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WESTERN CENTRAL ATLANTIC FISHERY COMMISSION

National report and selected papers presented at the fourth meeting of the

WECAFC AD HOC SHRIMP AND GROUNDFISH WORKING GROUP OF THE GUIANAS-BRAZIL CONTINENTAL SHELF AND CFRAMP SHRIMP AND GROUNDFISH SUBPROJECT SPECIFICATION WORKSHOP

Port of Spain, Trinidad and Tobago, 8-12 January 1996

Food and Agriculture Organization of the United Nations

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The work was accomplished under the guidance and supervision of the FAO/WECAFC.

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ABSTRACT

This publication assembles the seven national reports and technical papers presented at the Fourth Meeting of the WECAFC Ad Hoc Shrimp and Groundfish Working Group of the Guianas-Brazil Continental Shelf and CFRAMP Shrimp and Groundfish Subproject Specification Workshcp. Port of Spain, Trinidad and Tobago, 8-12 January 1996.

Nine technical papers dealing with biological data collection, the conceptual framework for shrimp and groundfish stock assessment, crustacean stock assessment techniques,the observer programme and the use of devices to avoid capture of undesirable species are included.

The papers are included in the language in which they were presented.

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National Report on the Shrimp & Groundfish Fisheries of Belize

Gilbert Richards[1]

DESCRIPTION OF THE SHRIMP FISHERY

INDUSTRIAL SHRIMP FISHERY

Fishing zones

The shrimp fishery of Belize is comprised of one fleet of inshore trawlers (The Industrial Fishery), and a small number of canoe fishermen who fish for shrimp in the southern waters of the country (Coastal Artisanal Fishery). The industrial fishery is regulated by an open season from 15 August - 14 April. Trawling occurs mainly along the south-central and southern reaches of the coast. The World Conservation Monitoring Center maps of fishing grounds for commercially important species in Belize show the shrimp fishing grounds (Figure 1). This is documented as one of the richest if not the richest area along the entire coast (Rath 1995). In his Marine Report for Natural Resources Management and Protection Project (NARMAP) Rath explained, "The area has numerous small river deltas, between which are small lagoons or beach ridge barriers. These rivers drain the Maya mountains carrying considerable nutrient materials and depositing it along the coastline."

This area is also bordered on the leeward side by mangrove marshes which are critical nursery habitats for shrimp.

Table 1: Characteristics and description of fishing grounds.

ZONE	DESCRIPTION OF AREA	SUBSTRATE TYPE	TOTAL AREA (km^2)	DEPTH RANGES
5	south-central region	n/a	2.46	20 - 30m
6	southern outlying region	n/a	0.66	30m +

Fleet

The industrial fleet is comprised of Gulf of Mexico type trawlers. They have in-board engines with an average horse-power of 365 (Cummins engines). The length of these vessels ranges from 33.2 - 36.4 meters. There are usually ten trawlers active, however for the 1995 season, only seven trawlers were active. The trawlers have a standard gear type, all are equipped with double outrigger shrimp nets, each boom having two nets attached to it. These nets are 40 ft. trawls that are retrieved by hydraulic winches. The vessels are Honduran owned and operate under a joint venture agreement between the trawler owners and Belizean fishermen cooperatives. The agreement allows trawlers to operate in Belizean waters with landings to be processed at and marketed by the cooperatives. Three cooperatives currently have such agreements with Honduran trawlers. They are National Fishermen Cooperative, Placencia Fishermen Cooperative, and Caribena Fishermen Cooperative. The landings of all three vessels are processed at National Fishermen Cooperative, as the other two cooperatives do not have processing facilities. The only other fishermen cooperative in Belize, the Northern Fishermen Coop, owns and operates two trawlers and processes its own landings.

[1] Fisheries Department, Princess Margaret Drive, Belize City, Belize, C.A.

Commercial trawling for shrimp in Belizean waters has only really developed over the past ten years. Concessions were originally granted to four trawlers which signed joint venture agreements with local fishermen cooperatives. Over the years the number of vessels has varied between 4-10 vessels. However, in 1995, several of the cooperatives, or cooperative members purchased trawlers. This initiative is encouraged by the Government under a general policy of increased local participation in the industry. In addition, it is anticipated that Belizean owners will be more receptive to implementing environmentally sound trawling practices. Four trawlers were bought by Belizeans, and concessions were granted to three others in 1995.

Fishing strategies

The trawler captains usually dock their vessels off the southern town of Dangriga. They leave from Dangriga every evening at about 5:00 p.m. and trawl until about 6:00 a.m. This activity continues on a daily basis for one month after which the catch is landed at the respective cooperatives. Vessels are fully equipped with sleeping and other amenities for the Captain and a crew of about 10 men. A condition of the license granted to each foreign owned vessel is a limit of six work permits for the hiring of a non-national crew.

During the open season, each trawler will have made approximately 7-8 trips. During a 12 hour trawling trip (5:00 p.m. in the evening until 6:00 a.m.), the vessel would average 3 trawls per net. As each vessel has two booms to which two nets is attached, each vessel completes approximately 12 hauls/night. Each trawling run lasts for about 4 hours.

Discards

From information gathered over the course of 1994, the quantities and types of discards were tentatively estimated. It was found that by-catch accounted for about 17% of the total landed catch. The fishermen identify drum and catfishes as the predominant by-catch. However, this information is anecdotal and the Fisheries Department is uncertain about other families that may comprise the by-catch. About 62% of all by-catch is discarded.

ARTISANAL SHRIMP FISHERY: FISHING ACTIVITIES

The Artisanal shrimp fishery is small. It is limited to fishing in the southern portion of the country, as is the industrial fishery. The fishermen generally take their catch home and sell it to neighbors that have previously requested shrimp. If they have a significant catch they may also land some of it at local markets in Dangriga, Punta Gorda, and Hopkins. It has been observed that this activity takes place in the rainy season. Particulars for this fishery in terms of zones fished and fishing grounds are similar to those of the industrial fishery. Similarly, nursery and spawning grounds are as outlined in the prior section. However, much of this information needs to be validated.

The fleet is made up of dug-out canoes and small wooden motor launches that are generally between 5-8 m ft in length. They are usually equipped with a small outboard (under 50 hp) and oars. A significant number of fishers use oars to reach the fishing sites. These sites are generally right in front of the towns or villages from which these fishermen set out to fish. Gear consists of cast nets with mesh size (measurement from knot to knot across the diagonal of the tightly stretched wet mesh) of 1.27 - 3.81 cm (½ - 1½ in). No further data (i.e. economic, catch, effort) are available for this fishery.

CATCH AND EFFORT STATISTICS AND ECONOMIC DATA ON THE INDUSTRIAL SHRIMP FISHERY

Landing and economic information is collected by the cooperatives on the industrial trawl fishery. These are totals from all the active cooperatives in the country. This was compiled for 1985-94 (Table 2).

PROCESSING AND MARKETING ACTIVITIES

There are two cooperatives located in the City of Belize; The Belize Northern Fishermen Cooperative, and the Belize National Fishermen Cooperative. These coops are the landing sites for the industrial trawl fishery. Table 3 outlines the grade categories used by the Cooperatives. Table 4 provides a description of the processing facility. The shrimp from the coop is processed, and packaged in 5 lb boxes.

Table 2: Compiled shrimp (trawl) statistics (US $1 = Bz $2.00).

YEAR	CATCH (LBS)	# OF TRIPS	TRIP TIME (hr)	CREW SIZE	COST /LB (BZ$)	TOTAL COST (BZ$)
1985	100,000	1.5	12	10	$7.00	$700,000
1986	235,000	"	"	"	$10.00	$2,350,000
1987	200,000	"	"	"	$10.20	$2,040,000
1988	250,000	"	"	"	$9.10	$2,275,000
1989	305,000	"	"	"	$9.10	$2,775,500
1990	230,000	"	"	"	$9.40	$2,162,000
1991	90,000	"	"	"	$9.00	$810,000
1992	105,000	"	"	"	$10.00	$1,050,000
1993	90,000	"	"	"	$9.30	$837,000
1994	42,000	"	"	"	$10.90	$457,800

Table 3: Shrimp categories utilized by the cooperatives.

GRADE CATEGORIES	COUNT PER POUND	GRADED CATEGORIES	COUNT PER POUND
1	10 - 15	9	46 - 50
2	16 - 20	10	51 - 55
3	21 - 25	11	56 - 60
4	26 - 30	12	61 - 65
5	31 - 35	13	66 - 70
6	36 - 40	14	71 - 75
7	41 - 45	15	76 - 80
8		16	80+

Table 4: Description of processing facilities.

PROCESS. INFO.	PLANT DESIGNATION	LANDED TYPE	GRADING SYSTEM	FREEZING CAPACITY. (Tons)	STORAGE CAPACITY (Tons)	ICE MAKING CAPACITY (Tons)	NO. OF WORKERS
Northern Coop.	Multi-purpose; Processes Shrimp, Conch, Lobster, Finfish.	De-headed & unsorted (Frozen in bags of about 60 lbs)	Manual Grading	35	45	15	50
National Coop.	Multi-purpose; Processes Shrimp, Conch, Lobster, Finfish.	De-headed & unsorted (Frozen in bags of about 60 lbs)	Grading Machine	75	100	40	40

On the local market, shrimp is sold from the coops to restaurants, hotels, and individual customers. Approximately 20 - 35% of the total catch for the year is sold in this way. Additionally, shrimp is sold from the markets by fishermen who are active in the artisanal shrimp fishery. The shrimp from the coastal artisanal fishery are sold whole and fresh.

Productions figures submitted by the cooperatives and compiled by the Fisheries Department indicate that 34,258 kg valued at US $413,000 were processed in 1995. Of this amount, 18,934 kg valued at US $228,050 were exported. Forty-five percent of the total production of trawled shrimp was consumed locally.

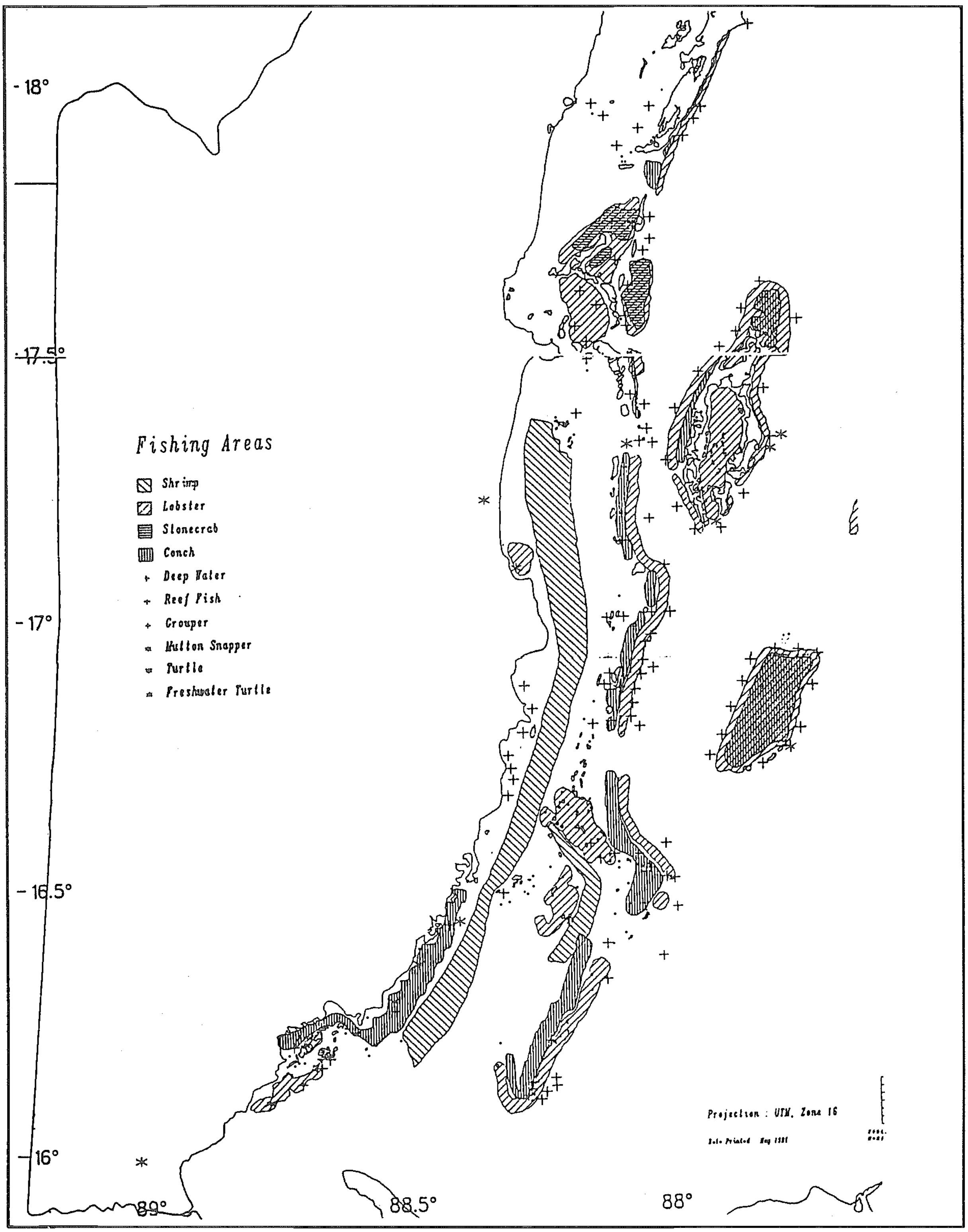

Figure 1: Shrimp fishing areas of Belize

National Report on the Shrimp & Groundfish Fisheries of French Guiana

Anatole Charuau[1]

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SHRIMP

SHRIMP FISHING ACTIVITIES

Fishing Zones

The entire French Guiana shelf, out to the slope, is harvested by shrimpers using various types of strategies. The seasonality seems to follow a pattern, but it is not exact. Log books are filled with great regularity, but no the data are not analysed.

There are many previous descriptions of the bottom which is primarily mud. The most important factor determining the fishing zones seems to be the migratory behaviour of the shrimps after they have left the rivers. Juveniles are concentrated at the mouths of the rivers and, according to the environmental factors, migrate from littoral waters out onto the shelf. That migration can be slow or quick, according to the salinity of the waters. The most exploited area is between 20 m and 90 m of depth. There is a regulation forbidding trawling inside 30 m.

Species and fishing activities

In the French Guiana EEZ, the main shrimp species exploited on the continental shelf is *Penaeus subtilis*, its landings representing nearly 95% of the total shrimp landings there. The second species exploited, *Penaeus brasiliensis,* is now considered a by-catch. There is no sorting of *P. brasiliensis* which usually constitutes the greater individuals of the shrimps. This fishery is controlled by a TAC system implemented by the EEC since 1985 (Table 1).

Table 1: Breakdown of the TAC and landings (in tonnes) from 1985-95

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995
RECOMMENDED TAC											
	a	a	a	a	a	3300	4000	b	4108	4108	4108
TAC											
EEC	1150	2000	2740	3300	4040	3800	4000	4000	4000	4000	4000
USA Japan	?	?	?	?	?	?	0	0	0	0	0
ACP Countries	190	294	238	108	108	108	108	108	108	108	108
Total	4000	3650	4300	4680	4810	4100	4100	4100	4108	4108	4108
LANDINGS											
U.S.A.	1639	1817	1550	1864	928	450	0	0	0	0	-
Japan	874	843	0	0	0	0	0	0	0	0	-
France	599	1073	2685	2392	2776	3477	3314	3987	3275	4125	-
A.C.P.	0	0	0	0	0	0	0	0	0	0	-
Total	3112	3733	4235	4256	3704	3927	3314	3987	3275	4125	-
Recommended TAC: (a) 4000 to 5000t, (b) 3700 to 4800t.											

[1] IFREMER, Cayenne, French Guiana

A fishery for deep water shrimps also exists on the shelf slope for *Solenocera acuminata* (200m depth) and for *Parapenaeus edwardsianus* (700m depth) (Table 2).

Table 2: Fishing effort, landings (tonnes) and catches per unit of effort (kg/day) for the slope of the shelf fishery over the period 1988-94.

	1988	1989	1990	1991	1992	1993	1994
Fishing Effort (days)	365	531	620	1457	1050	735	510
Solenocera accuminata							
Landings (tons)	98.7	142.9	166.9	80.5	73.5	17.3	55.2
CPUE (kg/day)*	267.9	269.1	269.2	55.25	70.0	23.5	108.2
Parapenaeus edwardsianus							
Landings (tonnes)	52.2	41.3	34.3	258.5	159.2	140.3	54.0
CPUE (kg/day)*	143.0	77.7	55.3	177.4	151.6	190.9	105.9
*Average yearly CPUE							

There is no special fishery for seabob (*Xyphopenaeus kroyeri*) although the resource seems to be very important. Only some fixed fisheries exist in the estuaries and their production is sold on the local market.

When the shrimpers are very close to the coast, Catches of seabob are customary, but these shrimps, especially if they are "headless" are considered as *P. subtilis*. The sea-bob is an important potential resource but due to the ban on fishing inside the 30 meter isobath, the resource is currently unexploited.

Fleets

From 1992, the TAC on *P. subtilis* has been complemented by a local licence system fixing the maximum number of trawlers allowed to exploit the stock. These are 72 in 1992, 70 in 1993 and 1994 and 68 in 1995 (Table 3). The nationality of the boats exploiting the shrimps in the waters of the French Guiana is exclusively French.

Table 3: Shrimp fishing activity over the period 1985-94.

	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994
Registered trawlers*	74	78	69	73	79	77	69	71	70	68
Average monthly active trawlers	74	78	69	73	79	60	53	54	54	46
Landings (tonnes)	3112	3733	4235	4256	3704	3927	3314	3987	3275	4125
Fishing effort (days)	22846	23553	20551	21430	22494	18854	14524	15783	15421	14694
CPUE (Kg/days)**	136.2	158.5	206.0	188.6	164.6	208.3	228.2	252.6	212.4	281.9
* Number of trawlers registered by the French Maritimes Affairs in Cayenne. ** Average yearly CPUE of *P. subtilis* and *P. brasiliensis*.										

From 1979 to 1990, that fishery was exploited by French, US and Japanese companies. Production of the various species of shrimps was exported headless to the USA and Japan. After the implementation of the fishery under the French flag due to the extension of the EEC area, new trends were observed in the markets and a demand was registered from European countries for whole shrimps of small sizes (Figure 1), in addition to big sizes, but always whole.

That market induced a change in the habits of shrimp-trawlers and during the second half of the year, the juveniles are exploited in the shallow waters (Figure 2). Due to the recent fluctuations on the international market a decrease of the demand was observed with a correlative decrease of the effort of the French fleets from 1990 (Table 3), from 22500 days at sea in 1989 to 15700 in 1994.

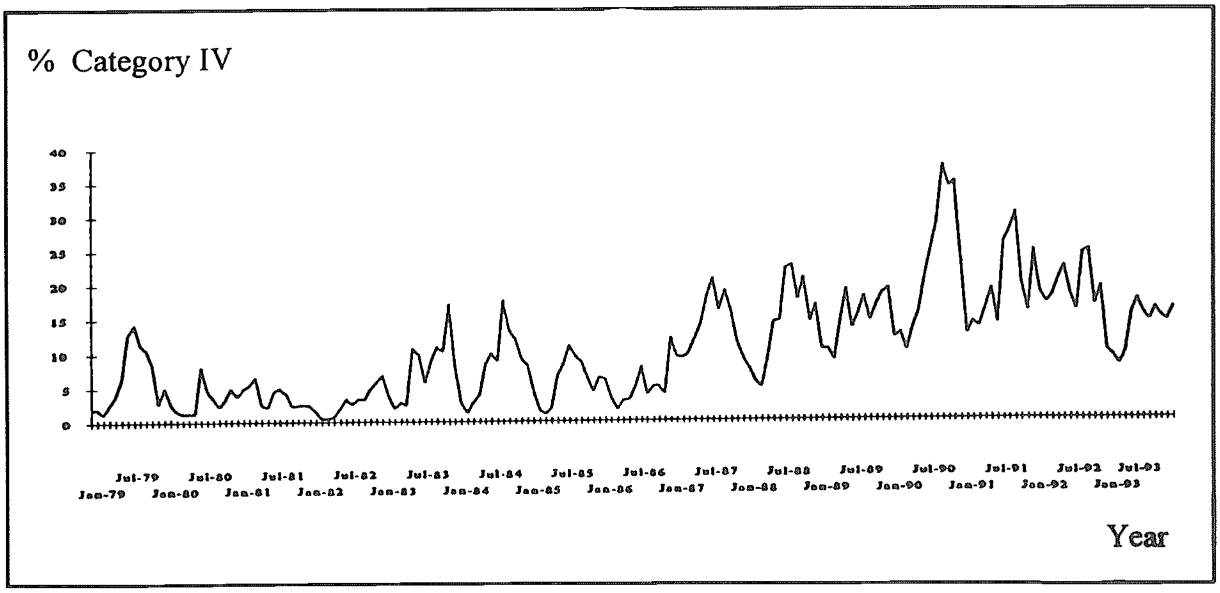

Figure 1: Percentage of the smallest commercial category in the monthly catches over the period 1979-93.

