, 1994).

The major importance of the Fisheries Sector is in its contribution to social welfare and stability. As it may be providing employment for about 8,000 fishermen. With the number of ancillary workers in the rural communities, the total number of people wholly or partly dependent on fishing may be in the range of 40-50,000. There would be major social and economic costs if, in the absence of employment in fishing or alternate rural employment opportunities, a significant number of these were obliged to seek a livelihood in urban areas.

An additional value of the Fisheries Sector, together with that of the Agriculture Sector generally, is the contribution it makes to the fabric and balance of society through the maintenance of economic and social life in rural areas (Draft Policy Directions for Marine Fisheries of Trinidad and Tobago in the 1990's, 1994).

The Demersal Trawl Fishery for shrimp and associated groundfish is one of the country's most valuable fisheries in terms of landings, dollar value and foreign exchange earnings. In 1991, an estimated 2,000 tonne of shrimp and 700 tonne by-catch valued at TT$22.4 million were landed by local trawlers. Shrimp exports for the same year was 400 tonne and were valued at TT$7.2 million (Draft Management Plan for the Trawl Fishery of Trinidad and Tobago, 1992).

The Fisheries Division Vessel Census of 1991 showed that there were 211 active, locally registered trawlers operating in Trinidad. These vessels belonged to four fleets: two inshore, artisanal fleets, one near shore, semi-industrial fleet and an offshore, industrial fleet (Draft Management Plan for the Trawl Fishery of Trinidad and Tobago, 1992). The fleet characteristics are set out in Table 2.

Table 2. Characteristics of Trawler Fleets

Trawler Fleet	Engine Type	Avg HP	Vessel Length (m)	Gear Type	Average Headrope Length (m)	Number of Trawlers in Category
I (artisanal)	Outboard	2 * 56	6.7 - 9.8	1 stern trawl manually retrieved	10.4	113
II (artisanal)	Inboard or In/outboard	137	7.9 - 11.6	1 stern trawl manually retrieved	10.6	66
III (semi-industrial)	Inboard diesel	176	10.4 - 12.2	1 stern trawl retrieved by hydraulic winch	11.6	9
IV (industrial)	Inboard diesel	356	17.1 - 22.9	2 nets on outriggers, retrieved by hydraulic winch	2 * 13.7	23

Source: Fisheries Division Vessel Census, 1991
Fisheries Division Trawl Gear Survey, 1991

Under Act No. 24 (1986) Trinidad and Tobago exercises, inter alia, control of Archipelagic waters, Territorial Sea and an Exclusive Economic Zone. Because of the configuration of the continental shelf, the maritime demarcation line with Venezuela, and archipelagic baselines, these various zones vary in terms of their proximity to the edge of the continental shelf. In the northeast of Trinidad and Tobago the EEZ consists mainly of oceanic waters whereas in the southeast and northwest of Trinidad it includes wide areas of continental shelf. In the southeast of Trinidad it is also more immediately under the influence of the Orinoco discharge (Fabres and Kuruvilla, 1992).

Demersal trawl fishing for shrimp and groundfish occurs mainly in the Gulf of Paria on the island's West Coast, the Columbus Channel in the South, off the North Coast and in the Orinoco Delta under the Trinidad and Tobago/Venezuela Fishing Agreement. The characteristics and exploited areas of each region are given in Table 3 (Fabres *et al.*, 1992). Groundfish such as croakers *(Micropogonias species)* and salmon (*Cynoscion sp.*) are also taken as incidental catch by drift/gillnets operating in shallow waters (Fabres and Kuruvilla, 1992).

Table 3. Characteristics and Areas of each Fishing Zone

Region Fished	**Substrate Type**	**Total Exploited Area (km^2)**
North Coast	Fine mud and sand with some coral communities	235
Gulf of Paria	Fine mud with occasional patches of shell debris and sand	1,957
Columbus Channel	Soft mud with some areas of rock	826
Orinoco Delta	Mud and sand	394

Source: Fabres *et al.*, 1992.

Type IV vessels operating offshore in the Columbus Channel land approximately *51% Penaeus subtilis*. *P. brasiliensis* is also abundant in the catches with some *P. notialis* also being landed. No *Xiphopenaeus kroyeri* is landed. Type IV vessels operating offshore in the Gulf of Paria land 60% *P. notialis* and 31% *P. subtilis*. Small amounts of *P. brasiliensis* occur, but *P. schmitti* is rare and *X. kroyeri* is absent from the catches.

Type III vessels operating nearshore in the Gulf of Paria land approximately 63% *P. notialis* and lesser quantities of *P. subtilis* and *P. sdchmitti*. Neither *P. braziliensis* nor *X. kroyeri* is landed.

Type II vessels operating in the southern Gulf of Paria land mainly *P. schmitti* with negligible quantities of *P. notialis* , *P. subtilis* and *X. kroyeri*, while type II vessels operating in the northern Gulf of Paria land approximately 50% *P. notialis*, with *P. schmitti* also being abundant. Some *P. subtilis* and negligible quantities of *X. kroyeri* are also landed.

Type I vessels operating inshore of the southern Gulf of Paria land more or less equal quantities of *P. notialis*, *P. subtilis* and *P. schmitti* with lesser amounts of *X. kroyeri*. The type I vessels operating in the Orinoco Delta ("Special Area") land approximately 69% *P. schmitti* and 31% *P. subtilis*. The artisanal fleet (type I and II) lands juveniles of *P. notialis* and *P. subtilis* and all

sizes of *P. schmitti*. *P. brasiliensis* rarely occurs in the landings (Fabres *et al*, 1992).

Depending on the type of vessel, heads-on or heads-off shrimp is either sold to processing plants for further processing and sale locally or overseas, or off loaded at markets such as Orange Valley, Waterloo, San Fernando and Otaheite where the shrimp and by-catch may be auctioned off to the highest bidder or sold retail (Fabres *et al*, 1992)

1.2.2. Assessment and Management

A number of trawl surveys on shrimp and related resources have been implemented in the coastal waters of Trinidad and Tobago since 1944. The surveys resulted from a variety of objectives such as exploratory fishing, gear trials, simulated production fishing and formal systematic sampling. During these surveys, a variety of trawl designs were utilized. Also, the fishing power of the vessels varied significantly (Fabres *et al.*, 1992). These surveys are listed in Table 4.

Table 4. Past Trawl Surveys in the Area of Trinidad and Tobago (1944-1988)

Survey Year	Vessel	Reference
1944	No. 305	Whiteleather and Brown (1945)
1951	Assault	Richards (1958)
1956-57	Bonny Ethel	Salmon (1958)
1962-64	Nereid	Cervigon (1965)
1963	Obraztsovo	Salnikov (1969)
1963	SRTR-9075	Alvarez Perez (1969)
1981	MV Provider	Manickchand-Heileman & Julien-Flus (1990)
1988	R/V Dr. Fridtjof Nansen	Institute of Marine Research (1989)

Source: Fabres *et al.*, 1992.

The research vessels Oregon and Oregon II of the NMFS, USA, also made a number of monitoring surveys in North-east South America, from Trinidad and Tobago to Brazil. At present, no trawl surveys were being undertaken.

Landings and effort data are collected by the Fisheries Division for types I, II and III vessels at the landing sites at Orange Valley, San Fernando, Otaheite, Bonasse, Fullerton and Icacos. Estimates of total catch for type I, II and III vessels, along with number of trips and CPUE are determined. No comparative catch and effort for the type IV vessels was available (Fabres *et al.*, 1992).

A logbook programme for type III and IV vessels was introduced in November, 1991, in an attempt to obtain more accurate catch and effort data, but the implementation of this programme ceased around mid 1992 due mainly to negative reactions by the trawler operators on the TEDs issue.

As part of a GOTT/UNDP/FAO Project, entitled, " Establishment of Data Collection Systems and Assessment of Fishery Resources" an on-going sampling programme for the collection of biological data from the trawl fishery was developed and implemented from March, 1991. The methodology for sampling was documented by Lum Young and Maharaj (1992). The programme is still being implemented for type I, II and III vessels operating from landing sites in the Gulf of Paria.

Not much work has been done locally with regard to the recruitment nurseries, and population dynamics of the penaeid shrimp species, but Fabres *et al.* (1992) have summarized the information obtained about the shrimp resources from surveys carried out locally. A summary of this information is set out in Table 5.

Table 5. Information Obtained About The Shrimp Resource From Surveys Carried Out Locally

Study Area	Time Period	Heading	Information Obtained	Reference
Inshore waters of Gulf of Paria, Trinidad	Oct 1984 - May 1986	Spawning	*X.* kroyeri mates all year round. Spawning is expected to coincide with or follow the periods when the number of mature females in the catch is highest, i.e., between July and September and March/April.	Henry, C. (1987)

Inshore waters of Gulf of Paria, Trinidad (contd.)	Oct 1984 - May 1986	Length at First Maturity	*X. kroyeri* females: 8.1 - 8.5 cm (total length). Smallest mature male was 6.3 cm.	Henry, C. (1987)
		Impact of Environmental Factors	*X. kroyeri* is highest in the catch when salinities are about 32%. Reduction in total numbers of *X. kroyeri* in the rainy season may be the result of environmental conditions acting to trigger short lateral migrations of the population within its depth range to perhaps facilitate spawning. Temperature did not appear to influence the distribution or abundance of shrimps generally or the catch of *X. kroyeri*.	
Inshore waters of the Gulf of Paria, Trinidad	Nov 1984 - Feb 1986	Life Cycle	It is suggested that both male and female *Penaeus subtilis* enter the coastal (nursery) areas as approximately one-month old postlarvae (at < 13 mm carapace length) in June, the beginning of the rainy season in Trinidad. October/November marks the emigration out of the coastal (nursery) areas to offshore, deeper waters. A second spawning was not evident from the data set.	Fabres, B. (1988)

Oropouche Bank adjacent to the mangroves of the South Oropouche Swamp	1983 - 1984	Species Composition	*X. kroyeri* dominates between September and April. *P. Schmitti* is the most common species during the period of peak rainfall and river discharge, i.e. June and July. *P. notialis* and *P. subtilis* are present in lesser quantities.	Ramcharan, E.K. (1989)
		Impact of Environmental Factors	The dependence of *X. kroyeri* on both mangrove and phytoplankton carbon is apparent. *P. Schmitti* is dependent upon the freshwater pulse, low salinity regime and mangrove carbon which is generated at the onset of the rainy season.	

Nearshore Gulf of Paria, Trinidad	Jun 27 - Jul 27 1990	Minimum and Maximum Lengths	Length frequency analysis of *P. subtilis* catches indicates smaller sized individuals for the northern Gulf of Paria than for the southern, with smallest individuals being 18 mm (carapace length) in the northern Gulf and 19 mm in the southern Gulf. The maximum length in the northern Gulf of Paria was 41 mm and 59 mm in the south. The large size of *P. subtilis* in the southern Gulf possibly reflects a faster growing population in this area due to enhanced nutrient content or a "micro-cohort" flushed out earlier from coastal nursery areas.	
		Catch Rates	There is no marked difference between mean day and night CPUE (kg/hr) for shrimp in both the northern and southern Gulf of Paria. (kg/hr) (kg/hr) Northern Gulf of Paria: Day 2.29 Night 2.47 Southern Gulf of Paria: Day 4.41 Night 4.50	Amos, M. (1990)

Nearshore Gulf of Paria, Trinidad (contd.)	Jun 27 Jul 27 1990	Species Composition	*P. notialis* and *P. subtilis* are the 2 most dominant Penaeid shrimp species. *P. brasiliensis* is caught in minimal quantities in the Gulf of Paria. *X. kroyeri* does not appear at all in the Type III catches; this species usually caught close inshore by the Type I and Type II trawlers. <u>Relative Contribution by Weight of Penacid Shrimp Species</u> Species — Mean % (wt): N Gulf Of Paria; S Gulf Of Paria; Total *P. brasiliensis* 3.64 5.01 4.46 *P. notialis* 30.19 39.35 35.69 *P. schmitti* 36.37 10.80 21.03 *P. subtilis* 29.99 44.85 38.92	Amos, M. (1990)

		Impact of Environmental Factors	The higher commercial productivity in the southern Gulf of Paria may be correlated to a higher nutrient content of the marine environment of the southern Gulf and/or the negative impacts of human settlement patterns and pollution (pesticides and industrial effluent) on the nursery grounds and inshore waters of the northern Gulf and the negative impacts of the significant inshore trawl fishery of Type I and Type II vessels operating mainly out of the Orange Valley region near the northern Gulf. *P. brasiliensis* prefers a more saline and deeper water environment and substrate of high sand composition as is found on the south portion of the Gulf and along the south coast of Trinidad. The apparent higher percentage occurrence of *P. schmitti* in the northern Gulf is due to the fact that this species is characterised as being an inshore species with preference for areas of muddy substrate and high organic content. The dominance of P. subtilis and P. notialis in the Gulf of Paria reflects their euryhaline preferences.	

Nearshore Gulf of Paria, Trinidad (contd.)	Jun 27 - Jul 27 1990	Species Composition	*P. notialis* and *P. subtilis* are the 2 most dominant Penaeid shrimp species. *P. brasiliensis* is caught in minimal quantities in the Gulf of Paria. *X. kroyeri* does not appear at all in the Type III catches; this species usually caught close inshore by the Type I and Type II trawlers. <u>Relative Contribution by Weight of Penaeid Shrimp Species</u> Species — Mean % (wt): N Gulf Of Paria; S Gulf Of Paria; Total *P. brasiliensis* 3.64 5.01 4.46 *P. notialis* 30.19 39.35 35.69 *P. schmitti* 36.37 10.80 21.03 *P. subtilis* 29.99 44.85 38.92	Amos, M. (1990)

(I) Catch/Effort system requirements.

Implementation of logbook system and monitoring programme for Type III and Type IV trawlers as well as ensuring that any system introduced is compatible with existing programmes in Guyana and Venezuela

Development of a user-friendly database/ information system to review and analyze historical catch/effort trawl data, including information on the Orinoco Delta Fishery.

(ii) Develop/Update bio-profiles of shrimp and groundfish species.

Update stock assessment, management and fishery biological information through FISMIS, FISHBASE etc.

(iii) Biological Sampling Programme

Extend the existing biological shrimp sampling programme to include the industrial component (type IV vessels) of the trawl fishery

B. Analysis of Fisheries Interactions

(ii) Interactions of artisanal/ industrial trawl fisheries.

Assess the impact of various trawl fleets (gauntlet/ sequential fisheries) on each other in terms of yield, shrimp size using BEAM IV.

(ii) Assess the impact of trawl fisheries on groundfish (by-catch issue).

Document by-catch of finfish in terms of gross volume, species composition and for selected species in more detail (length-frequencies, age/growth) in order to determine the impact of trawler fleets on fin-fish capture and to develop or introduce gear types and or fishing patterns that would tend to reduce by-catch.

(iii) Review historical demersal surveys and associated data to document changes in fin-fish biomass levels, and possibly repeat Explorer III surveys of Orange Valley to compare with work done previously on Type I by-catch.

(iv) Initiate work on bottom-set monofilament nets into shrimp and groundfish sampling programme in terms of analysis of catch composition and length-frequencies with a view to regulating the activity by area, mesh size etc.

SOURCE: Fabres *et al.* 1992

Stock assessment parameters for *P. schmitti*, *P. notialis*, *P. braziliensis*, *P. subtilis* and *X. kroyeri* have been compiled from a literature search (Lum Young *et al.*, 1992). Fabres *et al.* (1992) have also documented the existing information on the secondary resources such as seabob, deep water shrimp, and finfish and crabs as incidental catch.

Economic data is limited to the collection of prices for shrimp and fish of type I, II and III vessels and a study done by Ferreira and Maharaj (1993) entitled, "Preliminary costs and earnings study of the artisanal shrimp trawlers operating in the "Special Fishing Area" adjacent to the mouth of the Orinoco river (Venezuela)".

The Government's declared objectives are full utilization of the resource consistent with adequate conservation, and minimal conflict between artisanal and non-artisanal components of the fishery, and between trawler operations and those of other fisheries. The management unit for shrimp was considered to be the stocks distributed along the Guiana-Brazil shelf while that for finfish was considered to be most likely distributed along the Guiana-Brazil shelf with some species migrating among EEZs or territorial waters. Management would be carried out as if these (finfish) resources were localized in Trinidad and Tobago's waters, but should be coordinated with management in neighbouring countries.

Under the " Fisheries Control of Demersal (Bottom) Trawling Activities Regulations, 1991" regulations exist for the control of trawling in the waters of Trinidad and Tobago. These relate to depth and areal restrictions, and mesh regulations. There is a system of registration of all commercial fishing vessels, renewable every two years. For trawlers, Government has further mandated that no additional vessels be registered i.e that the existing fleet fishing power/size be maintained as a maximum. However, there is no formal system of licensing for national vessels that operate in the waters under the jurisdiction of Trinidad and Tobago. In the coastal waters of the Orinoco Delta (Venezuela), under the terms of the bilateral Fishing Agreement, the Government of Venezuela grants licences to the Trinidad and Tobago vessels (type I) based on a recommended list of applicants (Draft Management Plan for the Trawl Fishery of Trinidad and Tobago, 1992). TEDs are mandatory for type IV trawlers.