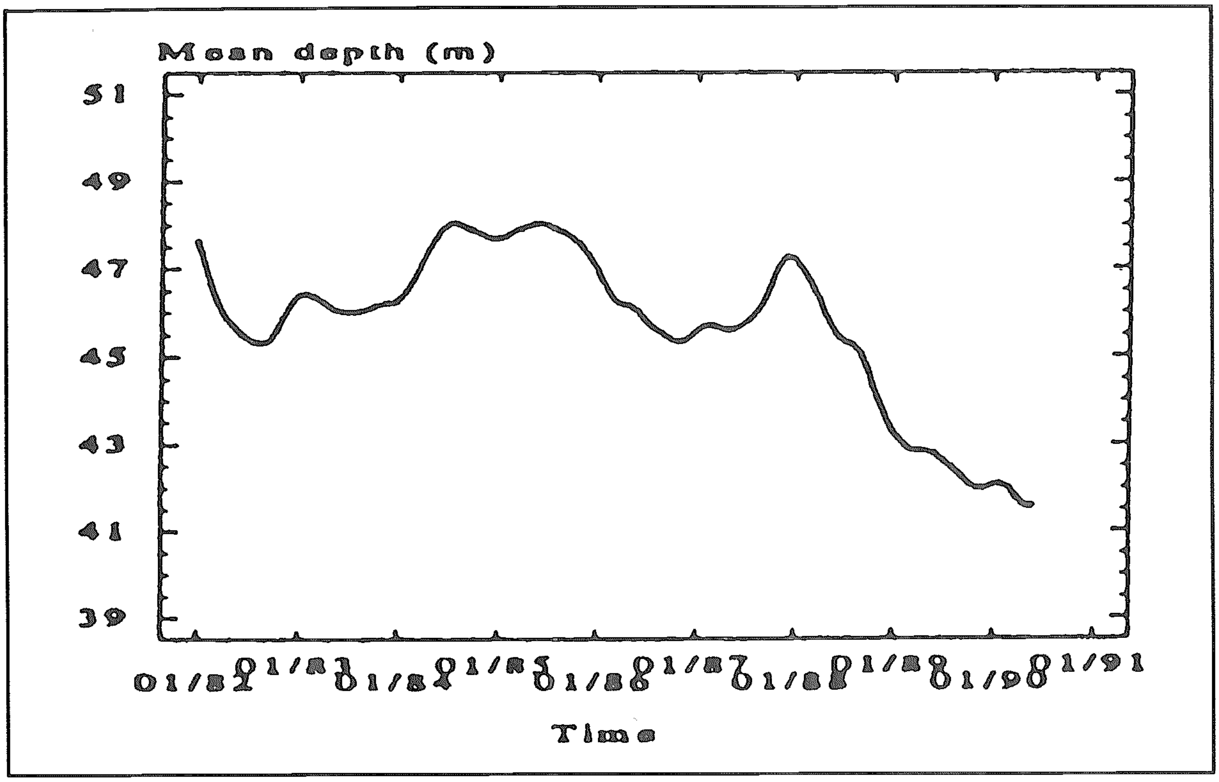

Figure 2: Annual tendency of the depth in the fleet activity.

Fishing strategies

From 1983, the fishery statistics are not reliable and cannot be used to analyse the fishery. This is mainly due to a change in the habits towards the size of the researched shrimps. Fishing is forbidden in the coastal waters, however many skippers do not observe that ban. Instead they do not enter all the details of their trips into the log books.

There are no data on the by-catch caught with the shrimps. And even if a part is frozen on board, the quantities landed are not known, because they are not registered but go directly into the local market.

The problem of fisheries statistics is due mainly to the will of the fishermen organizations, and has important consequences. All the shrimps are processed at sea and packaged frozen. Biological samples are made only on the boats which process in the port. Only two companies process in a factory, so the sample program covers only those boats. As the log book data for the other boats is unreliable, it is very difficult to extrapolate the basic sampling to the total fleet.

Market

There is no local market for the shrimps. They are exported in their entirety to Europe. Only seabob is sold very rapidly locally after being caught in the fixed fisheries. But as there is an interdiction on the use of these gears with no possibility to transmit them to the lineage, it is likely that they will disappear in the next years

ASSESSMENT OF THE SHRIMP RESOURCE

No assessment of the resource is available. Many trials were made in the past with global modelling, taking into account the activities of the trawlers on the whole Guyana-Brazil shelf, and analytical models were tested on length-compositions. The assessment of *P. subtilis* is currently impossible due to lack of knowledge about the biological parameters. Growth and natural mortality are not known, and even if they were know, annual estimates would remain an important parameter.

The duration of the life of the shrimp is very short, probably 18 to 24 months, and new recruits predominate in the water in the following months. Many attempts have been made to develop a reliable recruitment index.

The first way to have *a qualitative view of the phenomena* to describe the biological event. The second way to try to give *a description and a quantification of the numbers of larvae occurring in the estuaries of the rivers*. The third way to *model recruitment using environmental factors*. These attempts are summarized in the paper on recruitment (this volume).

The TAC applied in the fishery is a precautionary TAC and has no scientific basis. However, it is likely that the assistance of UE within the framework of the plan for ultra-peripheric regions is an important incentive to fish the whole TAC, even if the target is small shrimps. At the moment, the most important problem for that fishery is the absence of reliable statistics. Also, it is impossible to carry out a fleet analysis according to the categories of shrimps targeted and areas harvested.

FISHES

SNAPPERS

It is likely that the shrimp fishery and the demersal fishery are related. Previous observations show that small snappers are caught in the shrimp fishery. Due to the difficulties experienced in freezing these fishes, most are discarded at sea. No data are available on these discards. There are three main species: lane snapper (*Lutjanus synagris*), vermilion snapper (*Rhomboplites aurorubens*) and red snapper (*Lutjanus purpureus*). Only the latter is of real commercial interest. It is the target for Venezuelan hand-liners. As for shrimp-trawlers, a license system has existed for Venezuelan boats since 1985, with a reserve for ACP countries (Table 4). They are obliged to land 75% of their catch in French Guiana. Licences are only issued however if the shipowner has a contract with a processor in French Guiana. For that fishery, only lines and pots are authorized.

The fishing effort (Table 5) which was reduced in 1991, seemed to be stable from 1991 to 1994; close to 35,000 hours per year. The landings which also seemed to fall in 1991 and 1992 are now increasing slowly. Moreover, an analysis of the yields by stratum of depth shows that the fleet is now optimizing its strategy and is fishing now in the eastern part of the fishery and towards deeper areas (90-120 m). In 1993, the yields obtained in the usual area increased.

Table 4: Numbers of licences granted every year, from 1985 to 1994

	VENEZUELA	ACP COUNTRY: (BARBADOS)
1985	25	5
1986	20	5
1987	25	5
1988	25	5
1989	35	5
1990	35	5
1991	35	5
1992	41	5
1993	41	5
1994	41	5

Table 5: Activity of the Venezuelan fleet in the EEZ of the French Guiana from 1989 to 1993.

YEAR	MEAN MONTHLY NUMBERS OF			TOTAL FISHING EFFORT IN HOURS	LANDINGS (tonnes) IN FRENCH GUIANA	CPUE IN KG/HOUR
	BOATS	TRIPS	FISHING DAYS			
1985	7	8	102		295	
1986	9	12	230	12508	490	45.8
1987	10	15	238	27077	519	21.2
1988	13	19	378	24761	.808	33.1
1989	20	33	330	42587	989	22.4
1990	18	24	337	39118	925	23.1
1991	20	29	337	36703	807	22.1
1992	18	27	390	35760	867	23.8
1993	19	30	328	35075	1001	26.6
1994	20	31	360	35664	1063	28.3

The fleet seems to be well adapted to the fishery. In 1993 and 1994 levels of effort decreased slightly while production and CPUE increased.

COASTAL FISHERIES

The artisanal system, in contrast to the companies system on the shrimp fishery, is developed to exploit the inshore resources. The structure of the fleet is heterogenous, complex and adapted to the variability of the environment. The diversity of the species and the variations of their seasonal abundances, access to resources, costs of production and adaptability to the markets are the main factors which are conditioning the activities of these fleets. Nowadays, it is easy to collect the physical characteristics of the boats (Table 6) but difficult to have even a small idea of the species composition of the catch and the level of discards. A fleet analysis is now in progress and will indicate homogeneous groups of boats within which sample the catch.

These boats are fishing inside the 10 metre bathymetric zone, but it is likely that there are, even in these very coastal areas, interactions with the industrial shrimpers. In the coastal zones, the activities are seasonal and exclusively target fishes with gill-nets. These fleets operate within areas with relative low salinity and in the estuaries. The problem with this fishery is that there is no real abundant stock or the size of the fishes is too small to be used by the fish processors

It is likely that present production is not representative of the real potentialities of the area and in many cases fishing is a subsistence activity. The fishermen operating in the small-scale fishery are always foreigners; Brazilians, Surinamese and Haitians.

Table 6: Characteristics of the boats, of the gears and of the activity in the coastal fishery.

	CANOT CRÉOLE	C. CRÉOLE AMÉLIORÉ	CANOT INDIEN	PIROGUE	TAPOUILLE	BARGE	AUTRES
CHARACTERISTICS OF THE BOATS							
Number	79	11	15	16	9	5	9
Mean length in m	8	10	8.5	8	11.5	6	6.5
Mean age in years	7	8	6	8	8	2	7
Mean width (m3)	3.5	14	5	1.5	15	2	5
Power (ch)	50	75	30	30	90	90	45
GEARS							
Mean Sounding (m)	8	5	4	4	8	8	6
Mean length of the gill-net (m)	2600	850	350	550	2500	1250	450
ACTIVITY							
Activity (month)	8	6	8	6	7	5	4
Number of trips per day	3	3	3	3	3	3	2
Duration of trips (hours)	6	5	4	5	5	2	5

National Report on the Shrimp & Groundfish Fisheries of Guyana

Reuben Charles[1] and Dawn Shepherd[1]

BACKGROUND

Guyana, on the northern coast of South America, is the only English-speaking country on the South American continent. It has an area of 83,000 sq miles (215,000 sq km) and is bordered by the Atlantic Ocean on the north, Brazil on the south, Venezuela on the west and Suriname on the east. Geographically, Guyana is a part of South America, but it is culturally and socially more affiliated to the Caribbean, and it is an integral member of CARICOM. Guyana has a population of approximately 755,000, which represents one of the lowest population densities in the world. Most of the population lives on the coastal plain.

The country is divided physically into four regions; the Low Coastal Plain, the Hilly Sand and Clay Area, the Highland region and the Interior Savannahs. Administratively, the country is divided into ten regions (Figure 1) Marine fishing occurs in six of those regions, namely regions 1 to 6, with all of the industrial vessels having their operational base in region 4, and regions 4 and 6 having the largest number of artisanal vessels. Guyana has a 200 mile EEZ and a territorial sea with a limit of twelve miles from the shore.

DESCRIPTION OF THE FISHERIES

The Fisheries Sub-Sector of Guyana is made up of three primary components, each with further sub-divisions as follows:

a. Marine Fishery
   i. Industrial Trawl Fishery
   ii. Small-Scale Artisanal Fishery
b. Inland Fishery
   i. Subsistence Fishery (for food)
   ii. Ornamental Fish Fishery
c. Aquaculture
   i. Brackish-water Culture
   ii. Fresh-water Culture

MARINE FISHERY

Exclusive Economic Zone

The Maritime Boundaries Act 1977 established a Fishery Zone beyond and adjacent to the Territorial Sea (12 miles) and bounded on its seaward side by a line, every point on which is two hundred miles from the nearest point of the baseline of the territorial sea. On 23 February 1991, the zone became recognized as an Exclusive Economic Zone (EEZ) when the President of Guyana promulgated an order known as the

[1] Fisheries Department, Guyana

Exclusive Economic Zone (Designation of Area) Order 1991, acting under the provisions of Section 15 of the Maritime Boundaries Act, 1977.

Guyana has a coastline of 432 km and a continental shelf area of 48,665 sq km. The average width of the continental shelf is 112.6 km. The area of the EEZ is 138,240 sq km. The living resources being exploited within the EEZ are mainly the demersal fishery resources, and to a limited extent, the pelagic fish resources over the continental shelf and towards the continental slope.

Industrial Fishery

The industrial fishery consists of 117 trawlers, four major fish/shrimp processing plants and numerous wharves and dry docking facilities. Ice and freezing facilities servicing this fishery are owned and operated by participants within and outside of the fishery sub-sector. The trawlers are 51.3 percent foreign owned. Foreign trawlers mainly exploit prawns (*Penaeus* spp.) with finfish as by-catch while locally owned trawlers mainly exploit seabob, *Xyphoprenalus kroyeri,* and finfish. These trawlers average about 21 meters in length and use double outrigger shrimp trawl nets and operate in waters 18 to 91 meters in depth over the sea bed of mud, gravel or sand. Also, there are six stern trawlers which measure about 16 meters in length and which should fish in waters ranging from 14 to 30 meters deep for finfish.

Government's direct involvement in the industrial fishery is represented by Guyana Fisheries Limited, which has leased its facilities to private companies engaged in fishing activities.

Small-scale Fishery

The artisanal or small-scale fishery consists of approximately 1240 vessels ranging from 6 to 18 meters in length, and propelled by sails, outboard or inboard engines and using gear that include Chinese seine (a fyke net), pin seine (beach seine), caddell, drift seine and circle seine (modified gillnets). The largest vessels have ice boxes and go on fishing trips up to 18 days, while smaller vessels have no ices boxes and their operations are either tidal or diurnal. Except for the large handliners and drift seiners which may or may not be decked, most artisanal vessels are flat-bottomed dory type with little draft, which affords great manoeuvrability over shallow muddy and sandy bottoms.

There are about 4,500 small-scale fishermen and of these about 1,000 are boat owners. Sixty to seventy percent of the boat owners are members of Fishermen's Cooperatives (13 in all) which acquire and sell fishing requisites to their members (FDR, 1994).

The development of onshore infrastructure (wharves, ramps, workshops, fuel depots, requisite shops, ice machines and storage bins, and fish storage bins) at eight sites along the coast for this fishery, financed by government, with assistance from CIDA and the EEC, has been completed. Five of these complexes have been leased to the fishermen's cooperatives within whose boundaries they fall for management and operations. Poor management, narrow vision and lack of capital hinder the operations of these complexes (Charles, 1994). Joint venture arrangements have been proposed for the remaining three complexes.

INLAND FISHERY

Subsistence Fishery (For Food)

This fishery involves the catching of fish in rivers, lakes, canals, flood plains, etc., by subsistence or part-time fishermen for their own consumption or for sale. The activity tends to be influenced by the season and in some areas by the down periods for agricultural and other activities. For example, in the sugar estate areas the intensity of activity varies with the harvesting of sugar cane and rice. Small, flat-bottomed, long-type vessels and cast nets, seine or handlines are used in the exploitation of the fish.

Ornamental Fish Fishery

There is a small, but active trade of ornamental fish. Live fish are caught in the upper reaches of the rivers by collectors and brought and sold on the coast to six exporters of ornamental fish. The fish are exported mainly to the U.S.A.

AQUACULTURE

Brackish Water Culture

Brackish water culture occurs mainly in the brackish water swamps along the Atlantic Coast in Corentyne, Berbice. Sixty-four farms, including two registered fish culture cooperatives, utilize approximately 670 ha of coastal lowlands in what can be described as controlled exploitation of coastal swamps for a variety of fin-fish and shrimp species. The average size of a farm is 11 ha.

Utilizing tidal inflows of high tides, juveniles, larvae, eggs, etc. are trapped in the coastal empoldered swamps and allowed to mature to marketable sizes. In 1987, it was estimated that 91 mt of fish and shrimp were harvested from 400 ha of these swamps (FDR, 1994).

Freshwater Culture

The main freshwater species cultured in Guyana are *Oreochromis mossambica, Oreochromis nilotica* and, to a limited extent, *Hoplosternum littoral*.

This type of culture produced an estimated 34 mt of fish in 1987, from about 115 ha of ponds. The major producer is the Guyana Sugar Corporation Ltd, a parastatal sugar producing company, with about 40 ha of production ponds. Some schools and individual subsistence farmers are also involved.

DESCRIPTION OF THE INDUSTRIAL SHRIMP FISHERY

FISHING ACTIVITIES

Fishing Zones

For statistical purposes the fishery zone has been divided into fishing zones, which are defined according to the degrees of longitude within which they lie, with each zone being separated from the other by an interval of 30 degrees. The fishing zones range from one to nine. (Figure 2). The vessels targeting prawns (*Penaeus* spp) would generally fish at distances ranging from 40 to 145 km from the shore, at depths ranging from 18 to 91 meters, usually on mud and sand substrates. On the other hand, the vessels targeting seabob/finfish tend to fish much closer to the shore at distances ranging from 15 to 30 km offshore, at depths of 13 to 18 meters, also on sand and mud substrate (FDR, 1994).

Seasonal Shifts of Fishing Activity

During the first two months of the year, the water and the winds are very high and the seas rough, and only part of the fishing fleet works during that period. It should also be noted that during the period November to March, the catch rate for large penaeids decreases, and the vessels may be drydocked for maintenance, primarily during the first two months of the year.

Nursery and Spawning Areas

At some times of the year, some species of juvenile prawns are caught along the shoreline and in mouths of rivers, in water 33 meters (18 fathoms) or less, but no data is available on where actual spawning actually takes place.

Fleet(s)

In 1995, the industrial fleet was comprised of 117 trawlers of which 60 were foreign owned and the remaining 57 were locally owned. Of the foreign-owned trawlers, 54 belong to the Georgetown Seafoods Company and six belong to the Guyana Shrimp Operation Limited, formerly Nisshin Suissan KK.

All of the 60 foreign owned trawlers, along with seven locally owed trawlers, were licensed to catch prawns. The remaining 50 trawlers were licensed for seabob/finfishing. Of those, 28 were operative and 22 were inoperative. Almost 50% of the local trawlers have not been operational nor have they been licensed for a number of years. That situation ensures that less than 30 local trawlers are engaged in the seabob/finfish operation. See Tables 1a and 1b for details.

Table 1a: Composition and evolution of the industrial fleet engaged in the prawns and seabob/finfishing operation for the period 1986 to 1991.

YEAR	NUMBER OF FOREIGN TRAWLERS		NUMBER OF LOCAL TRAWLERS	NUMBER OF FOREIGN TRAWLERS
	AMERICAN	JAPANESE		
1986	61	12	55	128
1987	61	12	56	129
1988	61	12	46	119
1989	61	9	48	118
1990	61	9	52	122
1991	61	6	48	115
(Fisheries Department Records)				

Table 1b: Composition, evolution and nationality of the industrial fleet engaged in the prawns and seabob/finfishing operation for the period 1992 to 1995.