1.2.3. Country issues and requests

In keeping with the information required for the implementation of its management plan Trinidad and Tobago has identified five areas for consideration by the RAU, these being:

A. Strengthening the Information Base

C. Socio-economic studies for Fisheries Management Planning

(I) Augment the data collection programme in order to analyze each component of the trawl fishery to determine relative economic contributions using bio-economic modeling framework (BEAM IV).

(ii) Initiate socio-economic studies to evaluate the impacts of management alternatives on the fishing communities possibly through CFRAMP/ or other community -based programmes. There is a need to develop a high "social" profile if biological / assessment activities are to be supported by the community.

D. Capacity Building /Institutional Strengthening

Develop and strengthen capabilities within the Fisheries Division through training, attachments, workshops etc. Training must be included consciously in programme design and implementation and full participation of fisheries staff must be ensured in all aspects of project design, implementation, analysis and reporting.

E. Develop and strengthen sub-regional linkages

Support and promote the strengthening and formalizing of sub-regional linkages for information sharing on shrimp and groundfish through the WECAFC forum and CFRAMP Shrimp and Groundfish RAU and with Venezuela through the TT/Venezuela research protocol.

A comprehensive system for the collection of catch and effort, biological data, economic and social data will have to be designed and implemented to provide the data necessary for analysis to address the management issues raised above. This would call for very close collaboration between the Catch and Effort and Licensing and Registration Subproject, the Community Participation Subproject and the Biological Data Collection Subproject of the SVG RAU and the T&T RAU.

A study utilizing by-catch reduction devices would have to be designed. This could be done in collaboration with Venezuela where such studies have being carried out.

Hands-on training would be done within the workshops/seminars arranged to develop the projects for implementation in the countries as well as for the analyses of data collected for the assessment of shrimp and groundfish.

Collaboration with the non-CARICOM states in the Guiana-Brazil shelf area will be fostered through the FAO/WECAFC Ad Hoc Shrimp Group or a modified version of it. Venezuela had

signaled an interest in working with Trinidad and Tobago under the research protocol, but this would appear to be a more sensitive issue than it appears on the surface.

1.3. Guyana

1.3.1. Description of the fishery

Fish is the major source of animal protein in Guyana, and shrimp is the major source of foreign currency within the fisheries sub-sector (Table 6). It is estimated that the per capita consumption of fish was 45 kg in 1991, over 3 times the world average. The fishery sub-sector contributed G$ 3.3 billion, or 7% of GDP in 1993, second only to sugar (FTAP, 1994).

Table 6: Total value of Guyana fish products, 1993 (FTAP, 1994)

	Domestic	Exports	Total
Shellfish	$255,108	$1,806,434	$2,061,542
Finfish	$3,661,343	$1,169,729	$4,831,072
Non-edible	$0	$16,246	$16,246
Total	**$3,916,451**	**$2,992,409**	**$6,908,860**

There has been a dramatic increase in the value and total landing of the fishery since 1990. Most of the growth has taken place in the artisanal sector, (for historical comparison, FTAP (1994) and Chakalall and Dragovich (1979) provide good overviews), which is managed as an open access fishery.

Guyana's fisheries is currently undergoing an in depth reorganization, with the help of CIDA (the Guyana Fisheries Technical Assistance Project). Some of the key elements of the work pertains to the conservation of the resource and to ensure sustainable development by enhancing the DOF's capacity for effective management and conservation, and to determine approaches for the reduction of environmental degradation in coastal areas. The development plan will aim at providing the framework for economic growth of the fisheries and for improving government and private sector efficiency. Finally, the socio-economic objectives of the programme aims to

improve health, nutrition and income of the population through employment opportunities and stabilization of community structures.

1.3.2. Assessment and Management

A management and development plan (Phillips *et al.* 1992) and a fisheries sub-sector policy and planning statement (Phillips and Charles 1994) have been produced with aim to facilitate the development of the fisheries sector, including foreign participation, and includes amendments to reflect changes in the social and economic situation. Institutional strengthening, monitoring, training, enforcement and policy development are key elements of these documents.

Very little information is available on the assessment of shrimp populations in the Guyana EEZ. Phillips *et al.* (1992) describes the data collection system in place in Guyana. The information available is usually in the form of landing statistics from the large industrial fleet and obtained at the processing plants. A log book system is in operation for the industrial fleet, but the quality of the information is thought to be extremely variable. There was a corresponding log-book in operation in the artisanal sector, but its use has ceased because of problems with enforcement, reliability and collaboration from the fishing sector. However, the data are available and require analysis. There is no recording of landings by species and no comprehensive system for the collection and analysis of production in the marine fishery, although the problem seems to be more acute in the artisanal sector. Several frame surveys, particularly those in 1987 and 1993, require thorough analysis as the coverage is thought to be incomplete, and some information needs to be computerized. There is no information on capture per unit effort of the artisanal sector since the frame survey of 1987. However, some information indicates that the CPUE have remained stable. The data collection system presently being devised aims at a complete cover of the fishery activity through the use of log books for the artisanal as well as the industrial fleet. There are few management decisions being made from the artisanal fishery, as it is considered largely as an open access fishery. However, the DOF monitors fleet size and type using the licencing system in place for the industrial fishery, which is linked to the delivery of catch and landing statistics annually.

There is information on finfish distribution and biomass on the shelf area from ecosound surveys aboard the vessel R/V Nansen (Bergen 1989), but no equivalent information on shrimp. The available information of shrimp distribution come from research trawl surveys in the 1970's.

Shrimp landings by the industrial trawlers have been in decline in recent years, and some rationalization of the fleet is occurring. There is general agreement that the stock is over-exploited. There is some pressure, mostly by the foreign industrial fleet, to move to the exploitation of smaller, less valuable shrimp species, with an inherent risk of harvesting juveniles

of large shrimp. The small shrimp fishery has been controlled by limited entry. The exploitation of seabob (*Xiphopenaeus kroyeri*) has been going on since 1985, mostly by the local fishing boats. With the increased demand for finfish and the reduction is catches of shrimps, there appears to have been an important shift in fishing activity towards these species. It is believed that the exploited shrimp populations are cross-boundary stocks, in which the resource and exploitation is shared with Suriname, Venezuela, French Guyana and Brazil (FTAP, 1994). Artisanal fishery for seabob and whitebelly shrimp (*Nematopalaemon schmitti*) is done with the use of fyke nets, mostly at the mouth of rivers.

Morphometric parameters (length/weight, total weight/tail weight, tail weight/tail length, etc.) have been developed for seabob (*Xyphopenaeus kroyeri*), white shrimp (*Penaeus schmitti*) and brown shrimp (*Penaeus subtilis*) (Giménez *et al.* 1980) . Fecundity (Guitart and Reyes, 1979) as well as length and age at first maturity information (Guitart and Fraga, 1980) are also available for these species. As these are not recent studies, they require to be actualized or confirmed to be representative of the actual population structure.

There are few stock assessment yield estimates for the Guyana EEZ, and where there are, there is little agreement on the maximum sustainable yield estimates from different sources. Values derived from the research cruises of the 70's are at about 3800 t for the Penaeids only, but the landings average less than 2000 t. These values are derived from stabilized cath rates and extrapolation from the Oregon cruise surveys. There are no MSY values for the groundfish species or the small shrimps.

There is currently an effort in Guyana, through the Environmental Protection Agency of Guyana and the DOF, to monitor environmental variables considered requiring protection, intervention or which are of concern because of impact on human activities and resource conservation. These include (with the responsible agency listed in brackets) sediment loadings, chemical discharges and effluents from industrial operations, including pesticide and herbicide residues (EPA), coastal erosion (Land and Surveys), sea level rises and rainfall (Hydromet Department) and their impact on fish stocks (DOF). The DOF is planning to undertake a study of the influence of freshwater run-off on the recruitment of seabob.

1.3.3. Country issues and requests

Guyana is interested in assessing the shrimp (*Penaeus sp., Xyphopenaeus kroyeri, Nematopalaemon schmitti*) resources being exploited by their industrial/trawl fleets and artisanal/small-scaled fleets. They are also interested in assessing the soft-bottomed groundfish resources being exploited mainly by the small scale fishery but also being taken as by-catch in the industrial fishery. There was some concern over fisheries interactions and incidental catches in relation to Turtle Exclusion Devices (TED's) and By-catch Reduction Devices (BRD). There

is also the desire to collect data for use in the bio-economic models developed by FAO (the Bio-Economic Analytical Models series).

1.4. Jamaica

1.4.1 Description of the Fishery

In 1962, it was estimated that the Shrimp Fishery landed an estimated 162,546 lbs of shrimp, valued at $ 25,100 (Chuck, 1963). Later, in 1981, it was estimated that the Shrimp Fishery landed an estimated 22, 053 lbs of shrimp, valued at $ 102, 632 (Sahney, 1981). In 1994, the total production for marine shrimp was estimated at 276.69 metric tonnes. The local market was supplied with 235.19 metric tonnes of marine shrimp (Galbraith, 1995).

The Shrimp Fishery of Jamaica is an artisanal one, using shove nets, monofilament gill nets (china nets) and trawl nets. The number of fishermen operating in the Fishery is currently unknown.

Fishing is done mainly on the south shelf and to a lesser extent on the North Coast. Most shrimp fishing is done in the shallow areas of Hunts Bay, Kingston Harbour, by fishermen using shove nets. Shrimp fishing is also done in Milk River, Old Harbour Bay, Rocky Point, Kingston Harbour, and Holland Bay, St. Thomas. There are a few fishing boats, outfitted with trawls, that operate in Old Harbour Bay and Black River Bay (Galbraith, 1995).

1.4.2 Assessment and Management

Various studies have been undertaken to look at the abundance and distribution of shrimp in Jamaica. Studies were conducted by Iverson and Munro (1967) in 1958, 1966 and 1967 to evaluate the feasibility of certain areas for commercial shrimp operations. The investigations started in Hunts Bay, Kingston Harbour, and was then extended along the south shelf (Portland Bight and Pedro Bay). The investigations showed that commercially valuable species of shrimp were caught in areas where the bottom was smooth and muddy. The species found were *Penaeus duorarum*, *P. schmitti* and a few species of *Trachypenaeus*.

A subsequent study undertaken by Chin (1991), at seven sites (Plumb Point Lagoon, Hunts Bay, Fort Augusta of Kingston Harbour, Great Salt Pond, Old Harbour Bay, Farquhars Beach and Black River Bay) along the South Coast, identified seven species of shrimp, these being, *P. brasiliensis, P. duorarum, P. notialis, P. schmitti, Sicyonia laevigata, Trachypenaeus constrictus* and *Xyphopenaeus kroyeri*. *P. brasiliensis*and *P. notialis* were found at all seven sites during the

study. *P. notialis* represented 76.5 % of all shrimp caught and was dominant at most sites, apart from Hunts Bay and Farquhars Beach. *Trachypenaeus constrictus* occurred at all stations but was low in numbers. The remaining species were considered to be rare in terms of their abundance and distribution. *P. duorarum* and *Sicyonia laevigata* occurred in low numbers at a few of the sites. *P. schmitti* was found only in waters of low salinity and as such recorded high yields in Hunts Bay and Fort Augusta. Reeson (1971) had reported the presence of *P. schmitti* and *P. duorarum* in the Great Salt Pond. It is believed that the change in salinity due to the opening of the pond may have caused the disappearance of the species.

Iverson and Munro (1967) recorded good yields in all the areas of Kingston Harbour, mainly in depths 5 - 18 m. In 1958, over 75 of the shrimp taken were *P. schmitti* and in the later surveys 95 % were *P. duorarum.* In 1958, most of the shrimp taken were in the 9 m depth, but between 1967 - 1968, they were concentrated in the deeper areas. The catch rate was an average of 25 shrimp per 15 minute haul. The Pedro Bay area (20 - 30 m depth) recorded slightly lower yields in 1967. Iverson and Munro (1967) had divided the Harbour into three zones, the Main Basin, the Outer Harbour and Hunts Bay. The mean yield per hour for these three areas was 0.681 kg, 0.681 kg. And 0.5 kg respectively. They recorded individual catch rates of 1.99 kg of shrimp per hour.

Chin (1991), recorded an average catch rate of 1.10 kg h^{-1}. Most of the shrimp catch came from the Kingston Harbour area. Plumb Point Lagoon (2.09 kg h^{-1}), Fort Augusta (1.70 kg h^{-1}) and the Great Salt Pond (1.21 kg h^{-1}) recorded the highest yields. Hunts bay had the lowest catch rate (0.49 kg h^{-1}).

Munro (1968) noted that the catch of shrimp fell off during the summer months and the greatest catches occurred during the winter months. This was supported by Chin (1991) who reported that the cooler months (December - March) of the year produced an increase in the abundance of shrimp and that the lowest catch was during the summer.

Chin (1991) observed that ripe females were caught all year round. However, the number of shrimp with ripe ovaries increased during April 1984. He also observed the following size ranges for the various species of shrimp caught:

1. *S. laevigata* 20 - 29 mm.
2. *T. constrictus* 40 - 49 mm.
3. *X. kroyeri* 80 - 89 mm.
4. *P. braziliensis* 90 - 99 mm.

5. *P. duorarum* 80 - 89 mm.
6. *P. notialis* 20 - 195 mm.

The mean length was 77 mm. The modal size class was 90 - 99 mm. Approximately 80 % measured between 40 and 109 mm. The largest individuals came from deeper water. There was a positive correlation between depth and total length. Farquhars Beach had the largest shrimp, with the modal size being between 110 - 119 mm.

Chin (1991) also conducted supplemental larval studies at the seven sites. Additional deep water site (South Channel) were selected in the Kingston Harbour to investigate the possibility of deep water spawning. An increase in the abundance of larvae was observed in February 1984. The greatest numbers were observed at the Plumb Point Lagoon in Kingston Harbour (55.4 %) and Farquhars Beach (25.1 %). The other sites recorded a few larvae. Hunts Bay did not yield any larvae. Penaeid shrimp larvae were concentrated in the Harbour. Samples taken from the deeper water in the South Channel yielded over two times the number of larvae found at the other seven sites. The maximum larval abundance occurred during December 1983 and March 1984. The harbour mouth facilitates spawning since the temperature, depth and salinity approximate those conducive to spawning (Chin, 1991). The larvae then move to waters around the Port Royal and adjacent mangroves.

Iverson and Munro (1967) suggested that the Kingston Harbour, areas of Portland Bight, and the area south of Port Royal serve as nursery grounds. However, the integrity of these areas is suspect since they are subject to coastal pollution and dredging. Chin (1991) suggested that the Farquhars Beach in the Portland Bight may provide an adequate nursery area.

Iverson and Munro (1967), pointed out that there were sufficient shrimp stocks to support a small trawl fishery, especially in the Kingston Harbour. The potential catch was then estimated between 400,000 and 800,000 lbs. of shrimp per year on the basis of known yield from other areas of the tropics. They had recommended the use of pair trawls using canoes fitted with outboard motors as this would have lessened the start up cost and be more appropriate to the artisanal fishermen.

Chin (1991) and Iverson and Munro (1967) had noted that shrimp were less abundant during the summer months. The Fishery could be closed at this time since it would not be profitably exploited as well as during February/April when most females with ripe ovaries are found and when spawning occurs (Galbraith, 1995).

At present, the actual potential yield of the Fishery is unknown due to changes in the coastal environment which may have affected the resource.

1.4.3 Country issues and requests

Need to identify with DOF Jamaica!!!!!!!

2. FAO/WECAFC *Ad Hoc* Shrimp Group - Non-CARICOM States

2.1. Background

During the Third FAO/WECAFC Workshop on the Biological and Economic Modeling of The Shrimp Resources of The Guyana-Brazil Shelf held in Suriname, 22-25 June, 1992, participants (Brazil, French Guiana, Guyana, Suriname, Trinidad & Tobago and Venezuela) were informed of CFRAMP and the soon to be established Shrimp and Groundfish RAU in Trinidad and Tobago.

The Working Group had noted the potential contribution of CFRAMP's activities in Guyana and Trinidad and Tobago to its work, and had agreed that CFRAMP should actively participate in the Working Group on the Shrimp Fishery in the Guiana-Brazil region. Noting that the RAU would be based in Trinidad, the Group had suggested that the next meeting be held there in 1994.

Set out below are some of the conclusions and recommendations from the Workshop:

Data Collection

(1) The participants agreed on the need for improvement in data collection systems in most countries and to take steps in this direction where appropriate.

(2) Participants agreed to initiate the collection of biological, social and economic data required for bio-economic modeling.