YEAR	TARGET OF FISHING OPERATION	NUMBER OF FOREIGN TRAWLERS		NUMBER OF EXISTING LOCAL TRAWLERS	SUB-TOTAL	TOTAL NUMBER OF TRAWLERS
		AMERICAN	JAPANESE			
1992	Prawns	61	6	18	85	120
	Seabob/Finfish	0	0	35	35	
1993	Prawns	53	6	15	74	114
	Seabob/Finfish	0	0	40	40	
1994	Prawns	54	6	6	66	117
	Seabob/Finfish	0	0	51	51	
1995	Prawns	54	6	7	67	117
	Seabob/Finfish	0	0	50	50	
(Fisheries Department Records)						

NB i. Twenty-seven and twenty-two of the locally owned (private) trawlers licensed in the past to do Seabob/Finfishing were inoperative for the years 1994 and 1995 respectively. ii. The six stem trawlers which have been leased to Marine Food Products Ltd by the GOG are not included.

The Fishing Companies and Their Vessels

The Major fishing companies and the number of vessels owned by each are listed in Table 2.

Vessel Characteristics

Trawlers are standardized Gulf of Mexico type trawlers, with steel hulls and basic equipment such as compass, radio, direction finder, fathometer, (no fish finding gear) and are fitted for a three or four man crew.

An American owned trawler is on the average 20.4 meters (67 feet) in length, while a Japanese owned trawler is of a standard length of 19.8 meters (65 feet), and a local trawler ranges from 19.8 to 22.9 meters (65 to 75 feet).

The Fishing Gear for Each Type of Vessel

The industrial vessels normally use jib trawl nets, with stretched mesh size ranging from four to five cm in the wings and 2.5 to 3.5 cm in the cod end, whether exploiting prawns or seabob/finfish. (FDR, 1994)

Prawn trawlers may use one or two nets on each side of the vessel. When fishing with two nets, the head rope length of each net is 13.7 to 16.8 meters (45 to 55 feet); with four nets, the head rope length of each is 9.1 to 10.7 meters (30 to 35 feet).

The prawns nets usually have a tickler chain which drags along the bottom, stirs up the substrate, and causes the prawns to jump up and get caught in the nets. There is also a trynet or sample net, which is a net of smaller dimensions than the normal net. It is towed for ten or thirty minutes to test the area for abundance of shrimp. The Japanese owned vessels fish with two to four nets, each of length 13.7 meters (45 feet), and a stretched mesh size of 3.8 cm (1.5 inches), while the American owned vessels would generally use four nets. The seabob nets are essentially the same as the prawn nets, but they have no tickler chains (personal communication).

Table 2: Major fishing companies and the number of vessels each owns.

FISHING COMPANY	NO. OF TRAWLERS
Georgetown Seafoods & Trading Company Ltd	54
Noble House Seafoods	18
Guyana Shrimp Operation Ltd	6
Industrial Fishing Investment Ltd	1
Floss Fishing Company Ltd	3
Romar Company	2
Maurice Gopie Fishing Company	2
Ramroop Fishing Enterprise	2
B. Meghan	2
H. Dharmo & Chetram	2
R & R International	2
Interstate Marketing	1
Winston Rambarran	2
Clarke & Beepat	1
Others	19
Totals	**99**

NB In addition to the companies listed above, there are 19 other private owners/companies each having one vessel. (Fisheries Department Records).

Fishing Strategies

The American owned trawlers generally make eight trips per annum, with each trip lasting approximately 36 days. They make two to four drags a day a day, with each drag lasting between four and six hours. The shrimping operation is carried out mainly at night, with some shrimping being done during the day, mainly for the white shrimp (*P. schmitti*), which is more easily caught during the day.

The Japanese trawlers usually make six to eight trips per annum, with each trip lasting approximately 42 days. The shrimping operation is carried out predominantly at night, and occasionally during the day, and is concentrated in zones four, five and six, and infrequently in zone three. The daily number of drags is generally three to four, with each lasting five to six hours.

The **local prawn trawlers** average eight trips per annum, each trip being of 30 days duration. The operation is carried out day and night (but mostly at night), with an average of three to five drags per day, and each drag lasts four to six hours (Fisheries Department Records).

The **seabob trawlers** average 30 trips per annum. They fish in waters 13 to 18 meters deep, at distances between 15 to 30 km from the shore. Trips lasts approximately seven days, but range from five to nine days, with an average of six drags per day, each drag lasting three to four hours (Personal communication).

Discards

No prawns or seabob are known to be discarded at sea. The trawlers licensed to fish for prawns are required to land 1818 kg (4,000 lbs) of finfish per trip as by-catch (14,545 kg or 32,000 lbs/annum). However a significant amount of the smaller sized and juvenile fishes of the finfish by-catch are discarded at sea. Prawns trawlers use freezers to store the prawns catch, and the addition of larger quantities of finfish causes the temperature to rise significantly for some period. That fluctuation in temperature causes deterioration of the prawns and reduces their market value, so the prawns vessels tend to retain as little finfish as possible. The major by-catch species are bangamary, butterfish, croaker and sea trout. On the other hand, the seabob trawlers use ice to store their catch and thus retain as much finfish as possible.

Fishing Activities of the Artisanal Shrimp Fishery

In the artisanal fleet, the Chinese seine (fyke net) vessels capture seabob and whitebelly shrimp (*Nematopalaemon schmitti*), along with finfish such as bangamary, butterfish, cuirass, rockhead bashaw, catfish and some seatrout. That type of seine is funnel shaped and is four to six meters wide at the mouth end. The mesh size increases gradually from the funnel end to the mouth end - the range is usually 1-8 cm. The Chinese seine vessels are usually smaller, 5.49 to 8.53 meters (18 to 28 ft) than the other types of artisanal vessels and are equipped with sails or small outboard engines. They work according to the tide and make daily trips lasting from six to twelve hours (FDR, 1994).

Results of a 1994 artisanal frame survey[2] showed a national total of *253 Chinese seine vessels, with the largest concentration of vessels in Regions 4 and 3. Within Region 4 itself, the Better Hope landing site had the largest concentration of those vessels (over 50), followed by the Houston landing site.

PROCESSING ACTIVITIES

Industrial shrimp processing

The major processing companies are as follows:

[2] The 1994 artisanal frame survey was to some extent incomplete, and the true total number of artisanal vessels is closer to 1240 vessels overall.

i. Georgetown Seafoods and Trading Company Ltd. (GS&TCL), which processes the catch from its fleet of 54 vessels.

ii. BEV Processors, which does not own any vessels but buys and processes the catch (shrimp and finfish) from the local seabob vessels. They also buy and process seabob and finfish from the artisanal vessels.

iii. Marine Food Products Ltd (MFPL), which processes the catch for the Japanese from their fleet of six vessels. However, finfish, which MFPL purchases from the artisanal vessels at the Unity & Lancaster landing sites, is the major item processed.

iv. Noble House Seafoods (NHS), which owns 18 vessels - their original eight vessels plus the ten acquired in 1994 from the Guyana Libya Fishing Company, which closed down its operation. Those ten vessels are all inoperative to date, but when last operated, they were licensed to catch prawns. NHS anticipates that when they become functional, they will be permitted to target seabob/finfish. At present, NHS processes the catch from its operational fleet of eight vessels and some local vessels.

The approximate aggregate volume of prawns (tail weight) processed per annum by the major processing companies were as follows:

1992 - 3,160,244 lbs

1993 - 3,406,439 lbs

1994 - 3,251,398 lbs

The approximate aggregate volume of seabob processed per annum by the major processing companies were as follows:

1992 - 10,310,519 lbs

1993 - 10,258,247 lbs

1994 - 9,235,282 lbs

The only type of shrimp processing that takes place on board is the decapitation of the prawns (penaeid species). All other types of processing (peeling, deveining, etc.) takes place at the plants.

Artisanal Shrimp Processing

The artisanal seabob and whitebelly catch is processed by both the industrial and cottage processors, and a significant quantity is sold fresh on the market.

Table 3: Number of vessels landing by type (shrimp/seabob/finfish) at major processing plants.

PROCESSING COMPANY	NUMBER & TYPE OF VESSELS LANDING		TOTALS
	SHRIMP	SEABOB	
Georgetown Seafoods	54	0	54
BEV Enterprise	0	20	20
MFPL	6	0	6
Noble House Seafoods	0	8	8
Totals	**60**	**28**	**88**

(Fisheries Department Records)

MARKETING FOR THE INDUSTRIAL AND ARTISANAL SHRIMP FISHERIES

Types of Shrimp Products Sold, Sizes, Quality, Approximate Volume, Prices

Local Market

The types of shrimp products sold on the local market are:

i. Unpeeled/unprocessed seabob and whitebelly

ii. Peeled seabob and whitebelly

iii. Small quantities of prawns (to restaurants and supermarkets).

The quality of the products sold is generally fair to good.

Table 4: Average wholesale and retail prices of shrimp products.

PRODUCT	RETAIL PRICE (G$)	WHOLESALE PRICE (G$)
Seabob (unpeeled)	72	29
Seabob (peeled)	99	N.A.
Whitebelly (unpeeled)	41	18
Whitebelly (peeled)	81	N.A.
(Fisheries Department Records)		

Export Market

Table 5: The types of products exported and their approximate volume.

PRODUCT	VOLUME/YEAR (mt)	
	1993	1994
Prawns	1630	1483
Seabob & whitebelly	1215	1398
Dried shrimp	24	10
Finfish (frozen)	2720	2992
Finfish (fresh)	0	177
(Fisheries Department Records)		

The majority of the prawns is exported to the U.S.A. and Japan, with a smaller quantity going to CARICOM countries.

FISHERY ASSESSMENT

CATCH & EFFORT

The CPUE data available are basically the catch per vessel in the case of the American and the local trawlers and aggregate fleet catch for the Japanese vessels. The CPUE is relatively high from March to October compared to November and December.

Table 6: Total annual prawns catch per fleet per annum.

YEAR	VOLUME OF CATCH PER ANNUM (mt)		TOTALS (mt)
	FOREIGN	LOCAL	
1992	1383.45	97.85	**1481.3**
1993	1446.55	373.96	**1820.51**
1994	1417.03	472.69	**1889.72**
1995	*1241.95	*N.A.	***1241.95**
Totals	**5488.98**	**944.5**	**6433.48**

NB: * The figure shown for the year 1995 represents catch from January 1st to August 31st only.

There is some debate as to whether the large disparity in the 1992 and the 1993/1994 catch for the private vessels results from the inflation of catch figures.

Table 7: Number of landings of prawns trawlers.

Year	Foreign Landings
1993	487
1994	475
Totals	962

With respect to the foreign fleet, the average catch per vessel per trip for the year 1993 was 2.97 mt and 2.98 mt for the year 1994.

Description of Seasonal Trends

Data for the year 1991 indicates that for the prawns fleet, vessels operated in fishery zones one to six in January, moving gradually eastward to zones four to eight in April, and returning to zones one to seven in May. In June, July and August they operated in fishery zones one to eight, shifting to fishery zones two to six from September to November, and three to eight in December. That differs somewhat from the early 1980s when fishing was concentrated to the east of fishery zones five to nine. (FDR, 1994)

For the seabob fleet, vessels operated in fishery zone four in January, moving gradually east to zone five in March and six in April. They returned to zone four in May and fished there until August, after which most fishing is finished for the year, with the exception of a small amount of fishing effort in zone four in the month of November. (FDR, 1994)

ASSESSMENT OF THE RESOURCES

Penaeid Shrimps

Data are available on the overall weight per size-category, but there are no data available on the number of individuals per size-category nor on the mean weight of individuals per size-category per species. There are also no data available on the length composition of individual species.

Nurseries

Few data are available. At certain times of the year, some species of shrimp tend to come in closer to the shore in waters 18 fathoms or less, where the nurseries are presumed to be located. It is also thought that the mangrove areas serve as nursery areas for the shrimp species.

Recruitment

It should be possible to obtain some information on population density and recruitment by summarizing and analyzing the industrial log sheet data which is submitted to the Guyana Department of Fisheries.

EVALUATION/SUMMARY OF ASSESSMENTS CARRIED OUT TO DATE & OTHER PROGRESS IN THE KNOWLEDGE OF THE RESOURCES

Penaeid Shrimp

Few data are available. However, based on the steadily declining prawns production over the years, it is thought that the prawns resource is being fished at or above its maximum sustainable yield. One management initiative that has been implemented in response to that situation is that no new vessels will be added to the present prawns fleet.

Charles estimated in 1990 that the maximum sustainable yield of prawns (tail weight) was approximately 3,800 mt. However, actual landings for the period 1988 to 1993 ranged from 1,500 to 1,900 mt (tail weight), which suggests that the estimate of 3,800 mt was optimistic.

Seabob

The increased and sustained level of landings and catch per vessel (seabob) suggests that the seabob resource can sustain some expansion, but until further detailed information on the resource is available, caution is being taken. The limit on the number of vessels exploiting the seabob resource has been set at 30.

ECONOMIC ASPECTS

Following are the types of industrial shrimp products and their individual prices for the year 1995:

Prawns (export)	US$6.90
Seabob (headless shell on)	US$1.80
Seabob (headless broken)	US$1.30
Prawns (local)	G$1,026.00[3]
Seabob (local)	G$40.00

Cost Structure of the Fish Processing Activities & Comparison of the Different Fleets

The operational costs would vary according to the size and type of operation, the type of processing facility, the number of processing lines, etc.

SECONDARY RESOURCES

Status and Exploitation of Related Resources like Fish By-catch, Seabob, Deep Sea Shrimp

The industrial shrimp fishery at present has two categories of licensed vessels that are operational, and one category that at present has no vessels - those are as follows.

i. **Those licensed to catch prawns.** The by-catch would include finfish such as bangamary, bashaw, butterfish, croaker and sea trout. The by-catch landed would be mainly comprised of the larger sized fishes with the smaller fishes being discarded at sea

ii. **Those licensed to catch seabob/finfish.** The by-catch would include some prawns.

iii. **There is also a finfish category of trawlers**, but no vessel has been licensed in that category for the year 1995.

It should also be noted that the trawlers do not always adhere strictly to the type of operation for which they are licensed, because of the seasonal variations of the resources and because they all use more or less the same type of gear.

[3] US $1 = G $140

For the prawns operation, significant quantities of the small fish are discarded at sea. There are no known discards for the seabob/finfish operation. The types of processing and marketing are generally the same as for the target fish catch. There is essentially no exploitation of secondary resources in the industrial fishery.

A study by the Institute of Marine Research showed that the Atlantic seabob, the southern brown shrimp and the southern white shrimp are abundant in very shallow waters, while the redspotted and the southern pink shrimp occur in deeper waters. The catch rate is higher during the day for the shallow water species, whereas for the deep water species the catch rate is higher at night. The survey also showed the existence of the species *Polymixia lowei*, *Pontinus longispinus* and *Argentina* spp. in waters less than 400 meters deep, while *Benthodes mustenuis*, *Plesiopenaeus edwardsianus* and *Bathynomus giganteus* were found at depths greater than 400 meters (FDR, 1994).

SURVEYS ON SHRIMP AND RELATED RESOURCES

Phillips *et al.* listed the following surveys carried out in the past:

i. The first marine resource survey was carried out in the years 1957 to 1959, using the R/V Cape Mary.

ii. Under the auspices of the UNDP/FAO, another marine resource survey was carried out in the years 1967 to 1968, using the M.V. Calmar.

iii. Guyana was a participant in the Oregan II surveys which were carried out in the years 1972 to 1978.

iv. Guyana was involved in the NMFS funded project "Biological Sampling of the Landings of the Guiana Shrimp Fishery" in the years 1976 to 1979.

v. In the years 1977 to 1978, a survey was done using the R/V Kwant and in the year 1980, another was done using the freezer trawler Orkney, both being facilitated by Russian/East German cooperation.

vi. Guyana also participated in the WECAFC Shrimp Tagging Survey carried out in the years 1982 & 1983.

vii. A survey entitled "The Shrimp and Fish Resources of the Cooperative Republic of Guyana" was carried out in the years 1981 to 1983 by the Aquatic Biological Consultancy Services Ltd.

viii. In 1988, a number of surveys were done using the R/V Dr. Fridtjof Nansen. Amongst those were four surveys on pelagics, which were carried out during the period February to November, with approximately 40 fishing stations for each survey. One hundred and seven bottom trawl tows were carried out along the upper slope of the continental shelf, at depths ranging from 200 to 800 meters. Roughly 66% of the trawls were done at night, at which time many of the demersal species may have migrated towards the surface, thus biases might have been introduced. The size of the research vessel may also have introduced sampling errors due to the fact that it was unable to navigate and trawl in shallow water close to the shore, where a considerable stock biomass is likely to be located. No major geographic differences in distribution were found, but the biomass composition varied significantly with depth (FDR 1994).

ix. An Artisanal Frame Survey was carried out in 1992.

x. Another Artisanal Frame Survey was carried out in 1994, but that survey was incomplete since it captured only about 70% of the artisanal vessels (FDR, 1994)

Surveys currently being carried out are:

Guyana is at present involved in the CFRAMP Data Collection Subproject, which is jointly funded by CARICOM and CIDA. The objectives are to develop and enhance the fisheries management capability of the participating countries and to determine the status of the marine stocks.

Pelagic and deep slope resource assessment comes under the St. Vincent & the Grenadines Unit, while shrimp & groundfish assessment comes under the Trinidad & Tobago Unit.

MANAGEMENT

The fisheries management objectives are:

i. To develop and increase the potential of the marine living resources to meet human nutritional needs, as well as social, economic and development goals.

ii. To take into account traditional knowledge and interests of local communities, small-scale artisanal fisheries and indigenous peoples in development and management programs.

iii. To maintain or restore populations of marine species at levels that can produce the maximum sustainable yield as qualified by the relevant environmental and economic factors, taking into consideration relationships among species.

iv. To promote the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize the catch of non-target species.

v. To ensure effective monitoring and enforcement with respect to fishing activities.

vi. To identify, protect, and restore endangered marine species.

vii. To preserve rare or fragile ecosystems, as well as habitats and other ecologically sensitive areas, mangrove seagrass beds and other spawning and nursery areas.

viii. To promote scientific research with respect to the fisheries.

ix. To cooperate with other nations in the management of shared or highly migratory stocks.

With respect to prawns they are:

i. To stabilize landings/production at a sustainable level.

With respect to seabob they are:

i. To increase production on a sustainable basis, which would contribute to improved nutrition for the population, increased export earnings, increased incomes and employment.

Licensing Policy

It is mandatory that all fishing vessels be licensed. As mentioned before, there are at present three licensing categories in Guyana:

i. Prawns

ii. Seabob/finfish

iii. Finfish - none licensed for the year 1995.

For the industrial fleet, there is partly a "closed entry" approach for both prawns and seabob vessels.

Management Decisions and Rationale

With respect to prawns:

An upper limit of 100 vessels has been set for the prawns fleet, because of the reduced landings which indicate overfishing. However, the actual number of vessels in the fleet is at present 67.

With respect to seabobs:

A limit of 30 vessels has been set for the seabob fleet and that represents a precautionary approach, because even though the resource is supposedly healthy, further data must be obtained on the precise status of the resource potential and the amount of fishing mortality which it can sustain. When such data become available, the present vessel limit will be adjusted accordingly.

It is important to note that even though there are 50 seabob vessels in the fleet, only 28 were operational for the year 1995, which is within the limit stipulated by the management plan.

Regulations and Enforcement

The regulations and enforcements which apply to Guyana are contained in the Fisheries Act and the Maritime Boundaries Act. The FAO is also starting a project to update the fisheries legislation of Guyana. The enforcement aspect is done by the Guyana Coast Guard.

Evaluation of the Impact of Management Measures

With respect to prawns:

It has been noticed that the prawns catches have stabilized at a lower level, hence the management measures taken (closed entry, limited number of vessels), seem to have yielded some measure of success. However, the other management initiatives (closed season, prohibition of trawling for prawns from 18 fathoms shorewards, etc.) should be introduced, and cooperation with neighbouring countries should be formalized, especially with respect to the possibly shared/migratory stocks along the Guiana - Brazil shelf.

With respect to seabobs:

It has been noticed that the seabob catches have been increasing, which indicates to some extent that the resource is in good health. The impact of that fishery on the prawns fishery to the extent that juvenile prawns are caught by the seabob trawlers needs to be investigated.