(3) Participants agreed to contribute towards and complete the "common tool box" recommended by the Second Workshop (Cayenne, French Guiana, 2-6 May 1988).

Secondary Stocks

(1) The Workshop recommended that the shrimp industry in collaboration with governments should take a pro-active approach with regards to secondary stocks (fin-fish by-catch, turtles, marine mammals, etc.) rather than reacting to outside impositions which may have disruptive effects on the industry.

(2) It was suggested that studies relating to by-catch reduction (e.g. fish exclusion devices) be undertaken in anticipation of impositions by importing countries.

(3) There was general agreement on the need to conserve turtles. It was recommended that research should continue on TEDs, or be initiated where appropriate, to suit particular conditions and needs.

Bio-economic Models

(1) The Workshop requested FAO to explore the possibilities of organizing national and/or regional training workshops on the BEAM models.

(2) It was recommended that sufficient time (3-4 days) be allocated for bio-economic analyses of one or two shrimp fisheries of the region during the next Workshop.

Management Aspects

(1) It was suggested that a harmonized approach to management of the shrimp fisheries should start by acknowledging the common objectives, such as protection of nurseries, regulating effort, etc.

(2) It was recommended that countries analyze the impacts (evaluate and quantify) of the various management strategies applied in the region, for discussion at the next workshop.

Co-operation Investigation Programme and Status of the Working Group

(1) The Workshop recognized the need to formalize its meetings within a certain framework or mechanism to ensure continuity and to co-ordinate any co-operative investigation programme.

(2) The Workshop unanimously agreed that it would be desirable to establish a Scientific Advisory Committee for the Management of the Shrimp Fisheries in the Guyana-Brazil region (SAC).

(3) The Workshop agreed that Governments of the region should consider establishing SAC as soon as possible. Participants agreed to submit and support this recommendation to their Governments.

(4) The Secretary of WECAFC was requested to officially submit the Third Workshop report to the participating countries, noting the rationale for the formation of SAC, and request their

comments on the draft project outline in support of SAC.

(5) Pending the formation of SAC the Workshop requested FAO to obtain the reactions of potential funding sources to the draft project outline on a "Guyana-Brazil Shrimp Fisheries Investigation Programme", in support of SAC.

Other

(1) The Workshop agreed to establish a collaborative working relationship with the shrimp and groundfish assessment unit of CFRAMP, which will be based in Trinidad and Tobago.

(2) The participants from Guyana, Suriname, Venezuela and Trinidad and Tobago expressed satisfaction with the R.V. Dr. Fridtjof Nansen/NORAD resource surveys conducted in the region in 1988, and agreed to enquire directly with NORAD on the possibility of the return of the vessel to the region, with an information copy to the Secretary of WECAFC.

(3) The Secretary of WECAFC was requested to officially send a copy of the Third Workshop report to NORAD and draw their attention to the abovementioned request.

(4) Pending the approval of the Government of Trinidad and Tobago, the next workshop will be organized in 1994 by the Fisheries Division of Trinidad and Tobago, which will seek the assistance of FAO, IFREMER and CFRAMP.

2.2. Non-CARICOM country visits

The Subproject Initiation Mission to the non-CARICOM states to determine whether these countries were still willing to work with Guyana, Trinidad and Tobago and the T&T RAU within the framework of the FAO/WECAFC Ad Hoc Shrimp Group as well as to learn of their intersessional activities, yielded the following information:-

2.2.1. Suriname

a) Suriname had conducted a shrimp recruitment(mainly *P. subtilis*) and by-catch survey during 1993/94, involving five research cruises. This was a joint project with IFREMER which was funded by the European Community. The cruise and final reports were being prepared.

b) A deep-water demersal trawl fishery (hard bottom) had developed within the last four years with the introduction of four trawlers. These vessels target the lane snapper (*Lutjanus synagris*)

with an average catch of approximately one ton per day. According to the Central Vishery Haven (CEVIHAS), landings have been declining yearly since the inception in 1992.

c) Given the current lack of human and financial resources, the Surinamese felt that they now had enough information to manage the shrimp fishery without the stock collapsing; mainly by controlling the number of boats in the fishery, i.e., effort. There were about 110 trawlers catching Penaeids. They would now focus their current resources on generating data for the management and development of the small scale fin-fish fishery which had scope for expansion and for which they had very little information. And on the developing trawl fishery for lane snapper as they were concerned about the declining catches. However, they will continue to collect catch and effort data of the shrimp fishery through their existing "good" relationship with the shrimp companies.

In this regard, Suriname planned to review, improve and resuscitate the fishery information system developed by the FAO/UNDP Project SUR/87/001 — Establishment of a Fisheries Information and Resource Assessment and Management System, which was discontinued for a short period (about two years) due to the staff being deployed to conduct the shrimp recruitment study. They would also collect biological data on *Cynoscion acoupa*, *C. virescens*, *Macrodon ancylodon* and *Arius parkeri* as these were the four most important species of groundfish.

Suriname would be interested in collaborating with Guyana in data collection and analysis, especially for groundfish in the Corentyne area.

d)Suriname was also interested in preparing a map of the continental shelf showing bottom types (sand, mud, shells, etc.) since they are of the view that certain species are associated with certain bottom types which they believed changed periodically. This they felt would lead to more accurate estimates of biomass.

e) A new fishery for seabob, *Xiphopenaeus kroyeri*, was recently (1995) established with the introduction of ten trawlers. A processing plant for this species is currently under construction. As a precautionary measure, a fleet limit of 30 vessels had been proposed.

f) Suriname was concerned about the impact of the trawl fisheries on the small-scale fisheries both in terms of likely conflicts between fishermen as well as on the recruitment to these fisheries. They were also concerned about the impact of driftnet operations on turtles moving to their nesting areas.

g) Suriname would like to see a project aimed at evaluating the impact of various management strategies such as limited entry, closed seasons, etc. after they would have been implemented.

h) Suriname was of the view that most of the conclusions and recommendations of the Third Workshop on the Biological and Economic Modeling of the Shrimp Resources of the Guyana/Brazil Shelf, Suriname, 22-25 June 1992, were still valid. The joint FAO/CARICOM working group being proposed was seen as one way of moving forward. The Director of Fisheries strongly supported this proposal, possibly because Suriname had since become a Member of CARICOM.

2.2.2. French Guiana

a) IFREMER staff in French Guiana have been reduced to six persons; one scientist and two technicians and support staff.

b) Forty Venezuelan boats were licensed to fish for snappers and land approximately 1000 tons per year. Fifty five percent of the catch had to be sold locally. No local boats were involved. This fishery has been established for the past five years and in the opinion of IFREMER it was well-regulated and managed. The catch and effort have stabilized and the length frequencies were the same each month.

c) The shrimp fishery was managed by quota (under the EEC fisheries management regime) and limited entry using licences (local system). The quota was fixed at 4,180 tonne (with 180 tonne being set aside for ACP countries) while the fleet was set at 70, with about 60 - 62 vessels being operational. It was felt that a fleet size of 50 - 55 vessels would be more appropriate as the resource was being exploited to its optimum and as profitability could be improved by reducing costs. This would involve a reduction in fleet size and increase in the number of fishing days. Also, the processing plants would have to become more cost effective.

d) A census of the artisanal fishery (first ever) was recently completed and the data was being analyzed. There were 180 vessels fishing for sciaenids and catfishes, using gillnets. The information will be used to develop a management/development plan.

e) French Guiana had conducted a shrimp recruitment and by-catch survey in 1993/94 as part of a joint project with Suriname, funded by the European Community. The reports of the four cruises were published but had not been released for general circulation. The first draft of the final report was being reviewed. One of the conclusions of the survey was that there was continuous recruitment and that the peaks which had been identified in previous studies and linked to the seasons (rainfall) were due to the fishermen's fishing strategy i.e the movement of the fleet to shallow waters to catch smaller shrimp for the European market at specific times. The movement of the fleet accounts for the two or three peaks usually described as recruitment periods. Further research work would be required.

It was also observed that the local environmental conditions did not affect shrimp recruitment significantly. However, it was felt that the discharge of the Amazon had a more significant impact on recruitment and shrimp stocks.

f) IFREMER, ORSTOM and BRGM, at the level of French Guiana, have a joint coastal programme called ECOLAB. The programme focuses on geomorphology, sedimentology, oceanography, biology, fisheries, and mangroves of the coastal zone and the EEZ. ECOLAB is currently focussing its efforts on the study of the Amazon discharge and its impact on coastal and marine resources. In this regard, ECOLAB is collaborating with the Universidade Federal do Pará, Centro de Geociencias, on the physical oceanography of the north coast of Brazil and French Guiana and a study of the environment and discharge of the Amazon and the north-east coast of Pará, using remote sensing. ECOLAB intends to extend this programme to include Suriname in the first instance and possibly Guyana and Trinidad and Tobago at a later stage. The last meeting of ECOLAB was held in Belém, Brazil in March 1995 and the next meeting is scheduled for Suriname in April 1996.

g) Both IFREMER and ORSTOM, at the regional level, have agreed to participate in the proposed FAO/CARICOM Working Group on the Shrimp and Ground Fish Resources of the Guyana-Brazil Shelf. IFREMER indicated that a cooperative agreement existed between IFREMER and FAO. It was suggested that IFREMER Headquarters should be informed of this proposal through the focal point in FAO, Rome. IFREMER also has a technical cooperation agreement with the Institute of Marine Affairs of Trinidad and Tobago. ORSTOM would also like its Headquarters in Paris to be informed of whatever mechanisms would be agreed upon between FAO and CFRAMP for collaboration.

h) French Guiana (IFREMER, ORSTOM and BRGM) and Brazil (Federal University of Pará) are in the process of initiating a project to study the environment and discharge of the Amazon river and its influences on the north coast of Pará and French Guiana, using remote sensing technology. Physical oceanographic studies are also included.

2.2.3. Brazil

a) IBAMA, in collaboration with the Coast Guard and using their research vessel, *Navio Antares*, is currently conducting physical and chemical oceanographic studies in the EEZ of the North Atlantic Coast of Brazil as part of a five-year programme. These studies will be complemented by fishery research surveys using the soon-to-be-launched research vessel of IBAMA using the same 66 transects and 203 stations.

b) Two hundred and fifty licences had been issued for the shrimp trawl fishery. A closed season

is applied from December 1 to January 31.

c) IBAMA will continue to collect catch and effort data and biological data from the industry. The log book system has been revised and simplified in collaboration with boat captains and the industry. The captains and not the company will be responsible for the filling of log books. It was an obligation by law and captains could be fined for not complying. The log books would be re-introduced before the end of 1995.

d) The utilization of by-catch from the shrimp trawlers was considered one of the priority areas for investigation. It was observed that more companies were giving incentives (e.g., 50% of by-catch landed) to captains to encourage landing of by-catch. This could be due to the declining shrimp catches.

e) It was possible that due to declining shrimp catches, boats have been targeting seabob, *Xiphopenaeus kroyeri*, landings of which have increased over the past three years.

f) There was also a fishery for catfish, using pair trawling (three boats with two nets or two boats with one net). Converted shrimp trawlers were being used. Most of the catch is exported to the USA as whole, gutted fillets and steaks. It has been observed that over the years there has been a change in size frequency and catch composition. Forty eight licences had been issued for this fishery.

g) There is an association of fishery companies, SINPESCA (Sindicato de Pesca), which signed a technical cooperation agreement with IBAMA in 1994. SINPESCA claimed to be working closely with IBAMA and planned to support financially the fishery research to be conducted by IBAMA in Pará over the next five years.

h) IBAMA plans to conduct a census of the small-scale fisheries for seabob (using pullnets) and groundfish (using gillnets), beginning in June 1995. Based on the results of this census, a fishery management and development plan will be prepared, as well as a fishery data collection system based on the work done by FAO for Brazil. IBAMA was placing emphasis on research for the development and management of the small-scale fishery in Pará.

I) IBAMA would be willing to collaborate with the RAU, Guyana and Trinidad and Tobago within the framework of the FAO/WECAFC Ad Hoc Shrimp Group or a modified version of it to cover shrimp and groundfish.

2.2.4. Venezuela

a) Venezuela was still collecting catch and effort on shrimp and by-catch. During 1995, they intend to analyze the data in relation to the management of the demersal fisheries. Observers on board vessels was part of the data collection system.

b) They have been conducting studies using by-catch reduction devices and TEDs.

c)During 1995, Venezuela intended to put in place a biological data collection system for a selected set of groundfish species.

d) Venezuela was willing to work with Trinidad and Tobago under the joint research protocol.

e) Venezuela accepted the conclusions and recommendations of the Third Workshop of the Ad Hoc shrimp Group and saw FAO/CFRAMP cooperation as one way of implementation of the recommendations of the report. They were willing to collaborate with the RAU, Guyana and Trinidad and Tobago in the framework of the FAO/WECAFC Ad Hoc Shrimp Group or a modified version of it.

2.2.5. Regional focus

It may be coincidental that the countries of the region are shifting emphasis to the management and development of their finfish resources and the smaller shrimp species (*X. kroyeri*) or this may reflect the recognition that the shrimp resources (*Penaeus sp.*) are being fully fished or overexploited. Given the financial constraints and lack of human resources currently being faced by most countries, they have decided to place emphasis on the finfish fishery because it has a potential for some expansion and, more importantly, to be in a better position to manage the finfish resources. They will continue collecting catch and effort data and biological data on the penaeid shrimp fishery for the management of these resources. Also, they will begin to put in place data collection systems for the smaller shrimp where the development of these fisheries have begun or are now being viewed as economically important and requiring management.

Fishing gear interaction was also of major concern, especially the physical interaction (e.g.. trawlers running through gillnets) between different kinds of gear which may give rise to conflict. The competition for common fish resources by various fishing methods posed management problems as well and was seen as an area for research by some countries.

Besides collaboration in the areas set out for penaeid shrimp and associated by-catch in the draft Third Workshop Report, the RAU, Guyana and Trinidad and Tobago can collaborate with the non-CARICOM states in the establishment of compatible data collection systems for groundfish and small shrimp, especially where the resources may be shared or are being exploited by two or

more states. Also, they could exchange information on any studies carried out on these resources.

PART II: CONCEPTUAL APPROACH TO STOCK ASSESSMENT

3. ASSESSMENT ACTIVITIES IN THE REGION

The purpose of this section is to present and review the scientific activities and technical methods used in the Caribbean region and the Guiana/Brazil continental shelf area to determine stock assessment parameters for shrimp and groundfishes.

The rationale behind stock assessment is to improve our understanding of the status and condition of the shrimp and groundfish stocks in the area, as impacted by the trawler and artisanal fisheries. Stocks determined to be overfished are targeted for management action appropriate for the area and jurisdiction. Methods are put in place to monitor periodically the state of the resource and note any changes requiring management action. To conduct appropriate and accurate stock assessment, species-specific information must often be gathered.

While the primary objective of a fishery management body is to monitor the catches, it is also important to collect basic life history data (age, size, sex, sexual maturity, etc.). With this added information, more refined methods of population assessment can be developed over the course of a management period. Cross-verification of management advice using a variety of methods also becomes possible.

The methods of determining optimal fishing effort and natural productivity for a particular stock are based on two basic approaches: 1) vary the fishing effort so that some asymptotic function can be fitted to the relationship between productivity and effort. From this an optimal fishing effort can be obtained, or 2) carry on a detailed scientific program in which the productivity of the stocks within habitat types are estimated from information on recruitment and growth. The two approaches, namely fisheries monitoring and applied fishery science respectively, are not mutually exclusive, and most fishery research centers worldwide use a combined approach, based on practical limits to the availability of fishing data and research opportunities.

3.1. Status Of The Fishery Surveys And Associated Data

Shrimps of the family *Penaeidae* have been extensively studied worldwide. There appears to be a great deal of information scattered throughout the region on the shrimp resource and its exploitation in general. However, there have been very few attempts to pull all sources of data together and analyze it as such. Most of the capture and effort data relates to the industrial

fishery. The artisanal fishery, whether for shrimp or groundfish, has received very little attention anywhere in the region, with the possible exception of Trinidad and Tobago.

Shrimps of the family *Penaeidae* are caught throughout the region. Total landings have varied between 15000-20000 mt, with the larger quantities caught generally in the late sixties/early seventies. The most abundant species, Brown shrimp (*P. subtilis*), are captured mostly off Brazil, French Guyana and East Suriname in water of 25-70 m deep. Pink shrimp (*S. notialis*) are caught mostly off Guyana and Suriname and Trinidad, while pink-spotted shrimp (*P. brasiliensis*) are caught most off Venezuela, Guyana and Trinidad. More recent information indicates that there are large numbers off of the French Guiana coast. White shrimp (*P. schmitti*) are caught in smaller numbers and in shallow waters (less than 37 m) off Trinidad, Venezuela, and Guyana in the West and Para-Maranhao (Brazil) in the east, indicating the existence of 2 separate stocks. A separate document on the biology of the commercially important shrimp and groundfish species has been produced by the RAU and is available.

Maximum sustainable yields estimates of all shrimp species on the Guiana/Brazil Continental shelf area has been estimated mostly by the swept area method from research cruise activity. These estimates range from 13000-20000 t for the four mains species exploited (Jones and Dragovich 1977, Stephenson 1981, Venaille 1979). Additional information on the production potential of seabob (*Xyphopenaeus kroyeri*) and whitebelly shrimp (*Nematopalaemon schmitti*) appear inexistant, outside of actual landing data. There does not appear to be any other regional MSY estimates available in the literature.

The information of shrimp in specific CARICOM countries exploiting the Brazil/Guiana continental shelf shrimp stock is resumed by state/institution research cruises in the region, and resultant biomass estimates from swept area methods. Maximum Sustainable Yield (MSY) estimates for all penacid-species has been derived for the Trinidad fishery from the average landings of years with high stabilized effort (Turner, 1977 *in* Pauly and Ingles, 1986). Several published reports of MSY are available mostly for French Guiana and Brazil, but some (i.e. Jones and Dragovich, 1977) cover the several countries of the Brazil/Guiana continental shelf area (Lum Young *et al.* 1991). In these, the Schaefer and Fox and other surplus production models (defined later) derived from landing statistics have been employed. The precision and accuracy of these estimates, and the supplementary work that remains to be done to give an accurate picture of the shrimp potential yield remains to be determined. These estimates are also now quite dated and may not be of much value.

The vessel R/V Oregon II carried out research cruises throughout the Guiana/Brazil continental shelf in 1972, 1974 and 1975 to determine the composition and distribution of the penacid shrimp stocks available to the commercial fishery as well as to test some equipment and methods. The data includes catch records and station lists from Trinidad to Brazil. The three

main species of shrimp targeted (pink-spotted (*Penaeus brasiliensis*), brown (*P. subtilis*) and pink (*P. notialis*)) were found to have distinct but overlapping distributions, and have remained stable over the years studied. The white shrimp (*P. schmitti*) was not abundant in any of the operations of the Oregon II in the area, perhaps because this species as well as the seabob (*Xyphopenaeus kroyeri*) tend to be shallow-water species. The data of the Oregon cruises are available for analysis from the Pascagoula Mississippi laboratories of NOAA. The IFREMER office in French Guyana has a copy of the entire raw dataset, but they will not be using them as they feel that they are now too old to be of any value. This may depend very much on how the data is to be used. For example, these extensive cruises may be useful for a historical comparison of local abundance and distribution, or for determining associations between habitat and shrimp distribution.

The vessel R/V Fridtjof Nansen carried out acoustic and trawl surveys in 1988, covering the northeastern coast of South America from Suriname to Columbia. This operation was targeted primarily pelagic and demersal fin-fish resources although the bottom trawl operations also yielded some information of shrimp distribution and abundance by species. These data are also available. Excellent bottom topography data has been produced from these cruises, as well as distribution of functional groups of pelagic fishes. There is little information of shrimp and groundfishes. The Trinidad Fisheries Division has an early version of the dataset which should be updated.

Some work has been done on relating remote sensing data (coastal turbidity patterns) to shrimp distribution and abundance off South America (Brucks *et al.* 1973?). The technique proved to be a valid one and the authors claimed that "*a study utilizing the data and techniques similar to those described herein will significantly increase our knowledge and ultimate success in the management of the Guiana's shrimp fishery...*". France, through the research efforts of ORSTOM and IFREMER, are beginning a major remote sensing program of the entire northeastern coast of South America. The remote sensing images will be supplemented with an extensive direct land and sea sampling program. The data collected includes forest and coastal wetland habitats, geology, physical and chemical oceanography of the continental shelf, and biology of important species. There are already solid results available on coastal erosion and mangrove dynamics. The programme is now being expanded to include Brazil (in association with the University of Para) on Amazon river flow, sedimentation and continental shelf productivity. There is further interest in expanding the work northwest to Suriname, Guyana and Trinidad and Tobago. A pilot study of the coast for Guyana was done to demonstrate the cons-effectiveness and efficient source of baseline data provided by LANDSAT imagery (Singhroy and Bruce 1983).

A cursory examination of fishing statistics for the region indicates that the shrimp fisheries now appear to be in a state of economic or biological overfishing. The problem is not unique to the region. Similar conclusions have been drawn concerning the exploitation of marine shrimps

world-wide. As a result of this, recruitment-related research activities are now receiving greater attention (Garcia 1986). According to Garcia (1986), one of the current key issues in shrimp fishery management today is to determine the most appropriate age at first capture and total allowable catch, in order to balance immediate loss of small shrimp exploited too early with the added value of large shrimp later in the season ("growth overfishing"). This implies the use of yield per recruit analyses (discussed later in this document), with extensive use of pre-season surveys to determine the status of the cohort. On the management side, this implies closed seasons and areas as well as mesh-size regulations.

Shrimp fisheries essentially exploit a single year class. The annual yield is therefore a direct result of the strength of the cohort (i.e. the level of recruitment), and this is largely dependent on environmental conditions and the size of the spawning population. Garcia (1984) states that the importance of the environmental parameters responsible for the variation in shrimp production makes it difficult to develop an appropriate production model to assess the state of a stock and MSY, particularly if only short time series are available. This renders annual catch quotas difficult to implement because the established quota may be too low in one year and much too high on another year. The latter may have drastic consequences on the stock and the long-term economic well-being of the fishing fleet. In order to reduce this uncertainty, it is advisable to develop predictive models that are capable of forecasting the coming year's production several months ahead of the season, and allocate fishing effort accordingly. These models are either based on environmental factors (i.e. rainfall, temperature, river flow) or on pre-season indexes of recruitment (Garcia 1986). The current thinking on the entire management problem with shrimp could be summarized simply as follows: Management bodies (i.e. the fisheries departments) must develop the ability to react quickly to fishing activity, by either emitting quotas for the upcoming season a month before the opening of the season, or by reacting within the season to the results obtained from actual landings. This will avoid overfishing of the target species/stocks or uncoordinated redeployment of the fleet to secondary species/stocks/size-classes.

Although this approach may not be wholly viable in the present fishery management systems, or may only be partially viable, it nevertheless offers insight into the RAU's conceptual framework in which we will be developing our research strategy (see Chapter 4: CONCEPTUAL STOCK ASSESSMENT FRAMEWORK). In addition, shrimps are particularly amenable to nursery habitat management and conservation, because the strength of a year class is largely the result of survival of larval and post-larval stages in the near-shore littoral zones (Garcia 1986).

3.2. Life-history parameters and associated stock assessment data

A thorough review of the life-history parameters derived for the penaeids of major economic importance has been produced (Lum Young *et al.* 1992a). Life-history data is organized in

sections according to species.

Von Bertalanffy growth curves are often used in fishery models as a source of growth information. However, ageing shrimp often proves very difficult, and parameters must be estimated using various approximations. These estimated parameters are often derived and developped outside the region in which they are applied, without any tests for the validity of the estimates. This appears to be the case in the Caribbean region as well. There is therefore a need to quantify the growth rates of different exploited species. Willman and garcia (1985) reconstructed a growth curve from catch data at different times during the fishing season (Fig. 1). This growth curve is similar to other growth curves for Penaeidae elsewhere, and may be acurate, but many of the assumptions should be tested.

The U.S. NMFS (Galveston Labs) also employed von Bertalanffy growth curves in their effort to estimate parameters for the age-length relationship. The Galveston labs have also estimated natural and fishing mortalities for white (*Penaeus setiferus*), pink (*P. duorarum*) and brown (*P. aztecus*) shrimp species. Natural mortalities were evaluated at M=0.275 to 0.3 per month, depending on the species, as derived from mark-recapture data and catch/effort statistics (Nichols 1984; Nance *et al.* 1989). Other studies have used values of natural mortality as low as 0.2 per month. Age-specific fishing mortality estimates have been calculated on a monthly basis.

There does not appear to be any information available on the recruitment of shrimp into the fishery from Trinidad or Guyana studies.

In the Orinoco Delta, the maximum sustainable yield of *P. notialis* was estimated at 2.6 t km^{-2}, using the swept area method (Novoa 1982). This differs markedly from estimates derived using the Gulland (1970) method for the *La Broa* sound, Cuba (0.4-0.6 t km^{-2} , Novoa 1982), or from the 1.45 t km^{-2} for all penaeid species in the Atlantic coast of Nicaragua (Turner 1977 *in* Pauly and Ingles, 1986). Although penaeids are distributed through the Caribbean sea, recruitment appear to be mainly in April and October and mainly off French Guiana, Brazil and Guyana (Jones and Dragovich 1977), although the intra-annual cycle of recruitment is now disputted (Mogoudet, pers. com.). However, recruitment has been quantified in the Northeastern coast of Venezuela, the Orinoco Delta, Lake Maracaibo of Venezuela, off the northeast coast of Margarita (*P. Brasiliensis*) and Cuba.

An important stock assessment paper has been prepared for the "special fishing area" of Trinidad at the mouth of the Orinoco river delta in Venezuela (Lum Young *et al.* 1992b). Although the paper is presented as a "preliminary" analysis, it is quite thorough in its treatment of the causes of fluctuation in captures. In this paper, estimates of the Von Bertalanffy (1934) length at age equation parameters were derived using the Munro and Pauly (1983) approximation because age and growth estimates were not possible from length frequency distribution of the shrimp sampled

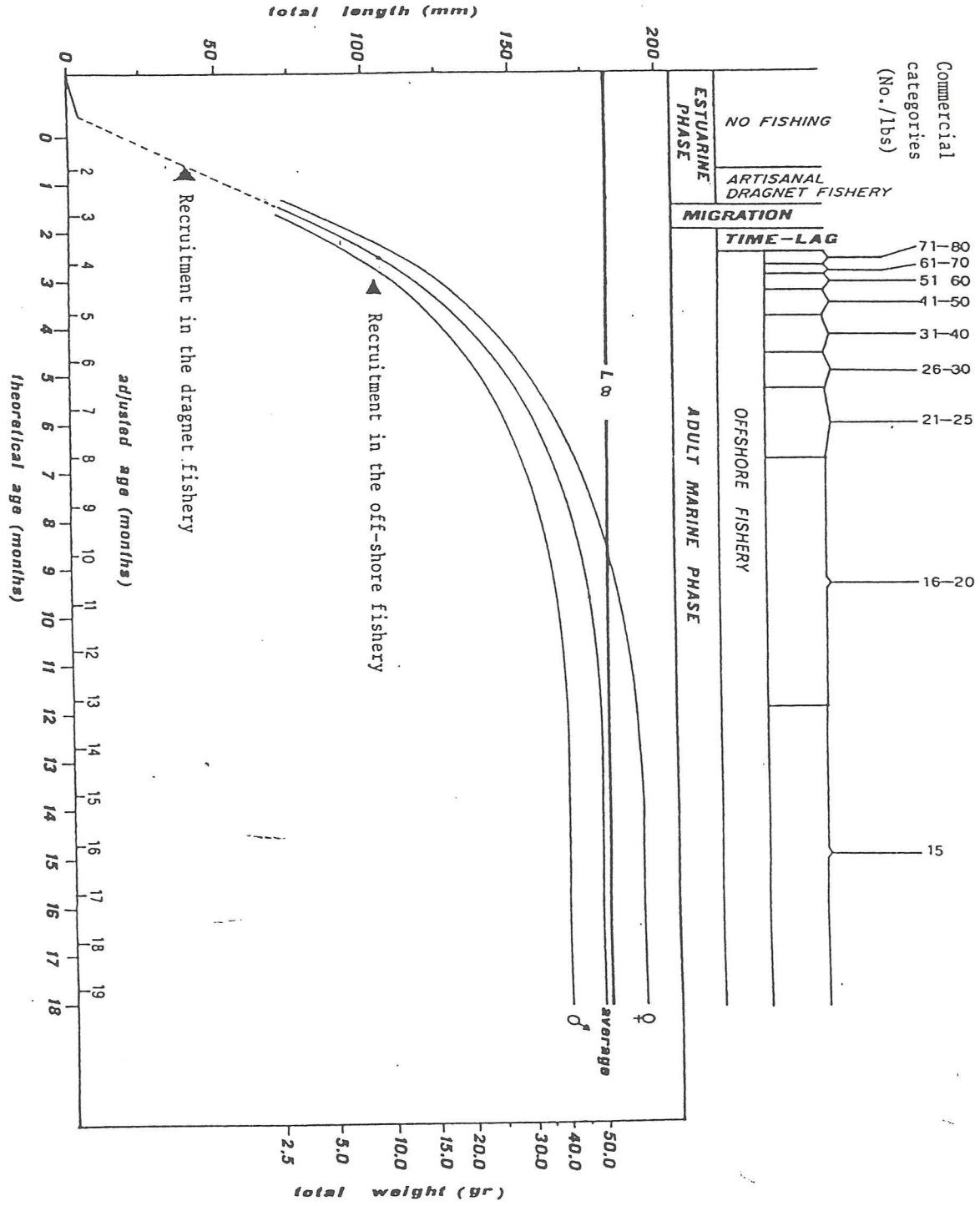


Figure 1: Reconstruction of the life cycle and exploitation sequence for *P. subtilis*. Figure from Willman and Garcia (1985).

in the landings. Maximum lengths from field data were used to estimate L_∞, and Munro's parameter for overall growth performance was obtained from the literature. Similarly, natural mortality estimates were estimated using an empirical multiple regression model from Pauly (1980), with L_∞, k and water temperature as independent variables. Although this method yields interesting results, the bias and precision of the method has not been assessed adequately, particularly since Pauly's equation has been developed from an interspecific collection of data from 175 fish species. The value of the results is pending verification, as it is very dependent on the assumptions inherent in the approach taken by the authors.

Although surplus production models (catch and effort models) have been used in the region, their success in determining optimal effort for the shrimp fishery are very limited, partly due to the inability of the model to reach an optimal, partly because of the availability and quality of the data (Suriname Fish. 1992). Predictive models (e.g. Thomson and Bell class of models) have also been used, but on an experimental basis only.

3.3. Artisanal fisheries

Shrimp are generally exploited by small-scale operations inshore and in the estuaries and by a large-scale or industrial fishery offshore. There is very little information on artisanal fisheries in the region, with the exception of the "artisanal" shrimp fishery in Trinidad, which might better be called "small-scale". Little is known of the artisanal fishery's contribution to the local economies and to local protein requirements, as these operations generally supply local markets, with again the possible exception of the Trinidad "small-scale" shrimp fishery. However, some preliminary studies in Suriname seem to indicate that the landing is about 3 times more important than official or previously thought figures (Charlier 1994). The value of the landings and associated fishing effort for the Trinidad small-scale fishery is known (Trinidad & Tobago Fish. Div., 1992; Maharaj *et al.*, 1992), but the associated data for the industrial fleet is lacking.

There is a great potential for conflict between the industrial and artisanal shrimp and groundfish fisheries. Already, there are counter-accusations as to the damage of fishing techniques on the environment, the extent of overfishing, the selectivity of gear types and targeted populations or life-stages. There is a general concern for the potential for habitat destruction caused by trawl fishing, particularly within the context of non-targetted species of economic importance (finfishes mostly), and the resultant loss in productivity.

3.4. Socio-economic data

There is very little socio or bio-economic data available in the region. Some shrimp prices are available from the fishing and processing companies. Although there is no socio-economic data for the shrimp and groundfish fleet, the operating costs may be accurately estimated from data available for other fleets in the region or elsewhere (Charlier 1994).

In the artisanal and small-scale shrimp fishery, socio-economic data is more difficult to obtain due to the dispersed nature of the fishing effort and the fact that shrimp fishing is only one of many fishing and non-fishing activities of the fishermen and the community. As most of the shrimp fisheries in the region appear to be in a state of economic or biological overfishing, there appears to be a general consensus in the region for the establishment of data collection systems aimed at providing the data required for bio-economic analysis of the industrial fishing fleet.

A bio-economic study of the artisanal shrimp trawler fishery in the "Special fishing area" adjacent to the mouth of the Orinoco river in Venezuela was prepared by Ferreira and Maharaj (1993). They recommend that the number of licenses be frozen at their actual level since the fishery appears only marginally profitable.

3.5. Management

The failure of many fisheries scientist to provide timely and accurate management advice that is required can be in part attributed to the lack of definition of management objectives, or even of conflicting objectives within the same department (eg. Subsidize a fishery while trying to maintain of reduce effort). Unless the scientist has a clear guidance on what the fishery will be managing for (maximizing employment, economic yield, MSY, etc.), it is extremely difficult to plan appropriate research activities and implement programs that will provide management advice (J. Caddy, Pers. Comm.). This usually leads to simplified objectives such as seeking biological solutions to achieving MSY, which may not be helpful in a greater context of multi-fleet, musti-species fisheries. The fisheries objectives as we understand them today are rarely to maximize some simple form of output, but to place much attention of the various sectors of the economy, environment and fisheries to balance the interactions among them in an "optimal" fashion (Gulland 1984). Is is not realistic to expect that some biological, social or economic analysis will generate a magical MSY or MEY that will indicate the management actions to be taken.