GROUNDFISH (SOFTBOTTOM) FISHERY

DESCRIPTION OF THE ARTISANAL GROUNDFISH FISHERY

Fishing Activities

<u>Fishing Zones</u>

Already described under the same heading in the Industrial Section.

The fishery zone has been divided longitudinally into nine zones, each separated by 30° intervals. Artisanal fishers operate on the continental shelf at distances up to 56 km (30 miles) from the shore all along the coast.

In the artisanal fishery, shrimp species are caught by the Chinese seine vessels. These vessels exploit areas relatively close to the shore, in waters two to six fathoms deep, and usually well within the 12 mile territorial sea limit. The gillnet and caddell fishers operate further offshore. Bottom areas tend to be mud.

Nursery and Spawning Areas

Few data are available. At certain times of the year, juveniles of some species of shrimp and finfish are found in the mouths of rivers in waters 33 meters (18 fathoms) or less, but no data are available on where spawning actually takes place. The mangrove areas apparently serve as nursery areas for some shrimp and finfish species.

Fleet(s)

There are four major types of artisanal vessels, defined according to gear type; namely, Chinese seine, pin seine, gillnet (nylon and polyethylene) and caddell. There are two other gear types which are less used and are very few in number; namely circle seine and handline.

i. The Chinese seine (fyke net) vessels capture Seabob and whitebelly shrimp along with finfish such as bangamary, butterfish, cuirass, rockhead bashaw, necklee, kukwarri, catfish and some seatrout.

   That type of seine is funnel shaped and is four to six meters wide at the mouth. The mesh size increases gradually from the funnel end to the mouth end - the range is usually one cm to eight cm. The Chinese seine vessels are small flat-bottomed vessels, with the majority ranging from 21 to 40 feet in length. They are usually equipped with sails, work according to the tide and make daily trips lasting from six to twelve hours (FDR, 1994).

   Results of the 1994 Artisanal Frame Survey showed a national total of 253 Chinese seine vessels, with the largest concentration of those vessels being in regions 4 and 3. Within region 4, the Better Hope landing site had the largest number of those vessels (over 50), followed by the Houston landing site.

ii. The pin seine (beach seine) vessels capture finfish such as bangamary, catfishes, croakers, mullet, queriman, snook and some bashaw. These vessels are mainly between 21 to 40 feet in length, with small outboard engines. Of the different types of artisanal vessels, the pin seine vessels are the fewest the 1994 Artisanal Frame Survey showed a national total of 46 such vessels.

   The seine is usually two meters in height and up to 2000 meters in length, and has a stretched mesh size of nine cm or less. The seine is usually set in the water during the high tide, so that when the tide falls the fish trapped can be retrieved.

iii. The gillnet vessels are all engine driven and are generally the largest type of artisanal vessel, with the majority being between 21 and 60 feet in length, some being less than 20 feet and a few being between 60 and 80 feet in length. The 1994 Artisanal Frame survey showed a national total of 558 such vessels. The gillnet vessels are either inboard engine vessels, outboard engine vessels, or cabin cruisers (fitted with cabins and outboard engines).

   There are two types of gillnets:

   a. **Polyethylene gillnet** - these are generally between 1,000 and 1,600 meters in length, with a stretched mesh size between 6.5 to 8.0 ins (16 to 20 cm). The major species caught by this gear type are grey snapper, gilbacker, sharks, sea trout, Spanish mackerel, kingfish, cabio, cavalli, snook and cuffum.

   b. **Nylon gillnet** - these are also referred to as "soft seine" and are generally about 300 meters in length, with stretched mesh size of eight cm. The major catch of this gear type is bangamary, butterfish, sea trout, Spanish mackerel, and some cuirass.

iv. The **caddell** vessels are engine driven and the majority are between 21 and 35 feet in length. The major species caught by this gear type are catfish, cuirass, gilbacker, kukwarri and sharks.

v. The **circle seine** vessels use a modified version of the nylon gillnet. These vessels are very few in number and are mainly located in the Corentyne area. The catch is primarily composed of lau lau, manari, silver bashaw and highwater.

vi. It has been estimated that there are currently less than five active **handline** vessels. They measure up to 18 feet in length and use handlines with baited hooks. They fish far out along the edge of the continental shelf, at depths greater than 120 meters. The major species caught are snappers and groupers.

Fleets According to Ownership by Individuals, Cooperatives, Characteristics of Vessel/gear, Areas Fished

All of the artisanal vessels are individually owned, with some individuals owning several. There is no known ownership of vessels by cooperatives, but approximately 70% of the vessel owners generally belong to a cooperative society, usually in the area in which their operation is based.

Table 8: Number of artisanal vessels by year for the period 1985 - 1993.

YEAR	NO. OF VESSELS
1985	1146
1986	1150
1987	1152
1988	1161
1989	1171
1990	1182
1991	1240
1992	1300
1993	1365
(Fisheries Department Records)	

Table 9: Composition of the artisanal fleet (all figures are based on the 1994 artisanal frame survey)

	NUMBER OF VESSELS BY GEAR TYPE BY REGION				
REGION	GILLNET	PIN SEINE	Chinese SEINE	CADDELL	TOTALS
2	52	7	20	9	**88**
3	51	5	69	14	**133**
4	250	6	86	27	**368**
5	64	7	38	18	**127**
6	121	21	40	11	**193**
7	20	0	0	0	**20**
Totals	**558**	**46**	**253**	**79**	**936**

NB The 1994 Artisanal Frame Survey was to some extent incomplete since it covered only 70% of the fleet and only four of the six marine fishing regions completely. The true number of artisanal vessels is close to 1240, whereas the frame survey shows a total of 936 vessels.

There are seven fishermens' cooperatives entities in Guyana:

i. The Morawhanna Fishermens' Cooperative Society.

ii. The Essequibo/Pomeroon Fishermens' Cooperative Society

iii. The Region Three Federation of Fishermens' Cooperative Societies (this is really a secondary society, which comprises five sub-societies).

iv. The Greater Georgetown Fishermens' Cooperative Society.

v. The Rosignol Fishermens Cooperative Society.

vi. The Corentyne Pin Seine Fishermens' Cooperative Society.

vii. The Upper Corentyne Fishermens' Cooperative Society.

Fishing Strategies

i. The **Chinese seine** vessels work according to the tide, spending between six and eight hours per day at sea. Some vessels make two trips per day, but the majority make only one trip. One set is made per trip and fishing takes place during the day or night. They fish at depths between two and six fathoms, at a distance of about one mile from the shore.

ii. The **pin seine** vessels also work according to the tide. These operate about 0.5 miles to 0.75 miles from the shore, in waters up to two fathoms deep and fish day or night. They normally operate on a daily basis, but on a few occasions they set their net and leave it for as many as three days, going out each day to retrieve the catch.

iii. The two types of **gillnet** vessel employ different strategies.

a. **Vessels using polyethylene gillnet** - the length of the trip varies according to the size of the vessel, the size of the icebox (7 to 10 tons capacity) and the seasonality of the target species, but they generally spend about ten to fifteen days at sea. They normally make two sets/hauls per day at roughly six hours per haul, and fish day or night. They fish between ten to thirty miles from the shore at depths ranging from eight to thirty fathoms.

b. **Vessels using nylon gillnet** - these operate on a daily basis, with a few spending two to three days at sea. The daily trips last for roughly 11 to 12 hours, with one haul being made per day. These vessels are equipped with iceboxes (2 to 3 ton capacity). They fish mostly during the day, but occasionally at night, and at distances between six to eight miles from the shore at depths ranging from six to fifteen fathoms.

iv. The **caddell** vessels have two to three trays per vessel, with each tray having from two to six main lines. Each main line is approximately 110 meters (360 ft) in length, with each main line having branches. The main line has 20 hooks, while the finer branched lines have 40 to 45 hooks. The branched lines are 0.46 to 0.61 meters (1.5 to 2.0 ft) in length. Keybrand hooks are generally used. They operate daily, with each trip lasting approximately 12 hours. They make two to three sets per trip, fishing mainly at night. Fishing occurs between three to five miles from the shore, in waters approximately three fathoms deep.

Table 10: Average distance from base by gear type.

DISTANCE FROM BASE (miles)	GEAR TYPE				TOTALS
	PIN SEINE	Chinese SEINE	GILLNET	CADDELL	
0 - 10	69	392	260	81	802
11 - 20	6	65	117	42	230
21 - 30	4	8	42	8	62
31 - 40	2	2	41	2	47
41 - 50	0	0	49	6	55
51 - 60	2	2	20	2	24
>61	6	2	289	17	314
No Response	1	34	46	19	100
Total	**90**	**503**	**864**	**177**	**1634**

(Fisheries Department Records)

Discards

Small fishes of commercial species such as catfishes, croakers, cuirass and bangamary, are discarded by the Chinese seine fishers, and these would be only a few centimetres in length. They also discard small fishes that have terminal growth (e.g. necklee and rockhead bashaw). The pin seine fishers also discard small fishes of commercial species.

Fishing Activities of the Industrial Fishery

See industrial fishery (sub-heading "Discards")

Industrial Fishery for Fish

The 50 seabob/finfish vessels target finfish species such as bangamary, butterfish and seatrout . The very small-sized and unmarketable finfish are discarded.

Processing Activities

Artisanal fish processing

The major processors at the cottage industry level are F. Jhuman, K. Seepersaud, E. Lord, A.A. Shakoor, Jasshri, and Balmacoon. There are also numerous small processors who produce dried small shrimp. These processors do not own vessels but are supplied primarily by the gillnet fishers from the Houston, Unity/Lancaster, and to a lesser extent, Rosignol landing sites.

The products derived from the cottage industry are dried shrimp, salted shark, dried shark fins, dried shark cartilage, salted fish, crab meat (mainly caught in New Amsterdam) and dried swim bladders (fish glue). The cottage industry is generally problematic in terms of hygiene, sanitation and quality assurance.

The major exporters in the cottage industry are F. Jhuman, K. Seepersaud, E. Lord, Jasshri and A.A. Shakoor.

Marketing for artisanal and industrial fisheries

Local Market

The types of fish products include the following.

Fresh fish and fresh fish on ice, which are sold to processing companies, wholesale and retail vendors, municipal markets and other outlets. Fresh fish is purchased directly from the wharves and landing sites by the processors and some retailers.

Frozen fish (primarily snapper and trout steaks) is sold to supermarkets and other retail outlets. Dried and salted fish, primarily sharks, but including some other species such as snapper, are sold to wholesale and retail vendors on the local market, but significant amounts are exported by the processors and some vendors. Smoked and pickled fish are produced in small quantities by MFPL and a few cottage processors and sold to the supermarkets.

The Nwike survey (1993) showed that the majority of artisanal fishers sold their catch to hucksters, while a smaller amount (primarily the members of the Greater Georgetown and the Corentyne Societies) sold their catch to processing companies/middlemen who represent same, with just over 10% retailing their catch on their own (Table 11).

Over 60% of those surveyed said that the price offered was the primary factor in determining to whom their product was sold, while 40% said that convenience also played an important role and approximately 20% said that they had no options with respect to markets. Prices for 1994 are shown in Table 12.

Export Market

Most of the exports (Table 13) were to the U.S.A. (fresh & frozen finfish), CARICOM (frozen finfish, salted fish & frozen crab meat), Hong Kong (dried shark fins, dried fish glue), (Fisheries Department Records)

Table 11: Destination of the artisanal catch by gear type for all sampled regions of Guyana.

DESTINATION OF CATCH	NUMBER OF VESSELS BY GEAR TYPE				TOTALS
	PIN SEINE	Chinese SEINE	GILLNET	CADDELL	
Wholesale to middlemen who sell to processing plant	4	21	201	10	**236**
Wholesale to vendors who sell in villages	10	92	119	25	**246**
Wholesale direct to processing plant	3	18	96	4	**121**
Wholesale to individual exporters	0	6	14	2	**22**
Other wholesale	3	3	24	2	**32**
Retail in markets	14	55	33	16	**118**
Retail in villages	11	53	58	13	**135**
Other retail	1	3	7	4	**15**
No Response	0	2	6	3	**11**
Total	**46**	**253**	**558**	**79**	**936**
(Fisheries Department Records)					

Table 12: Average wholesale and retail prices for the commercially important species for the years 1994 and 1995.

SPECIES	YEAR 1994	
	RETAIL PRICE (G$)	WHOLESALE PRICE (G$)
Bangamary	52	30
Butterfish	106	48
Bashaw	64	44
Catfish	69	31
Cavalli	85	40
Cuffum	111	43
Gilbacker	219	140.00 (with dye) & 97.00 (without dye)
Grey Snapper	183	107.00 (whole/gutted)
Mackerel	74	45
Phagee/Jackass	50	42
Queriman	131	62
Red Snapper	241	N.A.
Sea Trout	141	72
Snook	135	64
Shark	66	62.00 (large) & 39.00 (small)
Seabob (unpeeled)	72	29
Seabob (peeled)	99	N.A.
Whitebelly (unpeeled)	41	18
Whitebelly (peeled)	81	N.A.
Marine Fish	112	N.A.
Inland Fish	356	N.A.

Table 13: Fishery Exports (1990 - 1994).

ITEM	VOLUME EXPORTED PER YEAR (mt)				
	1990	1991	1992	1993	1994
Prawns	1665	1922	1526	1630	1483
Seabob & Whitebelly	662	1055	1204	1215	1398
Dried Shrimp	8	18	34	24	10
Finfish (frozen)	1320	1979	2747	2720	2922
Finfish (fresh)	—				177
Salted Fish	138	337	323	261	326
Smoked Fish	45	31	32		
Frozen Crab Meat	2	10	16	11	9
Dried Shark Fins	8	13	20	23	32
Dried Fish Glue	10	7	29	53	27

CATCH & EFFORT

The national number of vessels per gear type has already been shown in a previous table.

Table 14: Number of trips per month by gear type.

NUMBER OF TRIPS PER MONTH	GEAR TYPE				TOTALS
	PIN SEINE	Chinese SEINE	GILLNET	CADDELL/HANDLINE	
1	0	0	39	2	**41**
2	12	2	154	6	**174**
3	3	2	43	0	**48**
4	0	2	20	0	**22**
5	0	1	2	0	**3**
6 - 10	6	16	28	10	**60**
11 - 20	20	186	202	51	**459**
21 - 30	3	30	39	6	**78**
No Response	2	14	31	4	**51**
Total	**46**	**253**	**558**	**79**	**936**
(Fisheries Department Records)					

NB The gillnet vessels were not separated into the two different types - polyethylene & nylon. As mentioned before, the polyethylene gillnets usually spend ten to fifteen days at sea per trip, while the nylon gillnets spend one day and sometimes two or three days per trip.

Time at sea

The number of days spent at sea by gear type is summarized below.

Chinese Seine vessels : Usually one day

Pin Seine vessels : Usually one day

Polyethylene Gillnet : Ten to fifteen days

Nylon Gillnet : Usually one, but sometime two - three days

Caddell/Handline : Usually one day

Catch/landings

Monthly Landings, Total Landings per Year, Average Seasonal Fluctuations

Table 15 shows the total annual finfish landings of the artisanal fleet, the total number of vessels which contributed to those landings and the average volume of catch per vessel for the years 1985 - 1993.

Table 15: Artisanal fishery CPUE (vessels).

YEAR	VOLUME OF CATCH (mt)	NUMBER OF VESSELS	AVERAGE CATCH PER VESSEL (mt)
1985	28565	1146	24.93
1986	28840	1150	25.08
1987	29008	1152	25.18
1988	28310	1161	24.38
1989	28205	1171	24.09
1990	30124	1182	25.49
1991	35538	1240	26.24
1992	34112	1300	26.24
1993	35818	1365	26.24
(Fisheries Department Records)			

Available data showed that the 29,008 mt of finfish catch obtained in 1987 was divided among the gear types as follows:

Gillnet	60%	(17,405t)
Chinese seine	25%	(7,252 t)
Caddell	8%	(2,321 t)
Pin seine	5%	(1,450 t)
Handline	1%	(290 t)
Circle seine	1%	(290 t)

Average Seasonal Fluctuations

The most productive period generally starts in March, which is the time when most common species become abundant. Most Scombrid species are abundant from May to September. During the months of November to February, most finfish species are relatively scarce. From November through February, most species become scarce and that coincides with the period when the winds and water are generally high and the seas are rough, so the fishing activity during that time is greatly reduced.

Catch per Unit of Effort

Table 15 showed the annual aggregate catch of the artisanal fleet and the average annual catch per vessel. The data available is not species specific, nor is there a breakdown of the catch by gear type and the unit of effort used there was the number of vessels. Those deficiencies in the data collections system are currently being addressed under the auspices of the CFRAMP program.

ASSESSMENT OF THE RESOURCES

Species and Sex Composition Monthly, Annually and by Fleet/gear

Some data is available on the species composition by gear type (see section on description of gear types).

Guyana is at present participating in CFRAMP, which is designed to generate data to facilitate resource assessment. Activities will produce data that are species specific and that capture the unit of effort as the number of hours fished. Efforts are also being made to obtain data that gives a clear picture of the age groups and length relationships per species per gear type as well as the areas/fishing grounds and depth ranges where specific species are captured by specific gear types. A logbook system is also being implemented to complement the efforts stated above.

Length-frequency Distribution by Species/sex

A small amount of work was done (during 1995) on collecting length-frequencies (mainly for pelagic & deep slope species) and catch & effort data (for all species). There are, however, no historic data on length distribution by species by sex for the finfish and shrimp resource exploited by the artisanal fishery.

Nurseries

Few data are available. At certain times of the year, juveniles of some species of shrimp and finfish are found in the mouths of rivers and in waters 33 meters (18 fathoms) or less, but no data are available on where actual spawning takes place. The mangrove areas apparently serve as nursery areas for some shrimp and finfish species.

Evaluations - Summary of Assessments Carried out to Date

No work has been done so far with respect to analytical and production modelling. The FAO/Norad sponsored resource survey carried out in 1988 and the 1989 survey carried out by the Institute of Marine Research, yielded some information on the status of the finfish resources.

The FAO/NORAD survey generated estimates of the stock biomass of pelagic and demersal finfish, squids and shallow-water shrimp species, which are summarized in the following table.

Table 16: Estimates of biomass for some finfish, squid and shrimp species.

TYPE OF RESOURCE		VOLUME (mt)
Pelagic Finfish	Engraulids	55000
	Clupeids	105000
	Carangids	104000
	Scombrids	15000
	Barracudas	9000
	Hairtails	12000
Total Pelagics		**300000**
Demersals	Snappers	15000
	Grunts	4400
	Croakers	27500
	Groupers	800
	Other Demersal	21500
Total Demersals		69000
Shark spp.		**3000**
Squid		**2000**
Shallow water shrimp		N/A
Total		**374000**
(Fisheries Department Records, 1994)		

A poll conducted as part of the 1994 Artisanal Frame Survey yielded the information contained in the following table, which gives the fishers' views on whether they think the catches are increasing, decreasing, or remaining the same.

Table 17: Fishers' impression of the health of the resource.

CATCHES GOING	GEAR TYPE			
	PIN SEINE	Chinese SEINE	GILLNET	CADDELL
Up	8	19	48	9
Down	29	138	293	38
Same	9	96	217	32
Total	**46**	**253**	**558**	**79**
(Fisheries Department Records)				

SOCIAL AND ECONOMIC ASPECTS

A Review of Previous Social, Economic and Bioeconomic Evaluation and Information on the Number of Fishers, Marketers/distributors by Gender

Results of a survey showed that in 1990, the total artisanal workforce was approximately 3,884, of which 1,004 were male vessel owners, 28 were female vessel owners, 332 were captains and 2,520 were crew members. Of all the owners, 38% were below the age of 35.

The estimate of the artisanal workforce for 1992 was 4,500, of which approximately 1,000 were vessel owners.

The Nwike report (1993) gives the results of a survey which targeted members of four rural cooperative societies and the Greater Georgetown Fishermens' Cooperative Society. While that study was not complete in the sense that only 70% of the vessel owners are members of cooperative societies and of the seven cooperative societies, only five were a part of the survey, it nevertheless generated some useful data. That survey found that almost 75% of the fishers were age 50 or less, and of those, 36% were within age group 41 and 50. The 14 females surveyed represented approximately 17% of the total surveyed and they were generally older than the males. Approximately 80% of all surveyed had ten or more years of experience in the fishery, while for the females only, 5% had a similar experience.