A recommendation has been made at the Third Workshop on the Biological and Economic Modeling of the Shrimp Resources of Guyana-Brazil Shelf (Suriname Fish., 1992) to create a Scientific and Advisory Committee (SAC) for the management of the shrimp fisheries in the

Guiana/Brazil Management Area, where the SAC would provide scientific and management advice to national Fisheries Administrations, with support from FAO. The SAC would be a loosely structured group with no direct power to make fisheries management decisions. The SAC approach is valuable in that it facilitates the exchange of information on a regional and international scale. It can provide the numerical basis on which management decisions can be made, if a high level of scientific collaboration can be achieved. This implies that a common approach to many research efforts will be required throughout the region, so that, for example, common stock-recruitment or catch-effort functions can be developed.

Centralized management is another issue that, although it is never addressed in detail, is always present in any discussion on the role of CFRAMP/WECAFC/FAO etc, in a period where self-governance, co-management, decentralized management and other methods of reducing the hierarchical structures of management are being discussed and implemented worldwide. Several key issues must be considered before making recommendations for management, and these issues will orient the work of the RAU, and so must be considered in the planning phase. These issues include:

- Most fisheries department in the region lack the resources to implement comprehensive data collection and analysis systems and to ensure enforcement of regulations.

- One should not assume that quotas are respected when these quotas are constraining (in terms of fishing effort in the general sense) to fishermen and monitoring methods are inadequate.

- Management by quota system (including monitoring) of small-scale or artisanal fisheries is extremely expensive and requires a large administrative body with solid technology to back it up.

- The costliness of managing a multitude of small vessels as opposed to a few large ones.

- The greater difficulty of convincing 100 artisanal fishermen without a technical or theoretical background in fisheries that management rules and regulations must be respected as opposed to 10 large vessel captains with such training.

- The difficulty in reducing the fishing effort of the artisanal sector by 30% as opposed to the removal of 3 of 10 trawlers belonging to a large fishing company.

- The need to proceed with caution when introducing new fishing technologies to coastal fisheries, whether artisanal or industrial.

Some of these issues are discussed in detail in Lussiaa-Berdou (1992).

3.6. By-catch and groundfishes

Most industrial trawl fisheries have by-catches, but this problem is not exclusively one of large-scale fisheries. The fixed gear interception fisheries also capture large quantities of fish and other organisms, quite often juvenile of commercially important species.

In the Caribbean, trawls are normally employed by offshore vessels fishing for penaeids. Dragging speeds reaches 3 knots or more with the large vessels. Therefore, these trawls necessarily catch finfishes and other crustaceans as well as shrimp. Several estimates of by-catch have been published, ranging as high as 94% of total capture, and the ratio is generally in the range of 10:1 (fish to shrimp). The R/V Oregon II cruises reported 73-76% of fish in their experimental trawls at depths of 25 m or less but this value dropped to 60% at over 25 m of depth. In deep water surveys (>350 fathoms), the percentage of fishes dropped further to generally less than 40%.

Species comprizing the by-catch have generally not been marketed as they are often considered trash fish or species of little economic value. Nevertheless, there is some concern that the by-catch is excessive, as in heavily fished shrimp grounds, a substantial quantity of fish is dumped to sea after the shrimp have been sorted out. Furthermore, when forced to land by-catch, it is believed by many fishery officers that a separate set of trawls at the end of a trip are done which target marketable groundfish species. This is not truly by-catch since it is a separate targeted activity. In light of these findings, enforcement of use of by-catch as a management measure may be very difficult. Only in light of economic benefits will the industry convert to using appropriate technologies (through reduction of handling and sorting times and increased quality of the product) or landing (through the development of markets for species of low value). This will require technical advice and practical demonstrations to the industry sector.

Repeated attempts to deal with the by-catch issue is evident from the scientific and grey literature, preceding early WECAFC reviews of the state of exploitation of crustaceans (FAO/WECAFC 1980). In this latter report, the practical measures proposed were to set-up a series of research projects on the technological alternatives to reducing and/or recovering the by-catch for use. Further research into by-catch management has done little to resolve the issue. Several countries in the region, including Venezuela, are experimenting with by-catch reduction devices.

Points that need to be addressed with by-catch include 1) Marketing of the by-catch, and the waste of a valuable resource, 2) The reduction of by-catch with by-catch reduction devices mounted on the trawls, 3) Interception of juveniles of highly valued species of fish and crustaceans, 3) Turtles and associated excluding devices. There is a potential relationship

between a reduction in important finfish harvest, a reduction in the turtle population and the intensity of the shrimp trawl fishery. An investigation of these historical relationships is required.

Very little assessment information is available for the directed soft-bottom groundfishes fishery. Most of the work done to date appears to have been done in association with the by-catch of shrimp. The species targeted are in the Ariidae (marine catfishes) and Scianidae (croakers, drums, weakfishes and seatrouts). There are several pelagic species captured as well, as the capture methods are largely non-selective and the species captured relate more to the species composition of the particular habitat type (soft mud bottoms, hard bottom, corrals, etc.). The fishery targets species by setting nets in appropriate habitat, depending on the species sought. The capture of pelagic species appear to fluctuate more on a seasonal basis, as these are often migratory species. Suriname is apparently beginning a fishery catch and effort program aimed at the traditional small-scale fishery that will include the monitoring of the captures of hard and soft bottom species.

4. CONCEPTUAL STOCK ASSESSMENT FRAMEWORK

4.1. Background

The objectives of the management of fisheries resources in general, and the shrimp fishery on the Brazil/Guiana shelf in particular, are based on two very simple and global principles:

1) The long-term conservation of the resources

2) The economic optimization of the fishery.

The latter implies a long-term approach to the management of the fishery in order to optimize yields and economic rent in a renewable resource perspective. The former indicates a concern for the degradation of nursery grounds and sea bed as well as protection of the recruitment mechanism of the harvested species (i.e. recruitment overfishing).

According to the report of the Third Workshop of the Biological and Economic Modeling of the Shrimp Resources of the Guiana-Brazil shelf, held in Paramaribo, Suriname in 1992 and sponsored by the FAO, it was suggested that "a harmonized approach to management" in the region should start by acknowledging the objectives common to all countries concerned, and, while taking into consideration the priorities and capabilities of each country, should include the following activities:

1) The protection of nurseries,

2) The establishment of closed areas/seasons,

3) Regulation of effort.

It is our belief, and this has been confirmed by interview with fishery and research institutions in Belize, Guyana and Trinidad, that these objectives are shared by the CARICOM countries directly involved in the shrimp fishery. However, in order to effectively manage the fisheries according to these principles and objectives, a broad spectrum of information of good quality is required, particularly in the areas of fishing potential and opportunities, of the geographic distributional analysis of the resource being exploited and means and measures to control the fishing industry.

The management of shrimp is very different in terms of concepts than the management of the groundfishes. This is due to the very peculiar life history of the coastal tropical shrimps (*Penaeidae*) (see document of shrimp biology by Talbot *et al.* 1995) and the characteristics of the shrimp fishery locally (see background section of this document). The shrimps are intricately dependent on the estuaries on which they depend for reproduction and growout, yet there has not been much attention to this element in the management programmes. Shrimp are fast growing and essentionaaly complete their life cycle in about a year. This indicates very high natural mortality rates, and because of this, the determination of the best times, sizes and places to catch shrimp are critically sensitive to determinations of mortality and growth rates (Gulland and Rothschild 1984). Despite apparent very ligh fishing mortalities, it is still not clear what form the stock recruitment relationship takes, if it matters at all, or how the environment affects stock recruitment relationships. Because these two parameters are interlinked, it is not known whether high levels of fishing effort are increasing the instability of the recruitment processes.

In the scientific community world-wide, there is a great concern that the "traditional" approach to stock assessment, that is, using techniques developed mostly after World War II, are unsuitable. In the past 20 years, we have witnessed dramatic declines in the stocks of a number of economically important fisheries in the world. In the Atlantic, many demersal species (cod, haddock, halibut and flounder) stocks are low, and on the Grand Banks the Canadian government has imposed a 5 year moratorium on cod fishing. There is a drastic decline in many large pelagics in the Gulf of Mexico. Similar concerns are voiced for the Georges Banks fishery in the Northwest Atlantic and for many species in the Pacific (anchovies, salmon, ocean perch, tuna, etc.). Outside observers are concerned that the state of the world's fisheries may be in a critical stage (Wilson *et al.*, 1994; Ludwig et al. 1993). Closer to home, the shrimp fishery in the Guiana/Brazil continental shelf has been in a constant decline since the late seventies. Large operations are now targeting and catching much smaller shrimp, alternate species of lesser value,

or traditional secondary stocks of fin-fish originally discarded as by-catch. There is growing concern that recruitment and growth overfishing may be decimating the stocks. Experimental management practices in French Guyana, where the fishing season was extended by a few months to compensate for a poor year in 1994, is suspected to have had drastic consequences on the recruitment of brown shrimp (*Penaeus subtilis*) to the 1995 fishing season in French Guyana as well as in the Northwest coast of Brazil.

The use of "classic" stock assessment methods used to derive maximum sustainable yield information for management is extremely widespread throughout the world. Two major classes can be referred to as "holistic" or "analytical". These typically do not integrate environmental parameters and assume that recruitment tends towards a mean value (central tendency) with some "noise" in the system which can be assumed to be stochastic variability to be ignored, or just makes the manager's work a little bit harder. The same can be said about analytical bio-economic models, or predictive models incorporating economic information. The conceptual approach has been traditionally centered around the objective to reach a biological or economic equilibrium point between the resource and its exploitation, in order to obtain the maximum yield from the fishery, whether economic or biological. This strategy assumes implicitly or explicitly that fluctuation in yield or of the CPUE is a random oscillation around this point, or more simply that years are biological replicates of each other. The quest for a resource in equilibrium in a fishery in equilibrium is the overall driving management strategy behind this philosophy. The major appeal of this management approach is in its simplicity, probably a determinant factor in its widespread adoption. However, this has been achieved at the expense of creativity and adaptation of management techniques to the local conditions, species and geographic situation.

The failure of this management strategy worldwide in a wide variety of stocks and species has resulted in the questioning of the validity of this approach. Many well-funded fisheries research and management institutions have seen this approach fail when applied to real fishery situations. The Canadian cod fishery example is used often wherever these issues are discussed (e.g. Maharaj and Griffith, 1994). However, a purely empirical look at the fisheries of many species indicates that the classical approach may not apply except in specific instances. Both resource abundance and the spatial distribution of effort of the fishery fluctuate in time, partly as a result of predator (fisheries) - prey (resource) types of causal links, and partly independently of each other, in response to a series of external factors. These factors might be river run-off, temperature, lagoon salinity, habitat type and availability, primary productivity, etc for the recruitment of the resource, or fluctuation in market prices, regulations and fishing efficiency for the exploitation sector. The models described above are generally not designed to incorporate the dynamic nature of a fishery, do not meet many biostatistical assumptions, and assume that yearly fluctuations can be treated as stochastic events with a central tendency (corresponding to the MSY). This may be a sufficient assumption in a long-lived species with many overlapping cohorts (year-classes), but will fail in a fishery where the species are short-lived and fishing

mortality is very high. What must be understood is that, in such cases, environmental variables will play a key role in year-class strength and total mortality rate, thus affecting yields directly. These factors directly or indirectly drive the fishery and should be considered, also directly (indicator variables) or indirectly (monitoring of cohort strengths), in evaluating the resource, on a temporal cycle consistent with the resource and the fishery themselves.

Variability in resource abundance is distinguishable at 2 levels: 1) Seasonal fluctuation in life history characteristics, yield of the fishery, environmental conditions, market demand and prices, and 2) yearly fluctuations resulting from large-scale changes in climate, recruitment, loss of habitat or habitat disturbances, and evolution of the fleet. At what level can we consider ecological resilience of a species to perturbation in a fishery system, given the very important mortality rates imposed on the stocks? Ecological resilience is the ability of ecosystems to return to a stable state after a major perturbation, such as a massive die-off due to pollution or to excessive fishing pressure in a poor production year. How do these principles apply when the system is constantly perturbed by human activities, both in terms of increased mortality from fishing as well as environmental disturbances? Although we may not answer any of these questions through this programme, they are the basis of a more ecological approach to fishery management.

It seems therefore important to have an upgradable or " mixed" research strategy, where a "classical" stock assessment approach, based on catch and effort, is combined with the capacity to integrate age or length-structured analyses using life history parameters (mortality, size at age, age at maturity). A third level of stock assessment integrates external variables, either as simply establishing empirical relationships between potential yields and environmental indicator variables, or by approaching the forecasting of yields from different points of views, such as the recognition that there is no such thing as a maximum sustainable yield (MSY) except on a theoretical plane. A novel conceptual approach (what is called the third level of complexity in the present text) will require inputs from a variety of sectors, including physical and chemical oceanography, ecology and economics (Béné 1995). The challenge will be to integrate these factors in a management model designed around the principle of dynamic equilibriums. Simplifying methods are possible, where components are evaluated singly and integrated in a second or third level of analyses or refinements. As an example, one can refer to the simple regression models used at NMFS (Galveston, Texas) where salt marsh surface area is used to predict shrimp recruitment in the Gulf of Mexico. Although the NMFS (Galveston) laboratories are now exploring new approaches to habitat-based methods of evaluating recruitment into the shrimp fishery, classical approaches continue to be used and form the backbone of the management advice provided by NMFS. For example, Virtual Population Analysis (Gulland 1965; Ricker 1975) is used, based on life-history parameters and the availability of data, with mortality and somatic growth estimates derived from mark-recapture and catch-effort data. Virtual population analysis estimates age-specific monthly stock abundance and fishing mortality

rates (Parrack, ms). These in turn were used to calculate yield per recruits and the relationships between spawner abundance and progeny.

4.2. Statistical and analytical methods

Catch and effort data are generally analyzed with holistic-type models. These are classes of models that are not very demanding in terms of data requirement. They assume that the fishing stock is one homogeneous population biomass that is stable in time. Holistic models can be further divided into "swept area" models, mostly developed for research trawl surveys, and "surplus production" models, designed to use catch and effort data. Both predict maximum sustainable yields based on actual yields, and are therefore influenced by gear type and design, experience of the fishing or experimental fleet and historical events affecting distribution and abundance of the targeted species. Although this is the case (one should talk of MSY for the trawl fishery, MSY for the drift net fishery, etc.), there is always a very strong management desire to combine catches and effort across gear type and fleets to arrive at a global MSY. Worse, species, whether similar or not, are often pooled and analyzed as a unit, even though their life histories are either not well understood or simply quite different. A more practical problem is the absence os adequate historical data for plotting a surplus production model curve. A great deal of variation in effort is required for the modelling exercise to be credible. This is often difficult when the data available is obtained from a mature fishery only, and can even lead to quite eronious results if the fishery is on the decline from overfishing. Despite the severe limitations, catch and effort data is often the only type of data available, and will continue to be used, and may nevertheless give valuable insight into the nature of the problem ("qualitative results"). For these reasons, the use of production models to forecast beyond the limits of available information (observed variation in the effort vector) should not be attempted, as it can lead to important biases.

There are several variants on the theme of surplus production models, but basically all use the same structure and inputs. Information on the level of fishing effort (e.g. the number of fishing days trawling) in relation to the capture (e.g. kg of fish from that effort) is the basic data requirement. We will be making extensive use of surplus production models throughout the region's fisheries as a first level of structured "stock assessment" analysis.

If the fishery incorporates several levels of interaction among fleets fishing the same stock at different times of the life cycle of locations, then more sophisticated tools are required. These would permit to estimate mortality rates at different stages during the life cycle of the animal, such as provided by age or size-structured models. Models that can estimate mortality rates on a monthly basis, and which output results for yield per recruit types of analyses, while taking onto consideration that yields are not constant (environmental effects) and that recruitment may be affected by total mortality (Gulland 1984). The most important variation affecting yield is in

recruitment, and it's more important to look at some of the causes of variation in recruitment than to incorporate some stochastic component into recruitment variables in a model, which does nothing more than give you an indication of the variance of your output parameter. These causes of changes can be classified as: 1) Natural changes in the environment, 2) man-made changes in the environment (e.g. mangrove draining), and 3) changes in the abundance of spawners. Changes in recruitment have mots often been related to rainfall, river run-off or similar factors (Gulland 1984).

Analytical models, or "age-structured models" are more complex than surplus production models, because they do not make assumptions as to the homogeneity of the population age or size structure. The basic concept behind this class of model is that the age structure of the population yields valuable information on the level of mortality imposed by fishing. For these models, the age composition of the harvested stock needs to be known, that is, the number of fish caught for each age class in the population. As inference about the level of fishing is not done directly from observation of the catches as in surplus production models, intermediate steps are required in the analysis. The two major types of information required are mortality rate and body growth of the target species. It is also critical that each stock and species be treated separately. A breakdown of the population by cohort (animals of roughly the same ages) must also be possible (there has to be some annual cyclic nature to recruitment) and measurable. This class of models is thus more complex to develop as a management tool. However, the data required is relatively simple to obtain in many cases (albeit sometimes requiring important human resources), and methods of inferring some of the parameters from indicator variables have been devised. We will assure that the data collection for this class of model is implemented in all countries, and will integrate this approach to fishery department's analytical "toolboxes" wherever possible. Some countries, however, are already using this class of model in some of their experimental work (e.g. Trinidad). Although implementation will vary from country to country, focus on the refinements in the methods in place will also form a focal point of our activities.

Although these are the two basic classes of models, there are refinements to each of the methods presented. The best known class is the Virtual Population Analyses (VPA). Age-specific estimates of fishing mortality and stock sizes can be made with the help of these techniques, but the data requirements are very high. For these age-structured models, we require a complete and accurate catch by age table, an instantaneous rate of fishing and natural mortality for one age-group in each of the cohorts analyzed. Furthermore, a substantial time-series of these data are required. Although some of these parameters may not be known from direct measurements, they often can be approximated from other sources (literature, indicator variables, etc.). Species-specific growth curves (length-age or weight-age) are a requirement so that an age-specific catch table can be constructed. Age-specific mortality rates are more difficult to obtain and several steps are required. Total mortality rates must be estimated from the catch statistics or from direct observations (e.g. tagging data). Then, the relationship between total mortality and fishing effort

can be used to estimate natural mortality from the extrapolation of the observed functional relationship to zero fishing pressure. We will not be making extensive use of this subclass of model at the regional level, but may do so on a country basis (e.g. Trinidad) where the technological, statistical and human resources permit this. The expertise then created can be integrated into the region via some regional scientific collaboration mechanism. Furthermore, there may be valuable time-series available from the well-monitored fisheries (e.g. Gulf of Mexico) that could be analyzed by the RAU and applied to local fisheries for comparison purposes.

4.3. Tropical fisheries issues

Tropical fisheries scientists often find it very difficult to apply models that have essentially been developed for temperate countries, where cohorts are well defined and ages known with precision. For example, shrimp recruitment is probably spread throughout the year, with perhaps species-specific peak recruitment during certain favourable periods of the year, whereas the recruitment of temperate species is generally at the same time of year over a very short time interval. In the tropics, the concept of age needs to be defined on a fishery by fishery basis, particularly when no strong recruitment peaks are apparent. The ageing of shrimp has proven to be very difficult because of the numerous molts during growth and the absence of a terminal molt in most species. This has also hampered tagging studies and complicates converting lengths to ages, as there is little resolution in the size-classes. However, several methods are described in the literature to attempt to resolve these difficulties (e.g. the Bhattacharya method for ageing animals from size-frequencies, and the catch curve length frequency analyses for estimating mortality), and will be adapted by the RAU. Several analytical models have also been adapted for length-based analyses, but some conversion between length/age/growth remains a requirement.

Most serious of all the problems presented above is the conceptual approach prevalent in all these models, as discussed earlier. These techniques guide the biologist to seek a species and/or stock-specific maximum sustainable yield (MSY), even tough tropical ecosystems are infinitely more complex and multi-specific interactions unknown. This may or may not be an advisable course of action, and depends very much on the type of fishery and the resource itself.

The lack of time series data for most demersal stocks may not be easily corrected. Even if a time series were started now and extended for the next 10 years, it is not certain that there would be enough variability in effort to plot and estimate catch per effort models.To compensate for these absence, a reliance on yield per recruit models of virtual population analysis adapted to size-frequencies is possible, but the reliance on good biological information is costly. These models also assume that there is no variance in the annual time series, a condition which has been

demonstrated to be false repeatedly.Despite these reservations, these modelling appoaches are potentially useful as a method of demonstrating the impact of management measures on different fleets. The difficulty in this step is that fisheries management bodies in the region lack the ability to control effort (number of boats, gear type) that is required to reach optimized solutions suggested by the models derived.

There is concern in the region that the artisanal and industrial sector interfere in each other's production potential and economic profitability. To resolve this issue, detailed information on the species targeted, sizes, captures, and areas of activity is required. By comparing this information across fleet types, one can speculate on the "potential" for interference and exploitative competitions. There are also some packaged models available to speculate numerically on the level of interaction between artisanal and industrial fisheries. Ideally however, an experimental approach to testing the level of competition for the same resources should be considered, where closure of the fishery to certain fleet types are implemented in certain areas, and a corresponding closure of other fleet types are implemented in an adjacent area. This is equivalent to a incomplete block design in that specific sites cannot be replicated exactly across all effects. This type of experimental closure would yield the necessary information to establish the consequences of fisheries interactions on the resources and production. However, the sites chosen for this work would have to be selected carefully, as enforcement of the closures would have to be absolute and monitored carefully.

4.4. Biostatistics

Because of the wide range of situations and fisheries prevalent in the sector, it is likely that a very wide range of biostatistical techniques will be required and employed, from simple regressions of allometric-body morphometrics to the analysis of qualitative information, cluster analysis and multi-dimensional scaling of fishing fleets and proofing of log book data. Specifically, we will be doing size-frequency analyses, calibrating age to length-composition data, deriving functional regressions from morphometric analyses, developing or adapting estimation methods for non-linear regression analyses (e.g. von Bertalanffy functions), fitting growth curves to length-frequency data and estimating mortality rates (natural and fishing) by a wide variety of methods (exponential decay, catch curve analyses, empirical formulas, etc.). In addition to these activities, we will need to derive population variance estimators and confidence limits for many of the production parameters we will develop or adopt.

5. INFORMATION REQUIRED FOR STOCK ASSESSMENT OF THE FISHERY

Several types of basic information are required for a precise assessment of the shrimp fishery on the Brazil/Guiana continental shelf area. These can be broken down into several categories, based on the dynamics of a fish stock and "economics" of the fishery, as presented in the following sections.

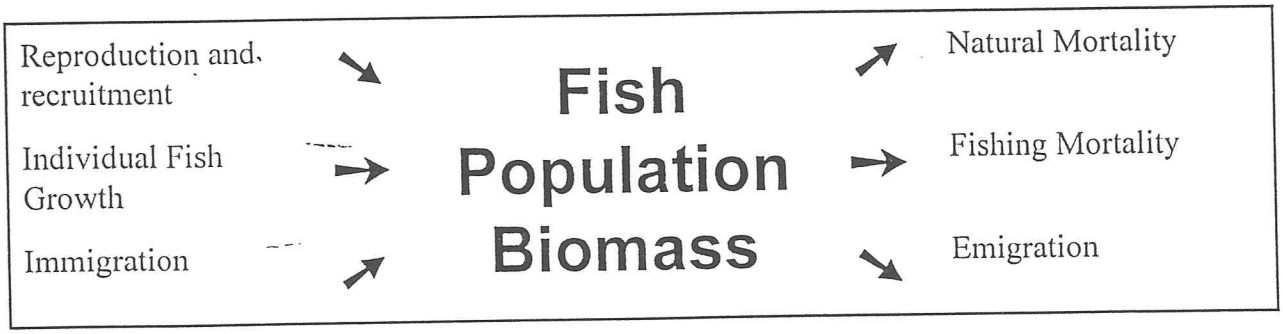
The information listed below only highlights the main types of information required. The methods that the RAU will use in pursuing its objectives will be determined at the subproject specification workshop, to be held in January 1996.

In all cases, historical information should be gathered from all sources, and integrated into as few a database as is possible so to facilitate the work of the biologist. In such a case, a contracted computer scientist could be hired and given the mandate.

5.1. Life history data (Biological data Collection)

A simplified model demonstrates the components of population dynamics of fish populations relevant to stock assessment methods (Figure 2). Elements of life history characteristics are necessary to develop models of productivity, as impacted by environmental conditions.

Figure 2: A simplified model of fish population dynamics (from Heileman 1995).



Life history data provide an understanding of biological aspects of the shrimp resource. These types of data include size (total and tail lengths or weights), size-at-maturity, growth, age, size at harvest, spawning periods, fecundity, larval development stages, etc. They would come primarily from a biological sampling program within certain project activities. Although we would not necessarily collect this information routinely in a Catch/Effort data collection program, collection of this type of data will be integrated into specific project activities.

A method of ageing captured shrimp must be developed so that various stock assessment techniques based on catch at age can be used. This can be accomplished by several methods, either experimental (e.g. Mark-recapture, surveys, etc.), from analytical approximations (e.g.. Von Bertalanffy growth conversions, catch curve analyses) or from the literature. Several approaches have been described in the region, particularly in the Gulf of Mexico, and one tagging study has been done off the Northeastern coast of South America (Cavalcante and Dragovich 1984).

Several studies in the Gulf of Mexico have revealed that adult and near-adult shrimp (*Penaeus sp.*) are capable of moving several hundred kilometers (Sheridan *et al.* 1986). Although each species may have a specific center of abundance on the continental shelf, mobility of adults and near-adults as well as the considerable larval drift expected from the strong coastal currents along the Northeastern continental shelf indicate that there are probably no genetic differences between localities.

Body morphometric models are also easily obtained and verifiable from the literature and the fishery. Mortallity estimates will also be required. The specific methods adopted will be defined and developped as part of project development.

5.2. Catch and Effort Data

The need for accurate catch and effort data is undisputable and forms the backbone of any monitoring of any fishery. However, the difficulty lies in the development of a monitoring system that is truly representative of the fishing activity in a particular country. This can be particularly difficult if fishing activity is diverse as in many tropical or developing countries. The RAU will have to collaborate closely with the Catch and Effort data system to insure that the relevant information sought is gathered and compiled appropriately.

Ideally, the capture data should be broken down by species. Total landing by weight per fishing days are required, accompanied by an estimated percentage of the captures of each species. The identification of location of fishing effort in time and space is also critically important, as very little can be done to establish productivity of a fishery, even from the most accurate landing statistics, if it is not accompanied by effort by fishing location information.

As the Catch and Effort sup-project is well under way, we do not need to specify implementation details in this document.

5.3. Bio and Socio-economic data

The RAU may be involved in bio or socio-economic modeling, through the interaction with the sub-project on community involvement or participation in a project of the CFU economist.

5.4. Research "Cruises"

Cruises can be used to collect data on several species groups (i.e. shrimp, groundfish, turtles). Individual cruises can be designed to collect data on a specific group, or in the case of shrimp and by-catch, on a set of groups. Near shore sampling can be achieved relatively inexpensively bi-annually using small-scaled fishery equipment. Offshore cruises require more expensive equipment/vessels. Data on abundance, size composition, sex ratios, maturation and fecundity, and the geographic distribution of species can be obtained from these cruises. Furthermore, the inherent bias from sampling sorted samples from the fishery sector is completely avoided. This can yield very useful information on recruitment, nursery grounds, growth and mortality.

5.5. Environment/habitat parameters of shrimp/groundfish production

The Guiana/Brazil continental shelf area is a formidable ecosystem. The influence of the Amazon river run-off reaches the coastal areas of the Gulf of Mexico (El-Robrini, 1995, pers. Com.), and nutrient-rich sediments are deposited by several major rivers all along the coast and into the gulf of Paria, making the area one of the most productive in the world. The site has been chosen for its qualities to be included in the World Ocean Circulation Experiment (WOCE). Major efforts are now undertaken by France, through the work of the ECOLAB project, a collaborative effort among several institutions, including the Institut français de recherche pour l'exploitation de la mer (IFREMER) the Institut français de recherche scientifique pour le développement en coopération (ORSTOM), and the Universidate Federal do Pará (Brazil), to map oceanic currents, bottom geology, physical and chemical oceanographic properties, and coastal living resources throughout the area. It must also be noted that there is a memorandum of agreement between IFREMER and the Institute for Marine Affairs (T&T) for collaboration in this area, although no activity has yet begun. The Fisheries Technical Assistance Project in Guyana has identified well over two dozen environmental issues and initiatives, from the protection of rainforest ecosystems to turtle conservation and fish community research.

Oceanic currents are strong in this area, where southeastern Atlantic water hits the northeastern coast of South America dead on and creates local upwellings. To this are added the influence of several major river systems draining millions of square kilometers of land, such as the Amazon, Orinoco, Essequibo Corentyne, and others. The result is strong northeasterly coastal currents and deposition of organic matter, mud and mud/sand sediments to 40 m of depth. Shrimp use these

habitats, and are known to spawn in waters of 20-40 m depth, from which point larvae migrate towards the protected coastal habitats (mangrove, salt marshes, lagoons). This creates a system where larval drift is likely to be very important. The potential for migration (active and passive) is important in this ecosystem. This will have an influence on stock definition, and requires some investigation. There is a large body of literature on the genetics of the main species of Penaeids which will be reviewed. Further work on the importance of passive and active migration of the different species of shrimp on the distribution of harvestable size classes in the different fisheries will be required. This approach will be initiated via literature reviews and develop into scientific collaboration with research institutions with expertise in this area. For example, the following governmental agencies in Guyana have environmental mandates (Table 7), and monitoring programs of some environmental variables could be developed in association with them. This should be a cost-effective measure of gathering environmental data for research on fish production.

Table 7: Governmental Agencies and Non-Governmental Organizations (NGO) with environmental mandates in Guyana

Agency	**Environmental Management Mandate**
Department of Fisheries	Fish exploitation, management and conservation
Guyana Agency for Health Sciences Education, Environment and Food Policy	National environmental policy, environmental monitoring and coordination
Guyana Natural Resources Agency	Manage and develop natural resources
Advisory Environmental Council	Coordination role at the country level
Guyana Forestry Commission	Managing lands and forests
Guyana Natural Energy Authority	Energy conservation; new and renewable energy sources
Institute of Applied Science and Technology	Research and development; lab analyses; monitoring
Wildlife Service Division	Management, conservation and monitoring of wildlife
Guyana biodiversity Society	Conservation

Table 7: Governmental Agencies and Non-Governmental Organizations (NGO) with environmental mandates in Guyana

Agency	Environmental Management Mandate
Guyana Environmental Monitoring and Conservation Organization	Environmental concerns of development policies, monitoring development projects, define parameters; support for ecological research
Special Environmental Enhancement Committee	Solid waste management
Ministry of Agriculture	Wildlife and fishery management, soil conservation, land use, agrochemical supplies

Environmental variables and parameters, as perceived to have the potential to become useful tools in predicting production potential for shrimp and groundfish in the region, will be targeted for a literature review, followed by the development of research initiatives in association with regional institutions. Such variables considered at this stage include major river run-off and its influence on coastal salinity, current strength and direction; coastal nursery habitat area and local shrimp production; shrimp distribution in relation to habitat types and surface areas from satellite imagery or ground surveys; etc.). Please note that research efforts will be directed at the most promising avenues after proper analysis of available information.

There has been much speculation and discussion on the best way of protecting the juvenile shrimp. Much of the discussion has centered on the protection of nursery habitats. However, that is not always obvious or the dtade-off between nursery protection and indudtrial development always put envoronmental concerns as secondary. To adequately protect nurseries, their production capacity must be quantified against other possible nursery sites to confirm their status. For the protection of the fishing industry in the long term, there is no question that protection of the nursery sites is required. More immediate and perhaps easier action for the protection of juvenile shrimp and fishes could take the form of closed seasons and areas. A combination of the two appraches would be optimal.

5.6. Industry participation and awareness of the scientific programme

It is envisaged to organize meetings for fishermen whose objective would be to increase the understanding and collaboration between fishermen and scientists. The first set of meetings should introduce fishermen to "scientific methods", pointing out in simple non-scientific language why data is important. This is to be followed by training for fishermen in taking observation and measurements of a scientific nature (in addition to standard catch and effort, one could consider such measurements as depth, water temperature and salinity, etc.). A second set of meetings might be considered to present results from the research programs directly to fishermen, handle their questions, analyze their own data, etc. This work will be proposed as a potential activity to be implemented in close collaboration with the Community Participation sub-project.

6. IDENTIFICATION AND DESCRIPTION OF THE PROPOSED STOCK ASSESSMENT ACTIVITIES

Since it is recognized that it is no longer correct to asume that the aim of management is simply to maximize the total catch, either for local consumption of for export, the first step would be to identify what are the aims of management (Gulland 1984; J. Caddy, pers. Comm). These new objectives are likely to be varied, complex and often incompatible. The best a biologist of fisheries sccientist can do in such a situation is to develop an information package to inform the managers as to the cost and benefits of each management option. The extent to which stock assessment activities will move in one direction or the other depends directly on the definition of these objectives. Ideally, all management objectives should be clearly outlined at the onset. This is not always feasible, and compensatory strategies must be adopted in prevision of new management guidelines. A ranking of priorities in terms of research, such as what is done is the USA (Gulland and Rothschild 1984) , might be a desirable second step. We retained the scores for the Management vs. Research objectives matrix as was presented in their text, which is likely to be similar in the Guiana/Brazil continental shelf area, but modified the "State of Knowledge Rank" to represent our understanding of the situation on the shelf at present. The resultant research priorities are given in Table 8.