Approximately 70% of those surveyed were engaged in the fishery full-time. However, for the fishers from the two Corentyne societies and the Essequibo-Pomeroon area, that percentage was around 60, while for Georgetown and Rosignol, the percentages were 82 and 89 respectively. More than 80% of all surveyed derived more than 50% of their income from fishing activities (FDR, 1994).

Table 18 provides information on the finfish production and net financial returns by gear type (for the year 1991).

Table 18: Finfish production and net financial gains by gear type (Nwike Survey).

CATEGORY	GEAR TYPE				
	PIN SEINE	CHINESE SEINE	CADDELL	POLYENE/ GILLNET	NYLON GILLNET
1991 Finfish landings (lbs)	70661	39678	81107	51725	66736
Finfish landed/trip (lbs)	639	164	590	2086	418
Number of trips/annum	140	217	162	34	169
Financial returns/trip (G$)	8071	1586	6094	33031	3157
(Fisheries Department Records, 1994)					

It is important to note that apart from the variations amongst the different gear types, there were also large differences in all categories (fish landed, number of trips, financial returns, etc.) within each gear type.

SURVEYS ON FISH AND RELATED RESOURCES

Present surveys and surveys carried out in the past: are already mentioned under the same heading in the Industrial Section.

Surveys planned for the future include tagging some species of large migratory pelagics such as Spanish mackerel (*Scomberomorus brasiliensis*) and tuna.

MANAGEMENT

General Management Objectives

The general management objectives have already been outlined under the same heading in the Industrial Section. However, a review is given below.

The fisheries management objectives are:

i. To develop and increase the potential of the marine living resources to meet human nutritional needs, as well as social, economic and development goals;

ii. To take into account traditional knowledge and interests of local communities, small scale artisanal fisheries and indigenous peoples in development and management programs;

iii. To maintain or restore populations of marine species at all levels that can produce the maximum sustainable yield as qualified by the relevant environmental and economic factors, taking into consideration relationships among species;

iv. To promote the development and use of selective fishing gear and practices that minimize waste in the catch of target species and minimize the catch of non-target species;

v. To ensure effective monitoring and enforcement with respect to fishing activities.

vi. To identify, protect and restore endangered marine species;

vii. To preserve rare or fragile ecosystems, as well as habitats and other ecologically sensitive areas, mangrove seagrass beds, and other spawning and nursery areas;

viii. To promote scientific research with respect to the fisheries resources;

ix. To cooperate with other nations in the management of shared or highly migratory stocks, e.g. large migratory pelagics.

Licensing Policy

It is mandatory that all fishing vessels be licensed. For the artisanal fleet, there is an "open entry" approach for all vessels.

Management Decisions and Rationale

For the artisanal fleet, there is no management in place beyond the licensing of vessels. However, there is some amount of concern about the large numbers of juvenile finfish and crustaceans that are destroyed by the Chinese seine and pin seine fishers. If such a situation is allowed to continue unabated, a long-term detrimental effect on the recruitment of shrimp and finfish species is almost certain.

Possible initiatives to remedy that situation include the following:

i. The establishment of closed seasons for the Chinese seines and pin seines.

ii. Closure of the nearshore fishing grounds for the Chinese seines and pin seines.

iii. Setting of a minimum mesh/hook size for each gear type, including gillnets and caddells.

iv. Limiting/reducing the number of Chinese seines and pin seines presently in operation and refusing entry for any new vessels of those gear types (there is also the possibility of limiting the number of seines per vessel);

v. Gradually phase out the use of Chinese seines and pin seines and possibly try to persuade them to convert to other gear types which are less destructive to juveniles and crustaceans.

vi. Restriction of the operation of the Chinese seines and pin seines to certain areas.

It is important to note, however, that the Chinese seine fishers represent the second largest category of artisanal fishers and they are generally among the least affluent of all fishers, so any proposed regulatory initiatives aimed at reducing and/or phasing out their operations would have to be carefully examined before being implemented.

Regulations and Enforcement

The regulations and enforcements which apply to Guyana are contained in the Fisheries Act and the Maritime Boundaries Act. The FAO is also starting to conduct a project aimed at updating the Fisheries Legislation of Guyana. Enforcement is by the Guyana Coast Guard.

Evaluation of the Impact of Management Measures

No work has been done in this area as yet.

REFERENCES

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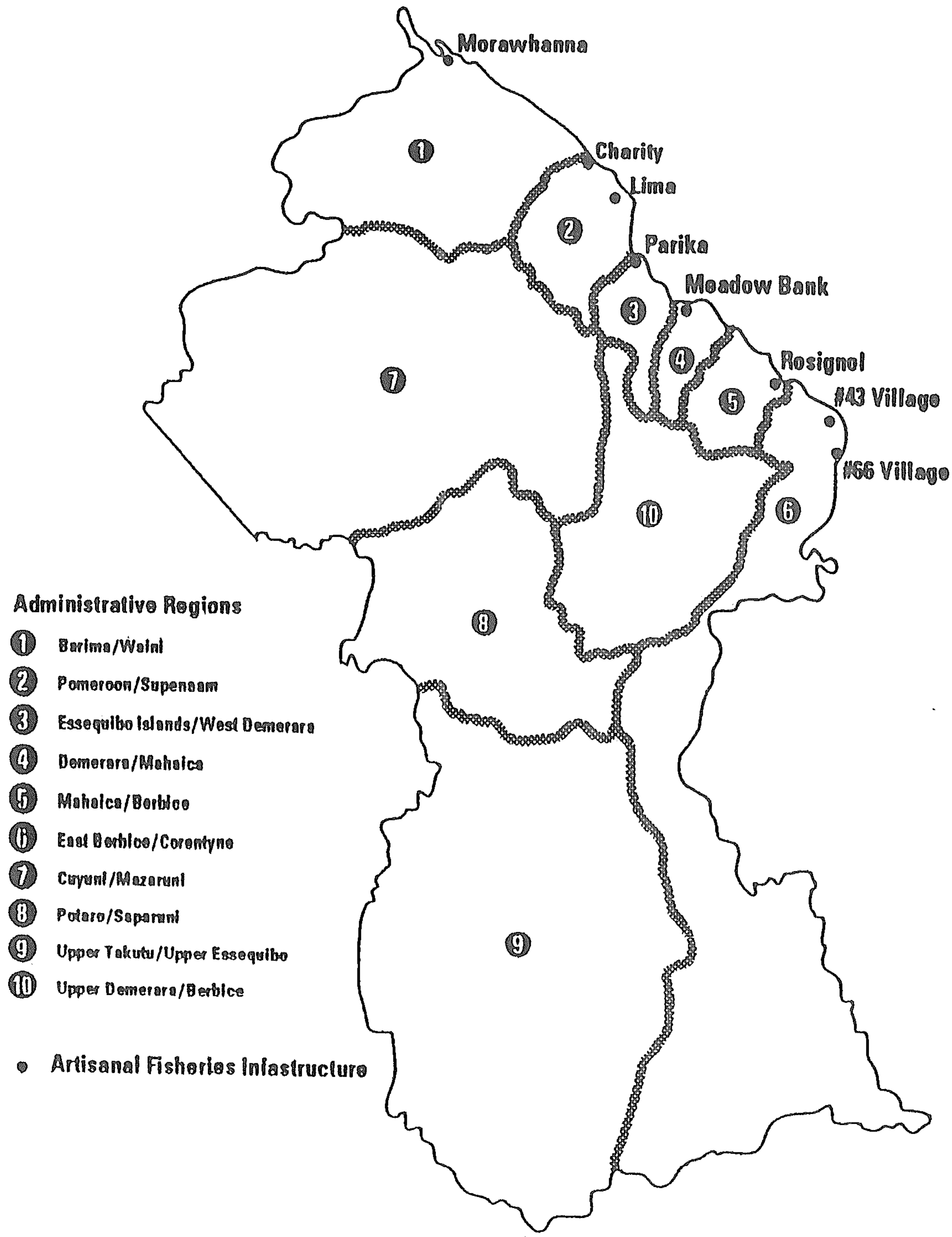

Figure 1: The administrative regions of Guyana.

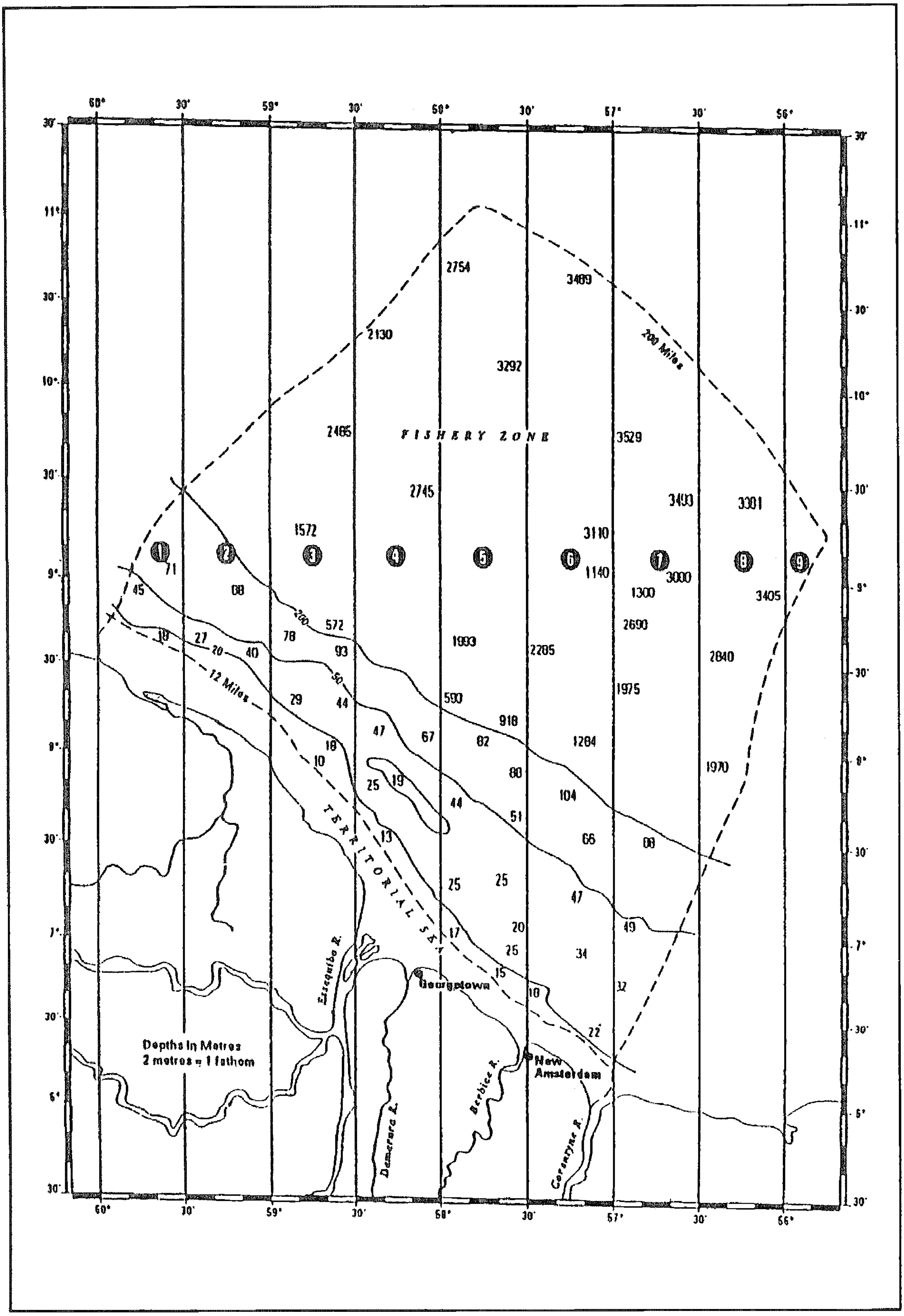

Figure 2: The fishery zones of Guyana.

National Report on the Shrimp & Groundfish Fisheries of Jamaica

Avery Galbraith[1]

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INTRODUCTION

Jamaica is situated in the Caribbean Sea, latitude 18° North and longitude 77° West. The island lies 145 kilometres south of Cuba and 161 kilometres west of Haiti. The nearest point of the American continent is the Mosquito Coast of Honduras, 499 kilometres to the south-west. The maximum length of the island is 238 kilometres with varying widths of 35 - 82 kilometres. The total area of the island in 10,991 km².

To the south-west of the island lie shallow seas which extend for 161 kilometres over the Pedro Banks, and their associated cays. The Morant Cays are 51 kilometres south-east of the eastern extremity of Jamaica at Morant Point. The banks and their associated cays are important fishing grounds for Jamaica.

In 1993, Jamaica was declared an archipelagic state. The archipelagic baselines extend from Negril Point in the west to South West Rock in the North-East Cay, to Portland Rock and finally the lighthouse on the Morant Cay and back to Morant Point. The island has a twelve mile territorial limit which surrounds the archipelagic baselines, and from which extends a 188 mile Exclusive Economic Zone (EEZ), this has effectively increased Jamaica's fishing area (see Figure 1).

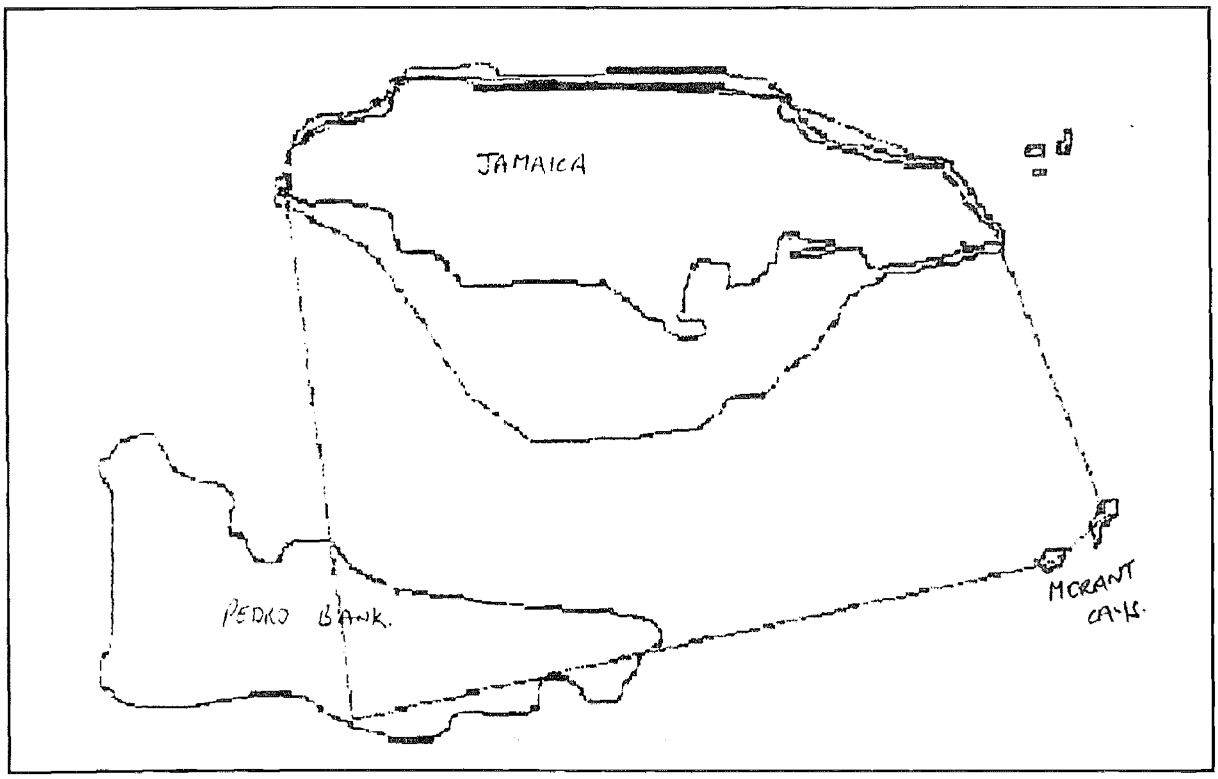

Figure 1: The archipelagic baseline of Jamaica.

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1 Fisheries Division, Jamaica.

The Jamaican marine fishery may be divided into an artisanal and an industrial fishery which are exploited in three distinct areas: the offshore banks, proximal banks and the island shelf. It is estimated that there are 20,000 fishermen and 9,000 boats operating in the fishery. The commercially exploited marine fisheries are demersal coral reef finfish species, inshore and offshore pelagics, molluscs (conch), and crustaceans (lobsters and shrimp). The artisanal fishery uses fibreglass fishing canoes in the size range 7.32 - 12.2 m powered by outboard engines which have a range of 10 - 55 HP and wooden or oar propelled canoes. The fishery is predominated by the fibreglass (FRP) fishing canoes, the approximate ratio being 60 : 40. The industrial fishery uses larger boats size (range 20 - 24 m) powered by 225 HP engines.

The Jamaican shrimp fishery is primarily artisanal in nature. There is also the recent development of commercial shrimp nurseries. The artisanal shrimp fishery supports approximately two thousand persons, including vendors and fishers. The fishery is an open access one and specific to certain areas. Appraisals have been made of this fishery in the past and these shall be referred to in the document.

THE FISHING AREAS

Most shrimp fishing occurs along the south coast of Jamaica. This may be attributed to the preferential habitat along the south coast by reason of fluvial discharge which provides a favourable mud bottom substrate.

The major areas in which shrimp fishing occurs are:

- Kingston Harbour
- Great Salt Pond (St. Catherine)
- Salt Gully (St. Catherine)
- Old Harbour Bay (St. Catherine)
- Black River (St. Elizabeth)
- Savanna-la-mar (Westmoreland)

To a lesser extent, shrimp is caught in areas such as Alligator Pond (Manchester) and Farquhars Beach (Clarendon); mainly as an incidental catch. In areas such as Leith Hall, Bowden Bay and Port Morant the shrimp is targeted primarily as bait.

Description of the Fishing Areas

The fishing areas are of varied habitat. Shrimping activity occurs in mangrove areas where fishers use shove nets and along muddy bottoms where trawling is done. The description of the fishing areas outlined below is site specific and based on information extracted from Iverson and Munro (1967).

Kingston

Kingston Harbour may be divided into three areas, the Main Basin, Hunts Bay and the Outer Harbour. The fishing zone extends from the main basin to the limit between Port Royal and Green Bay. Kingston Harbour comprises several ecosystems, mud flats, sandy seagrass areas and mangrove systems:.

- Main basin: Water 10 m - 14 m deep over thick, glutinous, black mud;
- Hunts Bay: The sediment in Hunts Bay is extremely soft, average depth approximately 3 m;
- Outer harbour: Sea floor is more sandy and firm than in other areas with depths between 10 m and 15 m. Shrimp fishing also occurs in the shallow mangrove areas of the Outer Harbour.

Portland Bight

Iverson and Munro (1967) suggested that the trawlable muddy bottom area of the Portland Bight was extensive. This totalled approximately 20 square nautical miles. However, shrimp fishing occurs mainly in the area known as Salt Gully. This is an extensive mud bottom which to some degree is influenced by a river which empties into it. There is a fringing mangrove system along the coast and trawling occurs at depths of 10 m.