TABLE 8: Example of decision analysis of research priorities (example management objective score taken from the USA fishery and the score of knowledge rank is estimated from the present document).

	Management Objectives							
Reasearch Objectives	*Opt. size**	*Max. Economic function**	*Minimize biological risk**	*Habitat Manag.**	*Total Score*	*Manag. needs rank*	*State of Knowledge Rank ***	*Combined Rank*
Growth	1	3	2	3	9	6.5	M/5	7
Nat. Mort.	1	3	2	3	9	6.5	L/1.5	4
Fishing Mort.	1	1	1	2	5	1	L/3	1
S/R Fcn	2	2	1	2	7	3.5	L/1.5	2
Inter-species relationships	3	3	1	1	8	5	L/6	6
Environmental interactions	2	1	2	1	6	2	M/4	3
Harvesting economic dynamics	2	1	3	1	7	3.5	M/7	5
Processing Economic Dynamics	3	2	3	2	10	8	M/8	8
Market economic dynamics	3	2	3	3	11	9	M/9	9

* Score Description (only 3 of each per objective)

1=Essential

2=Primary supporting information

3= Secondary supporting Information

** Level of current Knowledge

H= High

M=Moderate

L=Low

The results of this analysis indicate that top priority should be given to the evaluation of fishing mortality and research into the development of a stock/recruitment model. Estimating fishing mortality is important in the present context because fishing mortality varies during the life cycle of shrimps and groundfishes due to very different fisheries operating at different stages in the life cycle of the animal. The third highest ranking priority is the elucidation of causal links between local productivity and environmental factors. This includes a wide range of activities, from

identification of nursery areas and their protection, to the determination of human impact on the ecosystems. Also high on the list of priorities is the estimation of natural mortalities and Harvesting Economic Dynamics.

6.1. Common Activities

The proposed stock assessment activities are summarized from the above discussion. Due to the time constraints in developing the program, we concentrate on the activities likely to take place in the current fiscal year:

1) We will implement or improve/modify the existing implementations of catch and effort data collection systems in all countries. This will provide data for holistic models (surplus production models). These will be developed to cover adequately and in a representative fashion the artisanal as well as the industrial fisheries. The catch and effort data collection will be developed in accordance with and integrated into the existing CFRAMP sampling activities.

a) A log-book system will be implemented for industrial operations. This is done with the intention of obtaining a full coverage of the fishing activity in this sector. The information included will cover at least catch and effort, fishing site, species targetted and captures, and non-targetted species captured.

b) A sampling program, using a clustered stratified sampling approach, will be implemented for the artisanal sector. The derivation of the parameters and their variance estimators will require some fundamental work.

c) A sampling program aimed at detecting the arrival of cohorts into the fishery will be implemented, using different fishing gear of a wide range of size selectivity. We will attempt to choose gears that overlap in fishing time and space. We will work with existing fisheries as well as with experimental protocols.

2) Biological Data Collection will be implemented in each country. These will include, on a sampling basis, the variables described in Section 5.1 above. These data will provide the information required for age and size-structured analytical models. They will also provide information on the biology of the main species, including age at maturation, growth trajectories, age and size at capture, etc. The biological data collection will be developed in accordance with, and integrated into, the existing CFRAMP sampling activities.

3) Economic Data Collection will be implemented in each country. These will include, on a sampling basis, the variables described in Section 5.3 above and herein. The biological data collection will be developed in accordance with and integrated into the existing CFRAMP

sampling activities. Full implementation of a socio-economic study is not likely to be realized in the present fiscal year. However, basic economic data collection, such as market prices, wholesale prices and vessel operation costs are readily available and could be implemented quickly. These data form the basic requirement for bio-economic analysis of fisheries (i.e. FAO's BEAM IV).

Training of the data collectors and managers will be required for activities 1-3 above.

4) Analysis of historical data is required for establishing several initial parameters and orientations:

a) An analysis of existing log book systems and available data will help determine the best approach to take to insure that the data collected is of high and even quality, pertinent, and easily coded by the boat captains.

b) Analyses of the variances in the catch and effort data available in the artisanal sector will allow us to determine the sample sizes required to monitor this fishing sector. Previous to this, a needs analysis of the level of accuracy of the parameters to be assessed is required. This is done in order to maximize the cost/benefit ratio of sampling operations.

c) Analyses of the variances in the biological variables and parameters available in the artisanal and industrial sector will allow us to determine the sample sizes required to monitor these activities. Previous to this, a needs analysis of the level of accuracy of the parameters to be assessed is required. This is done in order to maximize the cost/benefit ratio of sampling operations.

d) An analysis of the biases involved in the biological data collection from specimens collected at landing sites will be required. If the biases due to sorting and handling at sea or elsewhere are thought to be too important, then the sampling program will be adjusted accordingly. This may require the placement of observers on board several fishing vessels or fishery types to test some relevant assumptions.

This work (4) will be done at the RAU, in collaboration with the Catch and Effort Sub-Project. Some components of this work (e.g. 4. b) may be entirely the responsibility of the Catch and Effort Sub-Project.

5) Fisheries Interactions: There is concern in the region, as discussed, that the artisanal and industrial sector interfere in each other's production potential and economic profitability. This is a difficult problem to unravel, and involves estimating mortalities at different life cycle stages for

each particular species. A starting position might be to simply list the species caught by different gears and in different parts of their life cycle to define the "fisheries interaction" level.

6) Environmental parameters/habitat mapping : This activity forms a very important component of well-funded research institutes (NMFS, IFREMER) in the region. The rationale for this program has been presented above. The RAU has initiated a literature review of the existing orientations and will continue to monitor ongoing research activities in this sector. The RAU will participate, through collaboration with local (i.e. IMA, UWI) and regional institutions, in identifying important parameters for management purposes, namely those that will be developed to predict production parameters (recruitment strength; species and stock distribution; nursery habitat degradation, location and area; location of fishing effort), location of landing sites, ports and other infrastructure. The expected output will be simple models and distribution maps to assist management of the fishing fleet movements, closures (spatial and temporal) and habitat protection. A Geographic Information System (GIS) would be used to gather the information. This project is not likely to be fully implemented in the current fiscal year.

7) By-catch and turtle exclusion devices: Several well-funded research institutes are presently doing trials and development of such fishing devices, particularly TEDs (e.g. NMFS Galveston, Texas; IFREMER Cayenne, Fr. Guyana). Canada has implemented regulations on the use of By-catch Reduction Devices in the northern shrimp fishery since 1993 with apparent success (Savard and Simard, 1994). We will conduct a literature review to determine the status of the present technology and ongoing research activities. However, this will not be sufficient to provide advice to the countries. After selecting a design, we propose to support financially a research institution involved in the development of TED's and BRD's to do test runs with our specifications. It is possible that such runs could be done within the region as well. This project is not likely to be implemented in the current fiscal year.

8) Bio- and socio-economic research: The unit is not capable of doing socio-economic studies on its own, because of human resource constraints. However, if collaboration can be established with experts within CFRAMP, either through the Community Participation sub-project or other, then we propose to develop such studies at the MACRO-economic level. For example, one would focus on the importance of the fishing sector or a component of it on the local economy, or on the importance of fishing activities in local economies, rather than household repartition of fishing income. This would address the more pressing issues raised by the senior fisheries officer in the region, who must advise their ministers on the effect of closures on community structures.

6.2. Belize

1) The data collection system proposed by Auil in 1993 will be refined and implemented.

2)The social data collection system will be developed and implemented in collaboration with the Community Participation Subproject.

6.3. Guyana

The Guyanese research program will be oriented to the maximum extent on the regional program outlined above. There are specific issues relating to the Guyanese fishery, however, that require a customized approach. These are outlined below.

1) Fishery interaction of *Penaeus sp.*, seabob and whitebelly shrimp. There are artisanal fishery types (mostly Chinese seines) that capture a mixture of seabob (*Xyphopenaeus kroyeri*), whitebelly shrimp (*Nematopalaemon schmitti*), juvenile finfishes and possibly juvenile prawns of the genus *Penaeus*. Although the distribution of these species is generally geographically distinct, with only some degree of overlap, there is concern that the behaviour of the fishing fleets is responsible for these potential conflicts, and that an investigation into the catch and distribution of fishing effort is required. It is also believed that if this practice continues, it will have a detrimental effect on the *Penaeus sp.* stocks, through increased juvenile mortality.

2) There is a need to find and define nursery areas for juvenile fish and shrimp, so that temporal and spacial closures can be implemented to protect the stocks.

3) Guyana seeks to collaborate closely with Suriname on the groundfish fishery in the Corentyne estuary.

4) Guyana would like to characterize their artisanal fishery into classes and types for management purposes. This is of some importance, given the constraints of small Fisheries Departments with limited budgets, and the complexity of the artisanal sector. Furthermore, Guyana would like to determine a standardized measure of effort so that different gear types can be regrouped for further analysis/synthesis and to link it with the fishing effort of the industrial fleet.

5) The historical frame surveys as well as log books need to be computerized and analyzed and integrated within the context of the latest available information (1992 frame survey). Improvements in the methodologies employed will be provided, and will lead, at least in part, into the Licensing and Registration System (Catch and Effort Sub-Project). A new frame survey may be recommended as a result of this work. This may be done in collaboration with the CFRAMP Catch and Effort Sub-Project.

Close collaboration with the Fisheries Technical Assistance Project (FTAP), now in its final phase of operation, will be required, particularly in the areas of improving the fisheries data collection and analysis systems and management. The FTAP will be producing a 5-year research and management plan that will influence CFRAMP activities. Integration of relevant FTAP recommendations into CFRAMP work plans will be required in the current fiscal year.

6.4. Trinidad & Tobago

1) A comprehensive system for the collection of catch and effort, biological data, economic and social data will have to be designed and implemented to provide the data necessary for analysis to address management issues. This would call for very close collaboration between the Catch and Effort and Licensing and Registration Subproject, the Community Participation Subproject and the Biological Data Collection Subproject of the SVG RAU and the T&T RAU.

2) A study utilizing by-catch reduction devices would have to be designed. This could be done in collaboration with Venezuela where such studies have being carried out.

3) Hands-on training would be done within the workshop/seminar arranged to develop the projects for implementation in the countries. Later, workshops will be held to analyses the data collected for the assessment of shrimp and groundfish.

7. COLLABORATION AND ASSISTANCE FROM OUTSIDE AGENCIES

Through the activities of the sub-project implementation mission, we have developed contacts with several agencies active in shrimp research and stock assessment. These people/agencies have been solicited to provide assistance and guidance as well as documentation pertaining to shrimp/groundfish resource assessment. Here is a narrative of the areas of collaboration envisaged.

7.1. National Marine Fisheries Service

The National Marine Fisheries Service in Miami provided us with much of the background information and documentation available at NMFS pertaining to the Guiana/Brazil shrimp fishery. Dr. Albert Jones, is ready, able and willing to collaborate with CFRAMP in the shrimp/groundfish fishery. Although he is not currently active in the region, his experience as a fisheries scientist might be of benefit to the project.

We proposed to expand our collaboration with NMFS through various mechanisms. Dr. Jones offered to be the contact point for any of our business with NMFS, and this might become a very useful entry point into the extensive NMFS resources (library, statistical and modeling advice, etc.). Furthermore, Dr. Jones may serve as an expert in the shrimp fishery to assist in developing our research program.

We have invited the resource people at NMFS, Galveston, Texas, namely Dr. Roger Zimmerman and Dr. James Nance, to seek and develop direct links and increased collaboration between their agency and the CFRAMP, Shrimp/Groundfish activities. We may call on them to review proposals, or to help directly with the development of research plans and protocols.

The outline of the subjects we have discussed and agreed to collaborate on fall into the general themes listed below:

1) The exchange of reports on shrimp stock assessment methods. In the early part of our program, the majority of the publications will be from NMFS to CFRAMP. However, as our reports and publications become available, we will reciprocate freely. As recognition that habitat characteristics can be used effectively in modeling production, we would also be seeking assistance to implement such projects. However, we do recognize that the northern shore of the Gulf of Mexico ecosystems (sea grasses and marshes) are profoundly different than the mangrove swamp in the Guyana/Brazil continental shelf.

2) NMFS/Galveston has agreed to collaborate on the review of work plans for our regional and national projects. Again, as these become available, we will forward them to NMFS/Galveston for comments.

3) NMFS/Galveston has proposed to receive and train fisheries officers and graduate students, should the opportunity present itself.

4) NMFS/Galveston will be available for research workshops and meetings in the region. For this we shall cover airfares and per diems.

7.2. University of Miami

Dr. Nelson Ehrhardt (University of Miami, RSMAS) is an extremely dynamic scientist, currently active in a wide number of projects in fisheries, including shrimp. He is supervising about 10 graduate students, mostly at the doctorate level. In association with his lab colleagues, he has written many simple programs for the stock assessment of shrimp in tropical countries, particularly in Nicaragua. He is keenly interested in becoming involved in CFRAMP. He has offered his services in helping to develop the work plan, in reviewing proposals from the

countries and providing assistance with the development of stock-assessment methodology adapted to shrimp and by-catch. Much of this work has been offered freely.

Dr. Erhardt has a great deal of experience in the region, particularly with the WECAFC shrimp subgroup. He has contacts in the region, particularly in Venezuela and Central America. Aside from his direct help as a fishery expert, Dr. Ehrhardt may be of great value in providing models, programs and documentation to the project.

We will require the help of Dr. Ehrhardt in the shrimp and related groundfish fishery to assist in developing our research program. He may be called upon to attend the SSW meeting in October 1995.

Dr. Ehrhardt proposed to follow up our meeting in Miami with documentation, a personal *Curriculum vitae* and advice on programs and methodologies that he and his lab have developed for Nicaragua and appropriate for our Shrimp/Groundfish Resource Assessment Unit, as this would be of great help to set-up our work program rapidly. Dr Ehrhardt has developped Fortran programs for the assessment of tropical shrimp and fishes, and these should be reviewed for their compatibility with our proposed activities. We also requested the computerized map databases of the region designed for the Grapher/Surfer mapping software.

7.3. Institut français de recherche pour l'exploitation de la mer (IFREMER)

IFREMER has offered to review conceptual approaches to fishery science, research proposals and work plans, and sampling methods (i.e. all matters of scientific and technical collaboration).

IFREMER resources are vast world-wide, and their expertise in tropical fisheries is well known. This link may be quite productive for the programme. They are also an entry poin into ORSTOM (Institut français de recherche scientifique pour le développement en coopération), where the remote sensing laboratories are situated, and BRGM (Bureau de recherche géologique et minière), through the ECOLAB and PNOC (Programme national d'océanographie cotière) projects.

7.4: Institute of Marine Affairs (IMA) and the University of West Indies (UWI)

Collaboration between CFRAMP and IMA has been ongoing through a series of arrangements, notably the ageing laboratory. The Shrimp/Groundfish RAU may require at some stage to collaborate for the determination of ages on some specimen. The library of IMA is a welcome supplement to that of the Fisheries Division.

The University of the West Indies, through the department of Zoology, may be called upon to participate in studies on the life history characteristics of juvenile shrimps and groundfishes. Dr. Peter Bacon has already expressed the Department's interest to collaborate. Furthermore, the Department is interested in participating in any of the workshop and seminars organized by CFRAMP.

8. FAO/CARICOM Collaboration

8.1. CFRAMP/T&T RAU Cooperation with the non-CARICOM states within the framework of the FAO/WECAFC Ad Hoc Shrimp Group.

One option is to establish a joint FAO/CARICOM Working Group (CARICOM being the institution and CFRAMP its fisheries programme) on the Shrimp and Groundfish Resources of the Guyana/Brazil Shelf under WECAFC. Since both the CARICOM and non-CARICOM countries participating in the Working Group are members of WECAFC, this Working Group should report to the WECAFC Commission, taking into consideration the CFRAMP reporting and approval procedures. All the countries visited have agreed, in principle, to the formation of a joint FAO/CARICOM Working Group and see FAO's involvement as necessary to ensure the participation of non-CARICOM countries.

The FAO/CARICOM Working Group on Shrimp and Ground Fish Resources of the Guyana/Brazil shelf being proposed should have a focal point in the region for coordinating activities among member countries and to liaise with FAO, and CFRAMP for technical backstopping. The focal point could be located in Trinidad and Tobago, either at the FAO Office (Regional Fisheries Officer) or the CFRAMP Shrimp and Ground Fish RAU. Since CARICOM and non-CARICOM countries are involved, a joint effort may be required. If a joint focal point is accepted, the responsibility would lie with FAO (Regional Fisheries Officer) and the CFRAMP Shrimp and Ground Fish Resource Assessment Unit (RAU), both located in Trinidad and Tobago, to work closely together. Even though most of the work (e.g.. provide advice on project proposals and assist in the information exchange process) would be done by the focal point, the body would also need technical backstopping at its meetings, depending on the subject matter, to review and comment on technical documents prepared for the meetings, etc. FAO, Rome, should provide this technical advice.

8.2. The Establishment of an FAO/CARICOM Working Group on Shrimp and Ground Fish Resources of the Guyana/Brazil Shelf

The CFRAMP Shrimp and Ground Fish Resource Assessment Unit (RAU) in Trinidad and Tobago has responsibility for shrimp and soft bottom ground fish resources, hence the suggestion that the name of the working group should be changed to include ground fish. This means the inclusion of the small-scale fin-fish fisheries of the region. Some countries were of the opinion that, ideally, two working groups — one for each of these resource groups — should be established. However, given the current economic constraints etc., the consensus was that in the interim one working group would suffice because the work of this group would concentrate on resource assessment of the most economically important fish species and not on social and economic aspects of the small-scale fishery. The social and economic aspects of the small-scale fishery could be dealt with by the WECAFC Working Group on Socio-economics and Planning and the CFRAMP Community Participation Subproject.

It is envisaged that the Working Group should meet in September/October 1995 in Trinidad and Tobago, which has indicated a willingness to host, with assistance from CFRAMP and the FAO. The report of the Working Group should be submitted to the meeting of the WECAFC Commission in November 1995 for adoption. Future actions/activities of the Working Group would be guided by this report.

The countries visited generally agreed with the goals and objectives contained in the project outline prepared by the Third Workshop on the Biological and Economic Modeling of the Shrimp Resources of the Guyana/Brazil Shelf, Suriname, 22-25 June 1992.

Based on these common goals and objectives, a preliminary and generalized programme for the assessment and management of the shrimp and ground fish resources of the Guyana/Brazil shelf will be jointly prepared by CFRAMP and FAO. This programme will contain details for Guyana and Trinidad and Tobago which have funding from CFRAMP. CFRAMP will submit the programme to its Programme Review Committee (PRC) for approval. The Programme Review Committee (PRC) of CFRAMP is scheduled to meet from 1 to 2 June 1995 in Dominica. The programme approved by the PRC will be submitted to the FAO/CARICOM Working Group (September/October 1995), who should expand and refine it, mainly with regard to the non-CARICOM countries. The report of the Working Group on Shrimp and Ground Fish Resources of the Guyana/Brazil Shelf should be presented to the next session of WECAFC, November 1995, for adoption.

After this, each country or group of countries acting independently or in collaboration with FAO or CFRAMP could seek funding for specific project activities within the framework of the work programme. This approach would provide the countries with flexibility to address diverse funding sources, including the private sector, that may be peculiar to them. Those with funding would press ahead with their project implementation. These diverse project activities should contribute to the common goal of building an information base for the management of the

fisheries of the region.

APPENDIX A: REFERENCES

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APPENDIX B: LIST OF REGIONAL AGENCIES/INDIVIDUALS BY COUNTRY

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- George Myvett, Senior Fisheries Officer
- Endhir Sosa, Quality Control Technician

b) National Fishermen's Cooperative Society Ltd.
- Miki Bradley, Executive Secretary
- Sydney Fuller, Member/Trawler Owner
- E. Bradley, Plant Manager

c) Belize Fishermen's Cooperative Association
- Nidia Heredia, Executive Secretary (ag)

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- Pierre Charlier, Fishery Biologist.
- Helga Matroos, Fisheries Assistant.
- Yolanda Babb-Echteld, Fisheries Assistant.
- Carlos Lietar, Belgian Fisheries Technical Cooperation Programme.

b) Suriname American Industries (SAIL), P.O.B. 3045, Cornelis Jongbawstraat 48, Paramaribo, Suriname. Tel: (597) 474014. Fax: (597) 473521.
- W. Tjitrotaroeno, Chief Quality Control Officer.
- Ing. Erroll K. Mannes, Managing Director.
- Maureen Brandon, Aquaculture Project.
- Televan Horenbeck, Researcher, Aquaculture Project.

c) SUJAFI - Suriname Japan Fisheries Co. Ltd., P.O. Box 1237, Dijkveld No.1, Livorno, Distrikt Suriname, South America. Tel: (597) 481122. Fax: (597) 482575.
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- Eng. Agr. Guiaracá Corrêa Gabriel, Diretor Geral.
- Eng. Agr. Hildegardo de Figueiredo, Secretário de Agricultura
- Ing. Geraldo Travares, Coordinador, 10 Nucleo Castanhal, SAGRI.
- María Dolores de Lima Amorium, Bióloga, Chefe de Disvisão de Apio A Aquicultura, SAGRI.
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e) Conselho Nacional de Desenvolvimiento Científico e Tecnológico Museo Paraense Emílio Goeldi, Av. Magalhaes 376, CEP: 66040170, Caixa Postal 399, Belém, Pará, Brazil. Tel: (091) 249 1302/0477. Fax: (091) 249 0466 BR.

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c) BEV Enterprises Ltd., Houston, East Bank Demerara, Guyana.
- Bruce Vieira, Director.
- Alan Spencer, Personnel and Industrial Relations Officer.

d) Guyana Seafoods Ltd., East Bank Demerara, Guyana.
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e) Greater Georgetown Fishermen's Cooperative Society Ltd., Lombard St., Georgetown, Guyana.
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b) National Organisation of Fishermen and Affiliated Cooperatives.
- C. Rogers, President.

c) Trawler Owners Association.
- B. Maharaj, President.

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- Victor Baeza, Administrator.
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- Miriam Salazar, Public Relations Officer.
- Manuel Puerta, Finance Manager.

e) DIPESCA, Cumana.
- Liz Villeges, Fishery Technologist.

f) Fundacion para el Desarrollo de la Ciencia y la Tecnologia (FONAIAP), Torre Este, Piso 11, Parque Central, Caracas. Tel: (02) 5752117. Fax: (02) 577468.
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g) Servicio Autonomo de los Rescursos Pesqueros y Acuicolos (SARPA), Ministerio de Agricultura y Cria, Torre Este, Parque Central, Piso 10, Caracas 1010. Tel: (02) 5090382-85.
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- Hugo Alsina Lagos, Director, International Affairs (Fisheries).
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APPENDIX C: Comments by John Caddy (FAO)

Some comments on the CFRAMP assessment framework for management of Guianas- Brazil shrimp fisheries

J.F.Caddy,
FAO, Rome.

The SPIM report describing the options for assessment and management of shrimp and finfish resources in the Guyanas-Brazil shrimp fishery covers fairly exhaustively the possibilities for assessment, and subsequent reports by Andre Talbot on data collection and catch/effort and economic data collection, provide a useful basis for fisheries sampling and statistics. I will not comment in detail on these, since I see the priority in another direction. I think where these reports have deficiencies may be in that they do not place their recommendations in a wide enough management framework. (This is not a criticism of the authors of the reports, since I am sure they were not asked to take a broad view of the management system that is supposed to react to the advice provided).

Although the SPIM report discusses objectives, which are provided from the top by the management authority at the political level, I didn't get the impression that such objectives have been provided by CARICOM or its member States. Inevitably, this tends to throw the assessment scientists back into a 'bottom- up' approach to assessment. They are unable as a result to take fully into account how the advice offered is likely to be used in the case of shared stocks (such as a number of Guianas-Brazil shrimp stocks and their finfish by-catch), and in the case of interracting fisheries (as for the shrimp and artisanal (especially finfish) fisheries. My comments will therefore be mainly devoted to considering the management context for necessary assessment work.

The resource context for management

I suppose we could start from the perspective that the shrimp fisheries also catch significant numbers of finfish by-catch which is in part discarded dead, and might otherwise feature in artisanal groundfish fisheries. Inshore fisheries (e.g. using fixed gear) also take some shrimp; mainly juvenile shrimp close to inshore nursery areas and estuaries. The problem of managing mixed fisheries pernaps then starts from recognising that optimal fishing rates and mortalities for shrimp are considerably in excess of optimal fishing rates for groundfish. A compromise in management needs therefore to be looked for in mixed fisheries, in seeking a joint exploitation rate for shrimp that is lower than optimal, and a groundfish fishing rate that is as high as can be sustained by the stock.

A/ BOTTOM-UP APPROACHES TO RESOURCE MANAGEMENT

One of common (mis)conceptions of the way stock assessments are integrated into management, is that the data is collected first, analysed, and then management options somehow developed as a result of the completed stock assessments. This may be referred to as a bottom-up approach, since so far, the managers/ governments who 'own' the resource have not yet said what questions they wish the assessment scientists to solve. I believe that this 'bottom-up' approach may be useful for preliminary reviews aimed at showing managers the general state of the fishery and stimulating them to ask more specific questions. In a managed fishery (and most Caribbean fisheries do not yet fit this description), the management framework (effort or quota control, and/or allocation of limited licenses or exclusive fishing rights) are already in place, and managers require that routine assessments be done to meet deadlines for routine advice, or require responses to specific questions such as: "What fishing areas/seasons will we have to close to the industrial shrimp fishery in order to reduce by-catch by 30%? What will this cost us in terms of reduced earnings and increased costs?"

I do not believe that a coordinated management framework for receiving assessment advice on the shared stocks of the Guianas-Brazil shelf is yet in place, so that a 'bottom-up' approach may be appropriate at this time, but not in the long term. Later in this report I suggest some ideas as to the structure for such a 'Management Authority' and its functions, which would support a 'top-down' management approach in which the assessment workers respond to options and questions posed by managers.

Incidentally, I distinguish between a 'bottom-up' management system as described above, and a management system where decisions are arrived at locally by fishermen and their communities, and passed up to the national level. This approach to management, which could be referred to as 'community-based' management, should be going on within the normal political-administrative structure of a country, but has less immediate relevance to the management system for shared international stocks, which should be coordinated at the governmental level (of course, with inputs from the fishing communities or sectors concerned).

BEFORE THE ASSESSMENTS BEGIN

Mapping, GIS and Surveys

In my view, a preliminary seasonal mapping of nursery areas and ports, research vessel survey results, and data on location of fishing areas by artisanal and industrial shrimp fleets, is of prime importance for providing a context for discussion at higher governmental levels. These maps or GIS systems, should also show migration routes of shrimp, and maritime boundaries, for what are

often shared stocks. Mutual recognition of the shared nature of resources should quickly translate at the political level into discussions on allocations of total catch, or preferably, allowable fleet size or fishing time on these resources by national fleets. Areas and seasons of interraction between artisanal and industrial fleets will need to be pinpointed, especially areas where high levels of valuable juvenile fish species are discarded. Such seasonal maps may provide the basis for seasonal and area restrictions to protect by-catch prone areas, and nursery areas for juvenile shrimp. It could also lead to a recognition of the importance of countries with nursery areas protecting them from excessive exploitation and effects of other human activities in an Integrated Coastal Area Management system.

The simplest approach to using this type of spatially differentiated catch/area and effort/area for groundfish is the composite production modelling approach. A more sophisticated way of modelling fishing grounds, fleets and ports may be a software such as SPATIAL, available from FAO.

Surveys are becoming a standard tool for obtaining unbiased data on abundance and distribution and should be included in the future assessment work in the region, since work elsewhere in the world has often foundered on the unreliability of catch reporting in ports; especially where discarding is intense. Another option is the regular use of observers on shrimping vessels, which is however likely to pose practical problems. It will be necessary in working with shrimping catches at sea, to develop a field guide for species caught in shrimp trawls, and to monitor changes in these catches by area and season and enter them on a data base.

A long-term charter of a shrimp vessel may provide the most cost-effective solution to work at sea, and could divide its time between test commercial fishing and scientific programmes and surveys. Its catches could be used for example to supplement charter costs, and to provide material for (e.g.) test marketing of by-catch species. Software such as NANSIS may be used to provide a first mapping of survey catches prior to developing a subregional GIS system (which is a high priority in my opinion).

A TOP-DOWN RESOURCE MANAGEMENT SYSTEM

Recent approaches to categorizing fisheries management systems (such as that included in the FAO Code of Conduct for Responsible Fisheries) point to the setting of objectives by the political authorities as the first step in deciding what the State wishes to obtain from the fishery, hence what options for exploitation rate need to be explored by assessment workers. This is what I mean here by top-down management. I am not familiar with any joint decisions by CARICOM that could guide the work of the Guianas-Brazil shrimp and groundfish group, but such

objectives need to be explicitly stated, since they result in different actions and end points which correspond to different rates of exploitation. Table 1 gives some common examples of management objectives for reference.

Management reference points

Recent experience has pointed out that the assessment team should spend some time attempting to develop reference points for resource management. Examples of these are given in a new technical paper by myself and Mahon, which I will send you. These are of two types:

a) Target reference points: the former favourite target was F(MSY), but this is now considered an unsafe target for reasons explained in the above technical paper. Others are F(0.1), f(2/3MSY), which can be found in Caddy and Mahon (in press).

b) Limit reference points: beyond this point (expressed as minimum biomass or fishing mortality rate, the fishery should not go).

Attempting to define appropriate levels of biomass and fishing or total mortality rate for targets and limits to exploitation, is one useful role of an assessment group.

Table 1: some fisheries objectives presented in simple terms.

OBJECTIVE	SYSTEM CHARACTERISTICS
Maximize sustainable yield (MSY)	Catch rates below that yielding Maximum economic yield, and costs of fleet and vessel operation are higher than at MEY. Possible impacts on finfish stocks caught with shrimp at shrimp MSY can be a serious decline. Employment levels depend on whether decision is made to favour small or large vessels.
Maximum economic yield (MEY)	Catch rates slightly higher that at MSY, and fleet size and effort levels lower. MEY for shrimp could still lead to somewhat higher than optimal effort levels on groundfish caought incidentally, but is generally ecologically less damaging than MSY.
Maximize levels of employment.	Generally this implies high levels of effort and economic inefficiency, but this can be mitigated if small scale vessels with hifgher crew sizes are used.It favours the small-scale artisanal fishery over industrial fleets, but does not necessarily imply low economic efficiency, since operating costs of small boats may be low, but may not earn the same level of foreign currency, although this may depend on infrastructure support. It can on the other hand, ead to diversification of fisheries products and reduction in waste and discards. If shrimp are exploited inshore by the small scale fleet, there may be losses due to predominantly small shrimp in the catch not reaching optimal size and unit price.
Maximize food production for food security	This may have similar results to the last objective since food production (of finfish) tends to be centred on artisanal and small industrial scale vessels. This objective may result in some losses of foreign exchange from exporting shrimp produced by industrial fleets, but such a conclusion should be supported by economic analysis.

COMPONENTS OF A FISHERIES MANAGEMENT SYSTEM

A/ Allocations

A management system involving a resource extending over more than one EEZ, or involving 2 or more national fleets sharing resources within an EEZ, will need to arrange negotiations on the relative levels of catches (or more feasibly in the circumstances), the number of vessels of known fishing power and capacity which each fleet can contain and still allow sustainable levels of exploitation to occur. There is little point in carrying out an assessment of TAC or sustainable overall effort level if an allocation of benefits cannot be achieved.

The data series that could support such a technical negotiation on allocations is precisely that which could be developed by a stock assessment group: namely, a mapping of the resource and fishing effort such as described earlier, estimates of the current state of exploitation, desireable targets for future exploitation rate and the ideal fleet sizes to achieve it, and historical data series of catch, effort and fleet size.

One basic component of such a management system is a common vessel registry system with vessel/gear operating information updated regularly (I provided you with a GFCM report on this for the Mediterranean). Negotiations on allocations (agreed fleet sizes, total capacity or total horse power of fleet) should procede at a high level once a good description of the fishery status has been arrived at, and could then lead immediately to agreements on some common elements for administration of the fishery (especially for CARICOM members) that do not contravene national sovereignty. With respect to one such priority, namely effort control systems, assessment workers may assist by measuring relative fishing power of the different vessel categories, and the relative changes in vessel numbers which need to be implemented to optimise exploitation.

B/ Managing shared stocks

Once agreement has been reached on the relative shares that can be take by each party from a common resource,(an issue that can only be achieved at the political level, and often only after prolonged negotiations), each party will have agreed to make their management systems, if not standardized, at least compatable. Arrangements will be necessary for regular exchange of standardized statistics, and a common and regular evaluation of the state of the stocks using standard methods. Any national monitoring control and surveillance systems on each side of national boundaries will need to be coordinated. Common or coordinated research programmes will need to be carried out in a coperative mode. All of these functions will be made more efficient if the fleets operating on the common resource within

their respective zones, come under the management control of a bilateral or multilateral commission or management authority with a management structure such as shown in the following figure. The different structure of the management authority followed in different parts of the world are outlined in an ICES report I published 2 years ago which I will send you.