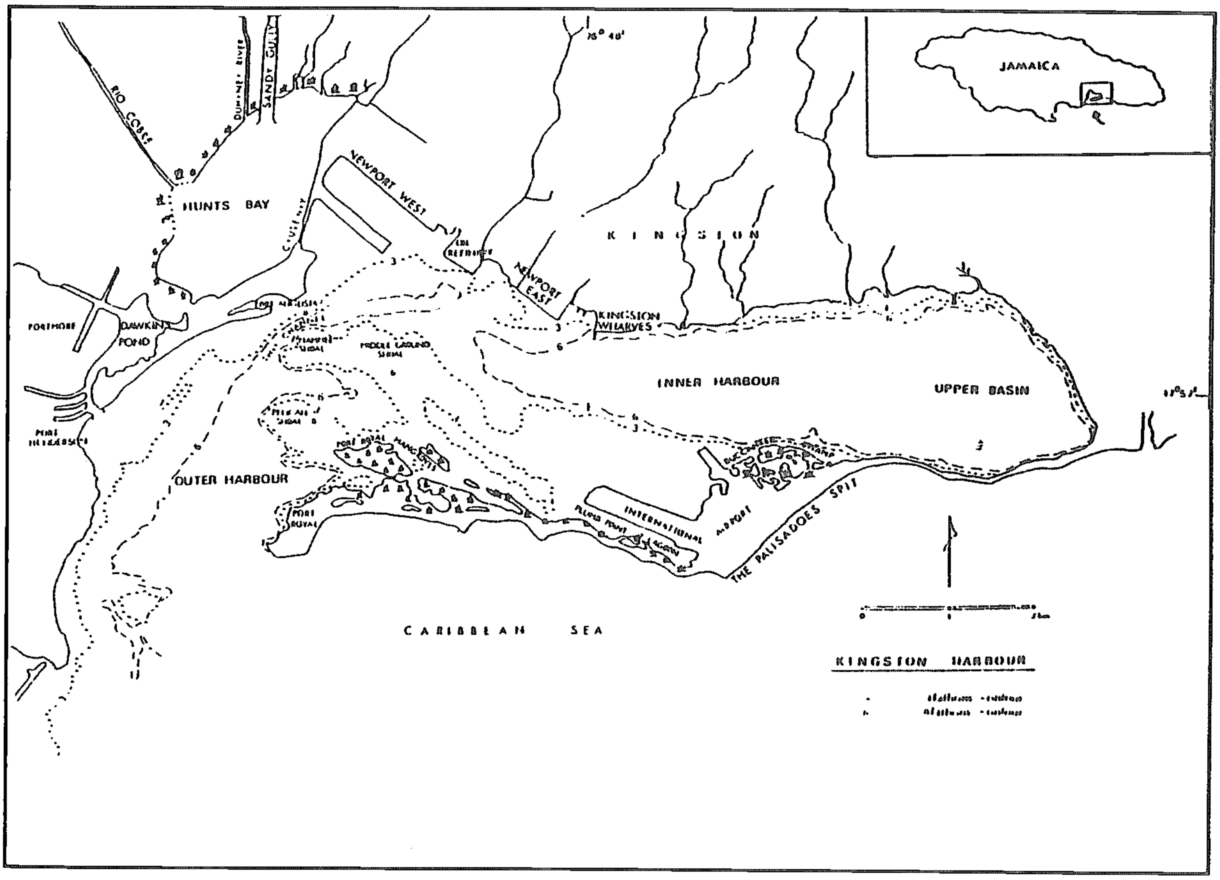

Figure 2: Map of Kingston Harbour.

Offshore shelf at Pedro Bay (Black River Bay)This area comprises some 50 square nautical miles of flat muddy bottom (Iverson and Munro, 1967). The depth range being 25 - 45 m. These represent the best trawling grounds and harbour shrimp stocks of comparable density to Kingston Harbour (Iverson and Munro, 1967). They also recommended that since this area lies under open sea, trawlers of moderate size could be allowed to work them.

Description of Nursery and Spawning Areas

Kingston Harbour, and specifically the shallows of Hunt's Bay, the area south of Port Royal serve as nursery areas (Iverson and Munro, 1967). There are adequate shallow areas suitable for nurseries in the Kingston Harbour. However, the integrity of these areas is suspect since they are subject to coastal pollution and dredging. Chin's study in 1991 suggests that Farquhars Beach in Portland Bight may provide adequate nursery areas.

Chin (1991) studied the biology of Jamaican penaeid shrimps at seven sites along the Jamaican south coast. These were Plumb Point Lagoon, Hunt's Bay and Fort Augusta in Kingston Harbour, the Great Salt Pond along the St. Catherine coast, Old Harbour Bay and Farquhars Beach in Portland Bight and Black River Bay in St. Elizabeth. In order to investigate the possibility of deep water spawning supplemental stations were sampled in the South Channel at the mouth of Kingston Harbour. An increase in the abundance of larvae was observed in February 1984. The greatest numbers were observed at Plumb Point Lagoon in Kingston Harbour (55.4%) and Farquhars Beach (25.1%). The other stations recorded a few larvae. Hunts Bay did not yield any larvae. Penaeid shrimp larvae were concentrated in Kingston Harbour. Samples taken from deeper water in the South Channel yielded greater than two times the number of larvae found at the other seven stations. Maximum larval abundance was observed during December 1983 to March 1984. The larvae then move to waters around the Port Royal mangroves and adjacent mangroves.

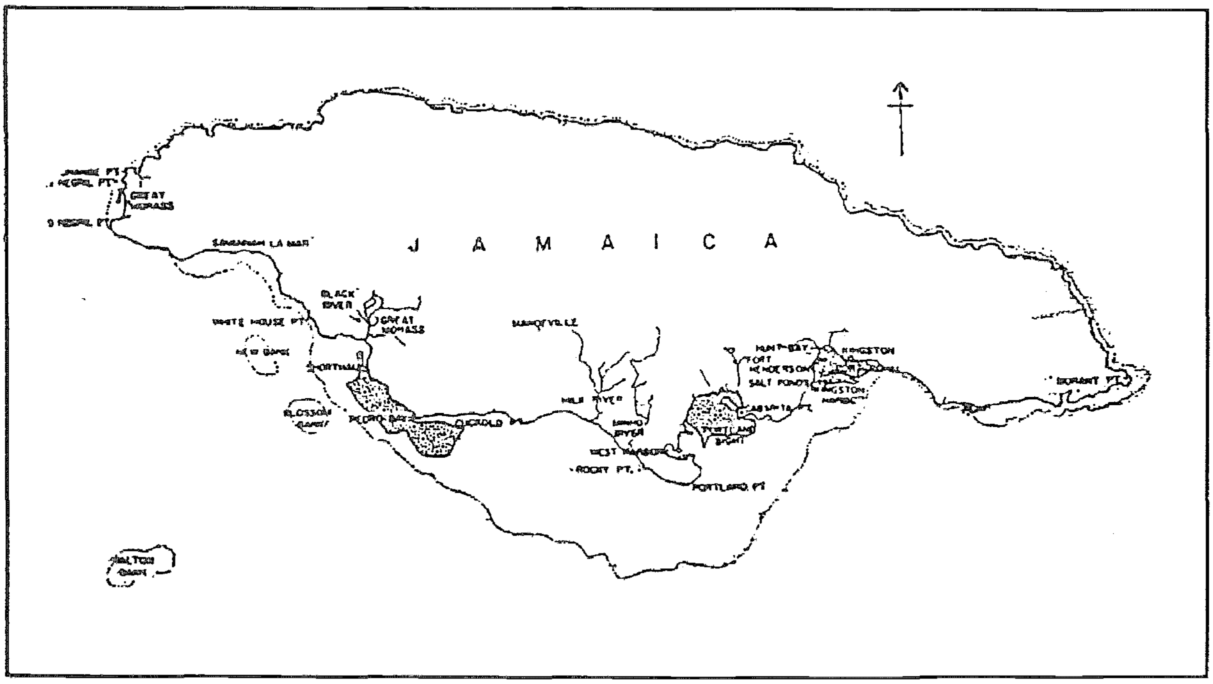

Figure 3: Map of trawling areas along the Jamaican south coast.

Fleets

The boats, gear and methods used in the exploitation of shrimp are as follows. The fishery uses mainly non-motorized wooden dug-out canoes approximately 4.88 m in length (oar propelled) and 8.54 fibreglass canoes powered by 40 HP outboard engines. The wooden vessels use monofilament gill nets top capture shrimp. These nets have a mesh size of 3.8 cm (1.5").

The fibreglass canoes are larger boats often equipped with 40 HP engines. The boats are involved in a trawl fishery for shrimp. Preliminary assessment suggests that wooden boats dominate the fishery.

Approximately one thousand fishermen fish shrimp in Jamaica. The fishery is exploited mainly on the south shelf and to a lesser extent on the North Coast. Shrimp fishing is done using shove nets (mesh size 0.5"/1.25cm), monofilament gill nets/China nets (mesh size 1"/2.5 cm) and trawl nets (mesh size 1.5"/3.75 cm).

Fishing Strategies

Fishing strategies are very much the same irrespective of landing sites.

Trawl Nets: There are approximately eight boats which use trawl nets in the Jamaican shrimp fishery. These boats are crewed by pairs. Shrimping is done primarily at night and lasts ten to twelve hours between 7 p.m. and 7 a.m. Trawls are drawn for approximately two hours. The trawl net is towed behind the boast for approximately two hours in a circular manner. The average number of tows per night is approximately six.

Monofilament gill nets: Monofilament gill nets have a mesh size of one inch. The net is thrown overboard and allowed to settle for five to ten minutes. The boat is rowed in a circular motion after this it is hauled in and the shrimp picked off the net. This method is repeated several times. The length of time spent catching shrimp is approximately eight hours.

Shove nets: These nets are used by fishermen who fish shrimp for baiting purposes. This is done in the shallow mangrove areas. Fishing may last from half an hour to four hours. The process involved men walking the mangroves with these nets and pushing them along the mud bottom and collecting the shrimp in the net. This method is also done in the seagrass beds.

Discards: The discards often consist of juveniles of various species of demersal fish. These are thrown back into the water. However, if they are of an edible size, they may be retained for household consumption.

Processing Activities

Processing involves storing on ice or freezing the product. Only one company is known to operate a plant that processes shrimp. This plant owns two 8.54 m and one 10.98 m fibreglass canoes that fish shrimp as the market demands. The company is involved in the processing of seafood and focuses on lobster and shrimp.

Shrimp are processed on shore and sold head-off. The product is frozen and packaged and not labeled.

Marketing

The shrimp fishery supports a substantial number of persons in terms of persons who fish and sell the resource, their families, and restauranteurs. Prices are basically the same, irrespective of landing site. The prices being sometimes subject to bargaining between the fisher and vendor. Usually small shrimp are sold for $150 - $200 / lb[2]. Generally, the price will increase if the product is scarce and decrease when the product is plentiful.

The shrimp is used to supply the local market and is often retailed to supermarkets, hotels and householders. The fishermen sell to the vendors who in turn retail to the hotels, householders and restaurants. The boatside price of shrimp varies with landing site but is in the range of $100 - $200 lb.

Outlined below is a pricing structure for shrimp at various landing sites:

Hunts Bay	$150 - $180
Galleon Bay	$180 - $200 (sells wholesale)
St. Thomas	$100 (bait)

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2 $US 1 = $J 38

Salt Gully $150 - $200 (sell wholesale to one buyer)

Fish vendors retail shrimp at $200 pound.

From interviews with persons involved in the trade it would appear that price depends on the supply of the product.

Once the shrimp is landed at the landing site it is sold to shrimp vendors, most of whom seem to specialize in the sale of this product. These vendors store the shrimp on ice packed in a bucket. On leaving the landing site, they go into the town or along the roadside where they sell their product to householders or small restaurants who may want to purchase.

Shrimp vendors also sell the product at the landing site, as some restaurant owners visit the site and purchase the shrimp from them.

In the case of the processor in the St. Elizabeth, shrimp is sold wholesale to the hotels along the North Coast. Since this individual has a ready market, shrimp is fished only to order or during the peak tourist season.

Catch and Effort

There is currently no data gathering information system in place to regulate catch and effort of the shrimp fishery. The estimated production of the shrimp fishery in 1994 was 276.69 tonnes of which 235.19 tonnes went to the local market. Preliminary interviews with the fishermen (re: effort and catch) will be discussed below as they relate to landing site.

Hunts Bay

In Kingston Harbour there are approximately four boats that trawl and an undetermined number of wooden boats involved in China net fishing. Interviews with trawler operators revealed that on the average they fish daily for eight hours and catch approximately 6.80 - 9.07 kg. h^{-1}.

Persons using the monofilament gill net (China net), also fish for eight hours after which the average yield is 4.54 - 9.07 kg. h^{-1}.

Salt Gully (St. Catherine)

Five boats trawl for shrimp in the Salt Gully area of the Portland Bight. These boats fish on average twelve hours per day. Fishing is seasonal and fishermen tend to fish alternately every other month. An average nightly trawl yields after ten hours 4.54 - 13.61 kg of shrimp. This yields 0.07 - 1.13 kg. h^{-1}.

Galleon Harbour (Black River Bay - St. Elizabeth)

There are three vessels that trawl for shrimp in Black River Bay. These vessels fish for eleven hours (7 p.m. - 6 a.m.). A trawl lasts for approximately 2 hours. Catch ranges between 7.26 - 27.22 kg after eleven hours. This averages 0.1145 - 12.35 kg. h^{-1}.

Surveys on Shrimp and Related Resources

Several surveys have been conducted in the past to assess the potential for development and the status of the shrimp resource in Jamaica. A brief synopsis of these are given below. The studies examined below are those of Iverson and Munro (1967), Chin (1991), Chuck (1962) and Sahney (1981).

Socio-economic Analysis

Table 1: Total quantity and value by parish, 1962 (adapted from 1962 sample survey of the fishing industry in Jamaica).

PARISH	QUANTITY (lbs)	VALUE (£)
St. Thomas	66	4
Kingston & St. Andrew	151,384	23,973
Westmoreland	915	127
Hanover	9,279	928
St. Ann	902	68
TOTAL	162,546	25,100

The 1962 frame survey of the Jamaican Fishing Industry, sampled fifty two fishing beaches across the island over a one year period. Both mechanized and unmechanized boats were sampled in this survey. Seven hundred and fifty seven fishing boats out of 3,487 boats. It was estimated that this number of boat trips made during this survey was 496,615. The total quantity of shrimp caught was 73,884 kg. This was valued at 25,100 J pounds. This survey also showed that the south coast was more productive than the north coast in terms of quantity of shrimp caught.

Sahney conducted a similar survey of the Jamaican Fishing Industry in 1981. This study also reinforced the importance of the South Coast as a shrimp ground. The sample survey of 1981 reported a total yield of 10,003 kg of shrimp caught with a value of J$102,632. The yield represented 0.1% of the total catch and 0.3% of the dollar value for the exploited fisheries.

Abundance and Distribution of Shrimp Stocks

Various studies have looked at the abundance and distribution of shrimp stocks in Jamaica. Iverson and Munro conducted studies to evaluate the feasibility of areas for commercial shrimp fishing. This study was conducted in 1958 in Kingston Harbour (Hunts Bay) and then extended along the South Shelf between November 1966 and May 1967. The study showed that trawling for commercially valuable species of shrimp was feasible in all areas where the substrate was smooth and muddy. These areas being Kingston Harbour, Portland Bight and the offshore shelf at Pedro Bay. The species encountered were *Penaeus duorarum, P. schmitti* and a few species of *Trachypenaeus*.

Subsequent studies by Chin (1991) revealed that seven species of penaeid shrimp were found along the south shelf: *Penaeus brasiliensis, P. duorarum, P. notialis, P. schmitti, Sicyonia laevigata, Trachypenaeus constrictus* and *Xyphopenaeus kroyeri*.

Penaeus brasiliensis and *P. notialis* were found at all seven stations during the survey. *P. notialis* represented 76.5% of all shrimp caught and was dominant at most stations 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 stations. These species were mainly concentrated in the Kingston Harbour. *P. schmitti* were found only in waters of low salinity and therefore recorded high yields in Hunts Bay and Fort Augusta. Reeson (1971) reported the presence of *P. schmitti* and *P. duorarum* in the Great Salt Pond (1971). It is believed that the change in salinity due to the opening of the pond may have caused the disappearance of the species.

Seasonality

There was an expressed seasonality in catch rates. 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). He reported that the cooler months of the year produced an increase in the abundance of shrimp (December - March). The lowest catch was during the summer.

Reproduction

Chin observed that ripe females were caught all year round. However the number of shrimp with ripe ovaries increased during April 1994.

Size

Chin's study revealed the following size ranges for the various species of shrimp caught:

S. laevigata	20-29mm
T. constrictus	40-49mm
X. kroyeri	80-89mm
P. brasiliensis	90-99mm
P. duorarum	80-89mm
P. notialis	20-195mm

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

Iverson and Munro recorded good yields in all areas of Kingston Harbor, mainly in depths 5 - 18m. In February 1958, more than 75% of shrimp taken were *P. schmitti* and in a later survey (1967 - 1968) 95% were *P. duorarum*. Most of the shrimp taken in 1958 were in the 9m depth and between 1967-1968 concentrated on the deeper areas. The catch rate was an average of 25 shrimp per 15 minute haul. The Pedro bay area (20-30 m depths) recorded slightly lower yields in 1967. Iverson and Munro divided Kingston Harbour into three zones, the Main Basin, the Outer Harbour and Hunts Bay. The mean yield per hour for these three stations was 0.681 kg and 0.5 kg respectively. Iverson and Munro recorded individual catch rates of 1.99 kg. h^{-1}.

Catch Rates (Iverson and Munro, 1967)

Area	Shrimp (mean yield per hour)
Main Basin	0.675 kg (1.5 lbs)
Hunts Bay	0.675 kg (1.5 lbs)
Outer harbour	0.495 kg (1.1 lbs)

Individual catch rates were sometimes as high as 1.98 kg (4.4 lbs) of shrimp per hour. This, Munro and Iverson believed, could be more indicative of what could be caught in commercial operations. Other edible fish were caught in the trawls. These, Munro suggested, could be used to supplement the catch.

Chin (1991) recorded an average catch rate of 1.10 kg. h^{-1}. Most 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}). Reeson (1971) using two types of gear recorded the yields shown in Tables 2 and 3.

Table 2: Total gill net catch from the Great Salt Pond.

	NUMBERS	PERCENTAGE
P. schmitti	181	75.4
P. duorarum	11	4.6
Other Fish		20

Table 3: Trawl composition of penaeid shrimp in the Great Salt Pond.

	NUMBERS	PERCENTAGE	NET WGT (g)	PERCENTAGE
P. schmitti	181	75.4	315.1	4.1
P. duorarum	11	4.6	3328.8	43.1
Other Fish		20		

P. schmitti was the most abundant species caught using the gill nets, however, this may be a consequence of gear selectivity and the smaller size of *P. duorarum*. In the trawl survey, *P. duorarum* represented approximately 74% of the catch and 43% of the total biomass. The approximate density of penaeids in the Great Salt Pond was 0.04 m^{-2}.

P. notialis represented 76.5% of total catch for all seven stations sampled. The highest yields coming from Plumb Point Lagoon, Fort Augusta and the Great Salt Pond. *P. brasiliensis*, *P. schmitti* and *X. kroyeri* represented 6.9%, 6.0% and 6.6 % respectively. Together they comprised 19.5% of the total shrimp catch by numbers. *P. duorarum, P. schmitti* and *T. constricts* represented only 4% of the shrimp caught. These may be considered as marginal species in terms of distribution and abundance. Originally *P. notialis* was believed to be a sub-species of *P. duorarum* therefore it is possible that reports by Reeson (1971) and Munro (1968) on the distribution and abundance of *P. duorarum* may have actually been lumped with *P. notialis* or *P. notialis* misidentified as *P. duorarum* (Chin 1991).

The three stations indicated above provided 65.2% of the shrimp caught in the study. The three stations contributed 43.0% of the total fishing effort. The data showed that 35.4% of the shrimp caught were from the Plumb Point Lagoon which had a mean yield of just over 2.0 kg. h^{-1}. In Hunts Bay, *P. schmitti* represented 52.3% of the catch and *X. kroyeri* represented 69.6% of the catch at Farquhars Beach.

Management

There is currently no management plan for the shrimp fishery. However, the regulations for the fishing industry fall under the Fishing Industry Act (1975) and the regulations of 1976. The Jamaica fishery is an open access one. All fishers are given concessions on the importation of fishing gear and equipment and also the purchase of fuel. It is required under the Fishing Industry Act, 1975, that all fishers be licenced and registered. The licences are renewable annually.

Based on their preliminary investigations of 1967, Iverson and Munro recommended that the shrimp fishery could support a small trawl fishery especially in the Kingston Harbour. The potential catch was then estimated at between 182,000 and 364,000 kg of shrimp per year on the basis of known yields from other areas of the tropics. Pair trawling using canoes fitted with outboard motors was recommended. This would lessen the start-up cost and be more appropriate to the artisanal fisherman.

Chin (1991) and Iverson and Munro noted that shrimp were less abundant during the summer. 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.

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

The management and regulation of the Jamaican Shrimp fishery could include the following:

a. The development and implementation of a data collection and monitoring system.
b. Habitat protection through protection of nursery areas;
   - banning fishing in certain nursery areas, limiting catches in nursery areas
   - banning the use of certain fishing gear in nursery areas.
c. Community education and participation.
d. Development of closed seasons based on period of low catches; peak spawning periods.
e. Zonation of the fishery and gear regulations.

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National Report on the Shrimp & Groundfish Fisheries of Suriname

P. Charlier[1], R. Lieveld[1] Y. Babb-Echteld[1]

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SHRIMP FISHERY

PRESENT SITUATION OF THE SHRIMP INDUSTRY

Fishing Activities

The Fishing Grounds

The fishing grounds exploited by the shrimp fishery in Suriname have been described in the national report prepared for the preceding session of the workshop (Charlier, *et al.* 1992).

The Fleet

Table 1: List of trawling companies and average characteristics of the vessels in 1995.

COMPANY	# BOATS	AVERAGE HP	AVERAGE LENGTH (m)	FLAG
Landing at SAIL				
Dong hee	8	425	20.88	Korea
Seoyang	7	365	20.42	"
Woojin	3	385	20.59	"
Young Jin	4	365	20.65	"
Jin Min	1	425	20.83	Vanuatu
Atlantic Star	1	365	19.63	"
Kaya Fisheries	3	365	19.63	"
Mona Fisheries	3	365	19.63	Panama
Se Won	2	425	20.80	Korea
Sae Woo	3	375	20.42	"
O Ri Fisheries	1	425	20.36	"
Shin Yang Trading	5	425	20.90	
Sugam	14	425	20.83	Suriname
S and V Seafood	2	425	20.84	"
Weibolt	1	375	-	"
Landing at SUJAFI				
Hakodate Kokai	16	425	19.07	Japan
Nisshin Maru	15	425	19.47	Japan
June enterprise	6	425	19.92	Vanuatu
Dong Nam	2	425	20.87	Korea
Estemar	1	425	19.98	Honduras
WooRi	7	425	19.87	Honduras & Japan
Chang Boksi	1	425	19.96	Honduras
Other landing places				
Weibolt	1	425	19.47	Suriname
Nelo Fisheries	3	425	20.92	Suriname
Cevihas	4	650	35.44	Curacao
Neptune Fisheries	5	425	20.88	Suriname
Jinnoe	1	85	14.22	"
Zwaluw	1	-	-	"
Liesdek	1	-	-	"
Guiana Seafoods	5	-	-	"

[1] Fisheries Department, Ministry of Agriculture, Livestock and Fisheries, Paramaribo, Suriname.

The shrimp trawler fleet was owned, in 1995, by 22 fishing companies, listed in Table 1. The fleet can be divided into:

- Japanese fleet (2 companies operating under Japanese flag) ;
- Korean fleet (hoist a number of different flags) ;
- Surinamese fleet, of which the SUGAM company is the main component. (Most of SUGAM boats are rented, operated and/or manned by Korean companies. The strategy of this fleet can be compared to the Korean fleet.)

All shrimp trawling companies use the same type of boat, the traditional double-rigged "Florida" or "Gulf of Mexico" trawler type. Differences in the gear (number of nets) and engine power are fading as old boats are replaced by 425 HP trawlers with 4 nets.

Almost all shrimp landings take place at the two shrimp processing facilities SAIL (Suriname American Industries Limited) and SUJAFI (Suriname Japan Fisheries).

Besides the shrimp fleet, there is a growing number of trawlers operating mainly on fin-fish. Except for part of the SUGAM fleet, which delivers at SAIL, most of the fin-fish trawlers use other landing places. Part of this fleet consists of former shrimp trawlers using a gear adapted to increase the fin-fish catch. The fleet includes also larger vessels, with engine power generally higher. The vessels operated by Guiana Seafoods are targeting sea-bob.

The number of trawlers with a fishing license, over the last 5 years, is shown in Table 2, for each company.

Table 2: Number of registered trawlers (shrimp, fin-fish) by year.

COMPANY	1991	1992	1993	1994	1995
Shrimp trawlers landing at SAIL					
Seoyang	7	7	7	7	7
Woo Jin	7	6	6	4	3
Atlanta Shrimp Company	1	1	1	1	-
Atlantic Star	1	-	1	1	1
Jin Min	3	1	1	1	1
Marine Enterprises	7	7	7	7	-
Silla Trading	11	5	-	-	-
Sugam	14	12	11	11	10
Weibolt	2	2	2	2	1
Young Jin	5	5	5	5	4
Mona Fisheries	4	4	3	3	3
Kaya Fisheries	3	3	3	3	3
Dong Hee	8	8	8	8	8
Sae Woo	4	4	4	3	3
Bogo Fisheries	2	1	-	-	-
Sung Ha Fisheries	5	4	4	7	-
Se Won	3	3	2	2	2
Jaha Fisheries	-	3	2	-	-
n.v. Kabla	-	2	2	-	-
O Ri Fisheries	-	1	1	1	1
Shin Yang	-	-	5	5	5
S and V Seafoods	-	-	-	-	2
TOTAL	87	79	75	71	54

Table 2: Number of registered trawlers (shrimp, fin-fish) by year.

COMPANY	1991	1992	1993	1994	1995
Shrimp trawlers landing at SUJAFI					
Nisshin Gyogyo	18	17	15	15	15
Hakodate Kokai	16	16	13	16	16
Dong Jo	3	3	-	-	-
June	6	6	6	6	6
Dong Nam	2	2	2	2	2
Estemar	1	1	1	1	1
WooRi	6	7	8	7	7
Chang Boksi	-	-	-	1	1
TOTAL	52	52	45	48	48
Fin-fish and sea-bob trawlers					
Sugam	5	5	6	5	4
Weibolt	1	1	1	1	1
Neptune	-	2	5	5	5
Oceanic Fishery	-	1	-	-	-
Caribbean Seafoods	-	1	-	-	-
Zwaluw	-	1	1	1	1
Cevihas	-	-	2	4	4
Soeboer	-	-	1	1	-
Scholsberg	-	-	1	1	-
Nelo Fisheries	-	-	1	1	3
Surya	-	-	2	-	-
Liesdek	-	-	-	1	1
Guiana Seafoods	-	-	-	-	5
Jhinnoe	-	-	-	-	1
TOTAL	6	11	20	20	25

Fishing Strategies, Discards, Artisanal Fishery

No new element of knowledge has been obtained on these subjects since the last workshop.

Processing Activities

The respective shares of the two processing plants (SAIL and SUJAFI) have remained around 60%: 40% of the landings. A third plant has been established in 1995 and is scheduled to start operating in 1996, processing and packaging mainly sea-bob.

Table 3: Production by processing plant in 1994.

SAIL: Shrimp (head-off weight)	1,410 tons
SUJAFI: Shrimp (head-off weight)	
Korean fleet	444 tons
Japanese fleet	580 tons

Each fishing company is under contract with one of the processing companies and delivers exclusively there. Currently 7 companies, of which 2 are Japanese and 5 are Korean deliver to SUJAFI, and 15 companies, of which 12 are Korean (different flags) and 3 are Surinamese are bound by contract to SAIL. The total number of vessels landing at SAIL is 58 versus 48 for SUJAFI.

Marketing Activities

The amounts sold locally by both processing companies show a decreasing trend (Table 4). As the categories which were traditionally reserved for the local market find their way to new export markets. Local sales by SUJAFI have become negligible.

Table 4: Local shrimp sales by the shrimp processing companies.

	1991	1992	1993	1994
SAIL				
amounts (tons)	349	428	296	218
value (1000 Sf)	15,860	24,830	54,438	198,727
SUJAFI				
amounts (tons)	130	65	14	7
value (1,000 Sf)	7,730	4,584	4,456	9,730

The bulk of the shrimp production is exported. Table 5 shows the volumes exported, from each of the processing plants, in the last years.

Table 5: Shrimp exports.

	1991	1992	1993	1994
SAIL				
Amounts (tons, head-off weight)	1,300	1,236	1,130	1,333
Value (1,000 US$)	17,604	16,337	15,030	19,652
SUJAFI				
Amounts of :				
Shrimp head-off (tons)	397	679	388	341
Shrimp head-on (tons, head-off weight)	418	267	342	448
Value (1,000 US$) :				
Shrimp head-off	n.a.	n.a.	6,055	5,370
Shrimp head-on	n.a.	n.a.	6,588	8,741

The main destination is Japan. The exports towards European countries have been significant in the last years, but remain largely below the Japanese share. Negligible amounts are marketed in the Caribbean (Curacao).

Table 6: Shrimp exports by destination in 1993-94.

	COUNTRY OF DESTINATION	QUANTITY (%)	VALUE (US $)
SAIL (1993)	Japan	71.7%	80.0%
	Belgium	14.2%	10.2%
	France	13.0%	9.5%
	Netherlands	0.8%	0.1%
	Curacao	0.3%	0.2%
SAIL (1994)	Japan	75.2%	83.9%
	Belgium	4.9%	3.1%
	France	17.1%	11.8%
	Netherlands	2.7%	1.2%
	Curacao	0.1%	0.1%
SUJAFI	Japan	100%	100%

RESULTS OF THE EXPLOITATION

Effort

The data available on effort include the number of boats licensed, the number of trips (deliveries) and the number of days at sea. The number of days at sea has been obtained for the vessels landing at SAIL since 1983 (see Table 7). More accurate effort units, like the number of hauls or of trawling hours could be extracted from the logbooks (not done currently).

Tables 8 and 9 show the distribution of effort from January to December 1994. The level of effort does not vary much from month to month. The slight peak which is generally observed in April-May (usually the best yields) can be detected in the number of days at sea (SAIL). There was a low in July and again in the last months of the year.

Data on the geographical distribution of effort are requested through the logbook system. The information has not been analysed yet.

Table 7: Annual effort by fleet.

	NUMBER OF DELIVERIES				NUMBER OF DAYS AT SEA
		SUJAFI			
YEAR	SAIL	KOREAN	JAPANESE	TOTAL	SAIL
1977		145	248		
1978	610	53	231	894	
1979	506	57	230	793	
1980	387	128	209	724	
1981	581	125	265	971	
1982	584	226	253	1,063	
1983	474	281	199	954	22,245
1984	485	291	182	958	23,646
1985	384	122	208	714	20,673
1986	388	49	215	652	23,415
1987	410	81	178	669	26,227
1988	425	113	167	705	27,273
1989	420	103	223	746	23,813
1990	381	104	227	712	21,797
1991	268	110	233	611	18,179
1992	298	119	242	659	20,651
1993	254	103	209	566	17,829
1994	235	105	231	571	17,786

Table 8: Distribution of effort (# deliveries) by month in 1994.

	1991			
		SUJAFI		
MONTH	SAIL	KOREAN	JAPANESE	TOTAL
January	18	10	20	48
February	18	8	22	48
March	19	9	15	43
April	18	8	20	46
May	22	6	20	48
June	21	7	19	47
July	18	7	17	42
August	26	13	19	58
September	23	8	21	52
October	18	8	20	46
November	18	10	18	46
December	16	11	20	47

Table 9: Distribution of effort (# days at sea, SAIL) by month in 1994.

MONTH	1991
January	1,574
February	1,236
March	1,418
April	1,648
May	1,762
June	1,735
July	1,108
August	1,961
September	1,555
October	1,359
November	1,378
December	1,052

Catch and landings

Table 10 presents the landings of each fleet for the years 1973-1994. All figures are expressed in head-off equivalents (tail weight). The figures for the years 1992-1994 are still provisional. The yearly production shows important fluctuations, with series of good years alternating with series of less favourable ones. After the last series of good years in 1986-1987, however, no real peak year has been observed. The production of "maximum" year 1991 (2,828 tons) remained well below the level reached in earlier peak years (around 3,500 tons).

The monthly pattern is shown in Table 11, based on the averages of the monthly landings during the period 1987-1991. Table 12 gives the monthly landings in the year 1994.

Table 10: Total landings by year and by fleet (in kgs of tails).

	HEAD OFF LANDINGS				HEAD ON	TOTAL
		SUJAFI			SUJAFI	(HEAD-OFF +
YEAR	SAIL	KOREAN	JAPANESE	TOTAL	(JAPANESE)	HEAD-ON)
1973	1,581,211					1,791,000
1974	1,425,290					2,022,000
1975	2,166,278					3,167,000
1976	2,771,022			3,613,588	168,030	3,781,618
1977	2,730,876	383,942	570,106	3,684,924	280,373	3,965,297
1978	1,916,555	150,676	496,350	2,563,581	187,461	2,751,043
1979	2,424,671	149,340	385,976	2,959,987	268,507	3,228,495
1980	1,793,858	546,667	403,160	2,743,685	327,155	3,070,840
1981	2,340,816	638,830	514,904	3,494,550	352,183	3,846,733
1982	1,645,442	991,264	306,948	2,943,654	484,092	3,427,746
1983	1,613,907	1,159,622	151,294	2,924,823	378,934	3,303,758
1984	1,516,090	874,262	72,558	2,462,910	294,700	2,757,610
1985	1,479,790	391,912	79,706	1,951,408	481,109	2,432,518
1986	2,196,969	238,172	313,976	2,749,117	562,758	3,311,876
1987	2,447,690	472,056	256,550	3,176,296	312,690	3,488,986
1988	1,903,630	423,198	117,046	2,443,874	311,009	2,754,883
1989	1,398,167	313,274	80,330	1,791,771	381,843	2,173,614
1990	1,671,362	337,290	67,128	2,075,780	490,442	2,566,222
1991	1,691,050	512,792	198,798	2,402,640	425,585	2,828,225
1992	1,549 t	544 t	317 t	2,410 t	262 t	2,672 t
1993	1,486 t	431 t	171 t	2,088 t	346 t	2,434 t
1994	1,410 t	444 t	125 t	1,979 t	455 t	2,434 t

Table 11: Average pattern of the monthly landings over the year (1987-1991).

MONTH	SAIL	SUJAFI (HEAD-OFF) KOREAN	SUJAFI (HEAD-OFF) JAPANESE	SUJAFI (HEAD-ON)	TOTAL
January	205,226	33,981	17,212	51,442	307,861
February	144,897	36,674	17,520	32,954	232,045
March	159,785	35,701	15,602	34,452	245,540
April	162,934	38,210	11,794	37,988	250,926
May	159,819	32,520	9,947	24,902	227,189
June	130,392	28,602	8,920	29,911	197,825
July	138,191	26,186	10,791	29,546	204,713
August	118,674	33,000	9,198	34,534	195,406
September	138,146	28,825	8,554	25,668	201,192
October	171,963	43,235	9,050	27,159	251,407
November	145,662	41,793	14,188	38,334	239,976
December	146,690	32,995	11,196	17,424	208,305

Table 12: Monthly landings in 1994.

MONTH	SAIL	SUJAFI (head-off) KOREAN	SUJAFI (head-off) JAPANESE	SUJAFI (HEAD-ON)	TOTAL (EQ. H OFF)
January	153,196	36,668	14,066	58,776	240,685
February	124,506	44,112	12,912	48,324	211,733
March	131,566	40,306	15,068	75,321	234,016
April	160,474	49,682	17,896	102,312	291,997
May	138,745	28,888	10,326	55,506	212,650
June	119,654	22,404	4,818	45,813	175,509
July	64,248	19,184	2,436	26,187	102,235
August	116,253	27,706	6,288	59,979	187,734
September	110,612	47,192	10,688	66,546	210,083
October	107,456	49,624	8,048	50,073	196,424
November	109,127	25,958	14,634	82,779	201,456
December	73,743	52,318	8,830	56,685	169,519

Catch per Unit of Effort

The best CPUE data available for the entire fleet is the landing per delivery. The landing per day at sea is only Available for the vessels landing at SAIL.

Table 13 gives the average value of each of these CPUE units for each component of the shrimp trawler fleet between 1977 and 1994. It demonstrates that the average landing per day at sea of the vessels landing at SAIL follow the same trend as the average landing per trip (for the whole fleet). The CPUE's of all components of the fleet (Korean/SAIL, Korean/SUJAFI, Japanese) also display similar pattern.

Table 14 produces the monthly CPUE values in 1994. A season of generally higher yields is recognizable in the first months of the year, particularly in March-April. The lowest yields were obtained from June to August, for both indices (kg per day at sea and kg per delivery).

Table 13: Annual catch per unit of effort, per fleet.

YEAR	LANDING (kg tails) PER DELIVERY				LANDING (kg tails) PER DAY AT SEA (SAIL)
	SAIL	SUJAFI		TOTAL	
		KOREAN	JAPANESE		
1977		2,648	3,429		
1978	3,142	2,843	2,960	3,077	
1979	4,792	2,620	2,846	4,071	
1980	4,635	4,271	3,494	4,241	
1981	4,029	5,111	3,272	3,962	
1982	2,818	4,386	3,127	3,225	
1983	3,405	4,127	2,664	3,463	72.5
1984	3,126	3,004	2,018	2,878	64.1
1985	3,854	3,212	2,696	3,407	71.6
1986	5,662	4,861	4,078	5,080	93.8
1987	5,970	5,828	3,198	5,215	93.3
1988	4,479	3,745	2,563	3,908	69.8
1989	3,329	3,041	2,073	2,914	58.7
1990	4,387	3,243	2,456	3,604	76.7
1991	6,310	4,662	2,680	4,629	93.0
1992	5,198	4,571	2,395	4,055	75.0
1993	5,850	4,585	2,484	4,300	83.3
1994	6,000	4,150	2,555	4,263	79.3

Table.14: CPUE per month, 1994.

MONTH	LANDING PER DELIVERY (KG)				LANDING PER DAY AT SEA (SAIL)
	SAIL	SUJAFI		TOTAL	
		KOREAN	JAPANESE		
January	8,511	2,920	2,780	5,014	97.3
February	6,917	4,379	2,673	4,411	100.7
March	6,925	5,007	4,051	5,442	92.8
April	8,915	4,927	3,026	6,348	97.4
May	6,307	4,241	2,179	4,430	78.7
June	5,698	3,201	1,761	3,734	69.0
July	3,569	2,887	1,771	2,434	58.0
August	4,471	3,994	2,068	3,237	59.3
September	4,809	4,390	2,404	4,040	71.1
October	5,970	5,117	2,495	4,270	79.1
November	6,063	3,561	2,965	4,379	79.2
December	4,609	4,248	2,723	3,607	70.1

Table 15 presents the global parameters of the fishery since 1973 (total landing, total effort and average CPUE per year.

ASSESSMENT OF THE RESOURCES, ECONOMIC ASPECTS, SECONDARY RESOURCES

Little progress has been made in the knowledge of these aspects during the intersessional period. It should be mentioned that the sampling programme on the shrimp landings at the processing plants has been discontinued in 1993. The review provided in the national report prepared for the preceding meeting remains applicable.

Table 15: Annual landings, effort and CPUE.

YEAR	TOTAL LANDINGS (TONS OF TAILS)	TOTAL EFFORT (NUMBER OF DELIVERIES)	CPUE	
			LANDING PER DELIVERY	LANDING PER DAY AT SEA (SAIL)
1973	1,791,000			
1974	2,022,000			
1975	3,167,000			
1976	3,781,618			
1977	3,965,297			
1978	2,751,043	894	3,077	
1979	3,228,495	793	4,071	
1980	3,070,840	724	4,241	
1981	3,846,733	971	3,962	
1982	3,427,746	1,063	3,225	
1983	3,303,758	954	3,463	72.6
1984	2,757,610	958	2,879	64.1
1985	2,432,518	714	3,407	71.6
1986	3,311,876	652	5,080	93.8
1987	3,488,986	669	5,215	93.3
1988	2,754,883	705	3,908	69.8
1989	2,173,614	746	2,914	58.7
1990	2,566,222	712	3,604	76.7
1991	2,828,225	611	4,629	93.0
1992	2,672 t	659	4,055	75.0
1993	2,434 t	566	4,300	83.3
1994	2,434 t	571	4,263	79.3

SURVEYS ON SHRIMP AND RELATED RESOURCES

The program of investigations on the recruitment mechanisms of *Penaeus subtilis*, announced in the 1992 national report, has been carried out by the Fisheries Department, in collaboration with the "Institut Français de Recherche pour l'Exploration de la Mer" (IFREMER), in 1993 and 1994. The main conclusions of the programme may be formulated as follows :

1. The supposed recruitment seasons did not appear as clearly as preliminary analyses on the size composition of the shrimp landings would lead to expect. Intensive recruitment has not been observed, in fact, during any of the surveys. The occurrence of juvenile shrimp in the landings of the commercial fleet, on which base recruitment seasons were assumed, might have as much to do with fleet strategy, exploiting particular fishing grounds at certain times of the year, as with real recruitment.
2. Another commonly admitted notion that seems contradicted by the results is that recruitment takes place in shallow waters, after which shrimp gradually migrate towards greater depths, resulting in gradient in average sizes. In fact, recruits have almost never been observed in very shallow waters (under 20 metres) during this programme, while concentrations of small-size brown shrimp have been detected in the 20-40 metres depth range.
3. Within the favourable zones, the recruits distribution appears very patchy. Even assuming that annual recruitment could be described by an index obtained in a particular season, obtaining reliable estimates of recruit density would probably require very extensive (and costly) sampling.
4. The apparent brown shrimp biomass estimates have been consistently much lower than expected. Possible explanations are the patchiness of the distribution (such that most of the biomass is concentrated in limited areas) and the retention factor (which has been given a value 1 in all

biomass calculations). For the same reasons mentioned in the previous paragraph, correct biomass estimates will be difficult be obtained by surveys, unless sampling effort is considerably increased.

5. The distribution by depth of the brown shrimp shows that maximum densities (within the surveyed area) were found, throughout the surveyed period, between 10 and 30 metres depth. A gradient towards larger sizes with increasing depth has not been observed.
6. The estimates obtained for the total fin-fish biomass have consistently fallen in the range 90,000 tons to 150,000 tons for the area included between 0 and 40 metres depth. It should be pointed out that the figures represent really the biomass accessible to the shrimp trawl, which is fitted out in a way to reduce the fin-fish catch as much as possible (small vertical opening). As for the shrimp estimates, fin-fish biomass has been calculated assuming a retention factor equal to 1, while this factor, depending on the species, could be much lower. The figures obtained should therefore be seen as minimal estimates to be compared with other methods results. The fin-fish/shrimp ratios should not be extrapolated to the commercial fleet and used, for example, to estimate amounts of by-catch harvested by the shrimp trawlers.
7. While stratification of the sampling scheme has been based exclusively on depth (by lack of better information), it has been felt throughout the programme that depth is only one of several important factors in the distribution of stocks, shrimp as well as fin-fish. The presence of several types of bottom has been noted. A much better stratification (hence closer estimates) could have been .worked out if information on the nature of the bottom had been available. It is suggested that the preparation of updated charts of the continental shelf, presenting detailed information on depth and bottom type, would be a step of extreme importance towards a better mapping, assessment and management of fishery resources in Suriname.

MANAGEMENT

Fisheries in Suriname are regulated by the Decree on Marine Fishery (Decree C-14), operational since 1 January 1981. This legislation has been revised and a new fisheries law has been drafted in 1992. It has not yet been promulgated yet, however. The new draft law i.a. prescribes the elaboration of annual management plans, in which all concrete regulation measures will be established, providing a flexible tool to adapt fisheries management to the changing conditions of the exploitation.

Regulations currently in force have been outlined in the national report written for the 1992 workshop.

GROUNDFISH (SOFT BOTTOM) FISHERY

THE ARTISANAL GROUNDFISH FISHERY

Fishing Zones and Areas

Fishing activities are carried out in marine waters, brackish waters, rivers and other inland water bodies. Areas available by depth are estimated in Table 16.

Types of Fishing Units, Classification into Fleets

Fishing vessels operating in Suriname waters can be classified (from largest to smallest) into trawlers, snapper boats, decked Guyana boats, open Guyana boats (without deck) and korjaal (canoes of different types). A number of small fishing devices are operated without a boat.

The main fishing gears are trawls (shrimp trawl, fish trawl), vertical hook and lines, drifting gillnets, kieuwnet and spannet (fixed gillnets), njawarie (pin seine), fuiknet (Chinese seine) of different sizes, haritete (river seine), drag nets.

Table 16: Depth zones and approximate areas.

FISHING ZONE	ESTIMATED AREA (km^2)
Sea (depth zones) [1]	
90-100 m	1,700
80-90 m	4,700
70-80 m	3,000
60-70 m	3,400
50-60 m	5,000
40-50 m	7,800
30-40 m	10,300
20-30 m	10,200
10-20 m	3,500
0-10 m (including estuaries)	7,200
Brackish water lagoons [2] (including mangroves)	474
Rivers	n.a.
Other inland water	n.a.

[1] Estimates based on available marine charts (dating from 1970)

[2] Estimated in 1989 by LBB (Forestry Department), based on 1970 aerial photographs

Fleets can be defined as combinations of boat and gear. Table 17 shows the combinations which are found in Suriname (X) and individualizes fleets (bold frames). Gillnets operated from decked and not decked (open) Guyana boats are considered separately. The vessels fishing with njawaries, however, can be seen as a single fleet, as the type of boat has no influence on the method, yield, fishing grounds. Each component of the fuiknet fleet should be taken separately.

A category "other" will include various types of gears of secondary importance, operated either from a korjaal or without a boat.

Table 17: Definition of fishing fleets.

	TYPE OF VESSEL						
TYPE OF GEAR	SHRIMP TRAWLER	FINFISH TRAWLER	SNAPPER BOAT	DECKED GUYANA BOAT	OPEN GUYANA BOAT	KORJAAL	NO BOAT
Trawl	X	X					
Hook & line			X				X
Drifting gillnet				X	X	X	
Njawarie				X	X		
Bottom longline					X	X	
Large fuiknet						X	
Med fuiknet						X	
Small fuiknet						X	
Kieuwnet						X	X
Haritete						X	
Lagoon drag net						X	X
Estuary drag net						X	X
Spannet						X	X
Chast-net							X

The fishing grounds exploited by each of the above fleets can be outlined as shown in Table 18.

Table 18: Fishing grounds by fleet.

TYPE OF BOAT	TYPE OF GEAR	FISHING GROUNDS	DEPTH ZONE
Trawler	Shrimp trawl	sea	20-80 m
Trawler	Fish trawl	sea	10-30 m
Snapper boat	Hook & line	sea	40-80 m
Decked Guyana	Drifting gillnet	sea	5-20 m
Open Guyana	Drifting gillnet	sea	5-10 m
Decked & Open Guyana	Njawarie	sea	0- 5 m
Open Guyana	Bottom longline	sea	2-10 m
Korjaal	Drifting gillnet	estuaries	2- 5 m
Korjaal	Fuiknet (various sizes)	estuaries	2- 5 m
Korjaal	Bottom longline	estuaries	2- 5 m
Korjaal	Kieuwnet	brackish lagoons	0- 1 m
Korjaal	Haritete	rivers	
Korjaal & no boat	Other	rivers & inland	

Number of Fishing Units Belonging to Each Fleet

Based on the licencing system, Table 19 shows the number of vessels of each type.

Table 19: Number of registered fishing units in 1991.

TYPE	NUMBER
Shrimp trawlers	137
Finfish trawlers	7
Snapper liners	0
Decked Guyana gillnetters	47
Open Guyana gillnetters	142
Njawaries	27
Open Guyana longliners	3
Korjaal gillnetters	91
Fuiknetten }	301
Korjaal longliners }	
Kieuwnetters	143
Haritete	10
Other	40

CATCH AND EFFORT

Effort

The number of days at sea (das) is recorded for the vessels that perform trips of several days (trawlers, coastal gillnetters), and the number of trips for the rest of the fishing crafts. Effort estimates for the year 1991 are shown in Table 20. The fishing effort corresponding to the shrimp trawlers which do not deliver fin-fish (by-catch) is not included.

Table 20. Estimated effort by fleet in 1991.

FLEET	# DAYS AT SEA	# TRIPS	# LICENCES
Fish trawler	641	56	7
Shrimp trawler	15,375	205	87
Decked Guyana			
gillnet	5,913	300	47
Open Guyana			
gillnet	8,544	1,252	142
njawarie	7,232	713	27
longline	105	27	3
Fuiknet			
large		5,826	}
medium		3,711	} 301
small		15,720	}
Estuaries			
gillnet		5,049	91
longline		1,486	301
Haritete		710	10
Kieuwnet		11,563	143
Other		630	40

Landings

Table 21 presents the estimates obtained by the Fisheries Information System for the landings by fleet in 1991. It can be seen that the fleet operating in the coastal zone (decked and open Guyana type boats) accounts for the largest part of the production (3,293 tons, or 43 %). The landings originated from the estuarine region are also relatively important (2,595 tons, or 34 %). Gillnets of different types constitute the most widespread, and important in terms of production, of the fishing gears used.

Table 21: Estimated landings by fleet in 1991.

TYPE	LANDINGS (t)
Fish trawler	761
Shrimp trawler	297
Decked Guyana	
gillnet	1,585
Open Guyana	
gillnet	1,021
njawarie	664
longline	21
Fuiknet	
large	747
medium	230
small	801
Estuaries	
gillnet	700
longline	131
Haritete	70
Kieuwnet	574
Other	19

Landings per Unit of Effort

Landing per unit of effort estimates have been calculated monthly, for each type of fishing unit. Based on these results, the average landing per unit of effort was calculated for the year 1991 for each fleet, as well as the confidence limits of these estimates, shown in Table 22. Shrimp landings are not included in the calculation concerning the shrimp trawlers. Discards are not taken into account for any of the fleets, which is particularly important to remember in the case of the trawlers.

Table 22: Estimated landing per unit of effort, and its confidence limits (95%), by fleet, in 1991.

FLEET	LANDING PER UNIT EFFORT			
	UNIT	ESTIMATED	MINIMUM	MAXIMUM
Trawlers				
fin-fish	kg/day	1,187	816	1,569
shrimp	kg/day	19	9	30
Decked gillnetters	kg/day	268	137	411
Open gillnetters	kg/day	120	56	189
Njewaries	kg/day	92	50	139
Open longliners	kg/day	205	117	311
Fuiknet				
Large	kg/trip	128	90	168
Medium	kg/trip	62	55	69
Small	kg/trip	51	39	63
Estuarine gillnets	kg/trip	139	98	183
Estuarine longlines	kg/trip	88	61	119
Haritete	kg/trip	98	64	135
Kieuwnet	kg/trip	50	31	68
Other	kg/trip	29	12	49

AVAILABLE STOCK ASSESSMENT RESULTS

The assessment of groundfish (softbottom) resources is based on the data collected during several surveys carried out in the last thirty years. The two most recent surveys produced comparable results, with MSY estimates falling within the range 10,000 - 23,000 tons. Considering the areas on which these resources are distributed, densities are found to be lower than densities in tropical regions considered particularly productive.

A review carried out in 1992 concluded that a MSY of 16,000 tons would seem appropriate as a preliminary estimate (Charlier, 1993). A distinction was made between large species, caught mainly by the gillnet fishery, and smaller species, which form the bulk of the catch (and by-catch) of the trawlers. Large species would account for a MSY of about 5,000 tons (which comes down to a MSY of 0.24 t/km^2 if an even distribution of these species in the 0-30 metres depth range is assumed).

The remaining 11,000 tons would correspond to small demersal species. Considering that these species are present down to the depth of 50 metres, an average MSY of 0.28 t/km^2 can be estimated, Most of the biomass is concentrated in the depth range 0-30 metres.

According to those preliminary estimates, and to the estimated current harvest discussed above, the large demersal fish resource is already fully exploited and could become overexploited soon if fishery keeps expanding. Fishermen already report decreasing catch rates and point to a depletion of the stocks.

Small demersals are probably still underexploited. It is impossible to know how much more this stock could yield, however, as long as there is no proper estimate of the volumes destroyed by shrimp trawlers, in addition to the landings estimated by the F.I.S.

MANAGEMENT

As mentioned above, marine fisheries have been regulated, since 1980, by the Decreet C-47. The new draft law makes provision for the elaboration of management plans, where management issues will be discussed in detail. Table 23 shows guidelines for the management of softbottom demersal fish (Charlier, 1993).

Table 23. Guidelines for management of demersal (soft bottom) fish resources.

	LARGE DEMERSAL FISH	SMALL DEMERSAL FISH
Estimated MSY (tons)	5,000	11,000
Exploitation by	Full	Underexploited
main fleet	Drifting gillnet	Trawl
secondary fleet	Trawl, njawarie	Njawarie
Management objectives :		
- current objectives	1. Long term conservation 2. Earn foreign currency 3. Supply local market (= MSY) 4. Employment	1. Long term conservation 2. Local market/low cost protein (=MSY) 3. Foreign currency 4. Employment
- long term objectives	Idem at Maximum Economic Yield (MEY)	1. MEY 2. Low cost supply for local market 3. Employment
Problems & conflicts	1. Rapid development of the gillnet fleet 2. Poaching/landings abroad 3. Destruction of juveniles by trawls and njawaries	1. No specific fleet 2. Waste of small sizes (inappropriate technology) 3. Gear conflicts with gillnet fleet
Management strategy	- Restrict landings abroad and poaching - Control effort - Create shore facilities - Limit catch of juveniles	- Experiment new harvesting technologies - Reduce wastes - Regulate overlapping with fishing grounds exploited by other fleets
Types of regulations (tools)	- Heavy penalties (poachers) - Fix # licences - Depth zones - Mesh sizes - Prohibit unselective and destructive types of gears	- Technological experimentation - Regulate type of boat/gear - Depth zones

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National Report on the Shrimp & Groundfish Fisheries of Trinidad and Tobago

A. Jobity[1], R. Kuruvilla[1], M. Amos[1], L.Ferreira[1]

INTRODUCTION

This report presents an overview of the shrimp trawl Fisheries of Trinidad and Tobago, including developments since 1992, when the workshop on the biological and economic modeling of shrimp resources on the Guianas-Brazil shelf was held in Paramaribo, Suriname. At present, the Fisheries Division is engaged in a biological sampling programme of the trawl fishery, for stock assessment purposes. Existing catch/effort data are being analyzed and a logbook programme for the country's industrial and semi-industrial trawlers has been introduced.

The demersal trawl fishery is the country's most valuable fishery, in terms of landings, dollar value and foreign exchange earnings. The principal exploited species are the Penaeids (*Penaeus brasiliensis*, *P. notialis*, *P. schmitti*, *P. subtilis* and *Xiphopenaeus kroyeri*). Apart from the demersal trawl fishery, there also exists a seasonal beach seine shrimp fishery on the island's South Western peninsula and a cast net fishery in river mouths and mangrove areas for harvesting shrimp (Fabres, 1989).

DESCRIPTION OF THE SHRIMP INDUSTRY

FISHING ZONES, FLEET DESCRIPTION, AREAS OF OPERATION AND FISHING STRATEGIES

The demersal trawl fishery of Trinidad and Tobago consists of two (2) inshore, artisanal fleets, an offshore, semi-industrial and an offshore industrial fleet. Trawling occurs mainly in the Gulf of Paria on Trinidad's west coast, the Columbus Channel in the south, off the north coast and in the Orinico Delta under the Trinidad and Tobago/Venezuela Fishing Agreement. The characteristics and exploited areas of each region are given in Table 1.

Table 1: 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

There has been an expansion of both the artisanal and industrial trawl fleets over the years. In a overview of the shrimp industry, Jordan (1969) identified one hundred and sixty-six (166) locally registered (artisanal type) trawlers, ninety-five percent (95%) of which were active, and eighty-five (85) foreign-registered industrial trawlers fishing off the coast of Northeast South America (Guiana - Brazil Area) but landing their catch in Trinidad for processing and export. Chin Yuen Kee (1984), described the local trawl fishery as comprising of some two hundred and fifty (250) artisanal vessels, 22 Gulf of Mexico type trawlers, three (3) combination fish/shrimp trawlers and eight (8) mini-stern trawlers. In addition to these, the state owned National Fisheries Company Limited (NFC), had access to ten (10) Barbadian-owned Gulf

1 Fisheries Division, Ministry of Agriculture, Land and Marine Resources, Port of Spain, Trinidad and Tobago.

of Mexico type trawlers. In all, twenty (20) of the Gulf of Mexico type trawlers and the three (3) combined shrimp/fish trawlers were operated by the NFC Limited. Ten (10) of these vessels had access to Brazilian waters under a joint venture agreement with the Company. Other vessels, along with privately owned trawlers, operated within the twelve (12) nautical mile territorial waters of Trinidad & Tobago.

Table 2: Trawler categories.

TRAWLER CATEGORY	ENGINE TYPE	AVG HP	VESSEL LGT (m)	GEAR TYPE	AVG HEADROPE LGT (m)	# TRAWLERS IN CATEGORY
I (artisanal)	Outboard	2 x 56	6.7 - 9.8	1 stern trawl, manually retrieved	10.4	113
II (artisanal)	Inboard or Inboard/ 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	10
IV (industrial)	Inboard diesel	365	21.6 - 22.5	2 nets on outriggers, retrieved by hydraulic winch	12 x 13.5	23

Source: Fisheries Division Vessel Census, 1991. Fisheries Division Trawl Gear Survey, 1991. Fisheries Division vessel registration records, 1994.

An update of a census of fishing vessels conducted in November 1991, has identified some two hundred and twelve (212) active, locally registered trawlers. These vessels have been categorised into four (4) types according to their lengths, engine horsepower and degree of mechanisation (Table 2).

Shrimp and Finfish By-Catch is landed exclusively along the Gulf of Paria and the South-Western Peninsula. There are four (4) major landing sites: The National Petroleum (NP) facilities at Sea Lots which is the main landing site for industrial (Type IV) vessels, the Orange Valley Fish Market, where the semi-industrial (Type III) fleet is based, and the San Fernando and Otaheite Fish Markets, which are mainly Type II landing sites. The number of vessels operating at each landing site is given in Table 3. In addition, there are seven (7) lesser landing sites.

Table 3: Number of trawlers per landing site.

LANDING SITE	# TYPE I TRAWLERS	# TYPE II TRAWLERS	# TYPE III TRAWLERS	# TYPE IV TRAWLERS	TOTAL # OF TRAWLERS
Port of Spain	1		1	2	4
National Fisheries Co. Ltd.				16	16
Blue River	2				2
Cacandee Sluice	4	3			7
Waterloo	1	11			12
Orange Valley	4	12	9	5	30
Carli Bay	3				3
San Fernando	1	17			18
Otaheite	3	23			26
Bonasse	25				25
Fullerton	25				25
Icacos	44				44
TOTAL	113	66	10	23	212

Source: Fisheries Division Vessel Census, 1991. Fisheries Division vessel registration records (1994).

Vessels operating from Bonasse, Fullerton and Icacos are all Type I and trawl in the Gulf of Paria, however, some of these together with other similar vessels from Otaheite and Orange Valley are allowed to trawl in the Orinoco Delta between the months of December to June. These vessels normally operate at depths of 1.2 to 3.6m.

Type II and III vessels operate exclusively in the Gulf of Paria at depths of 1.8 - 18.0m and 9.0 - 41.4m respectively. Type IV vessels fish all year round in the Gulf of Paria (between 18 - 41.4m) and in the Columbus Channel (between 9.0 - 57.6m). These vessels also fish on the North Coast during the months of October to January at depths of 37-58m. The depth fished and areas of operation of each vessel type were determined from interviews with trawl fishermen by staff of the Fisheries Division during January 1992 - April 1992. These areas are given in Figure 1. The existence of the Fisheries (Control of Demersal [bottom] Trawling Activities) Regulations, provides a regime which governs the area where trawl activity can occur with regard to depths and distance from the coastline as related to vessel type.

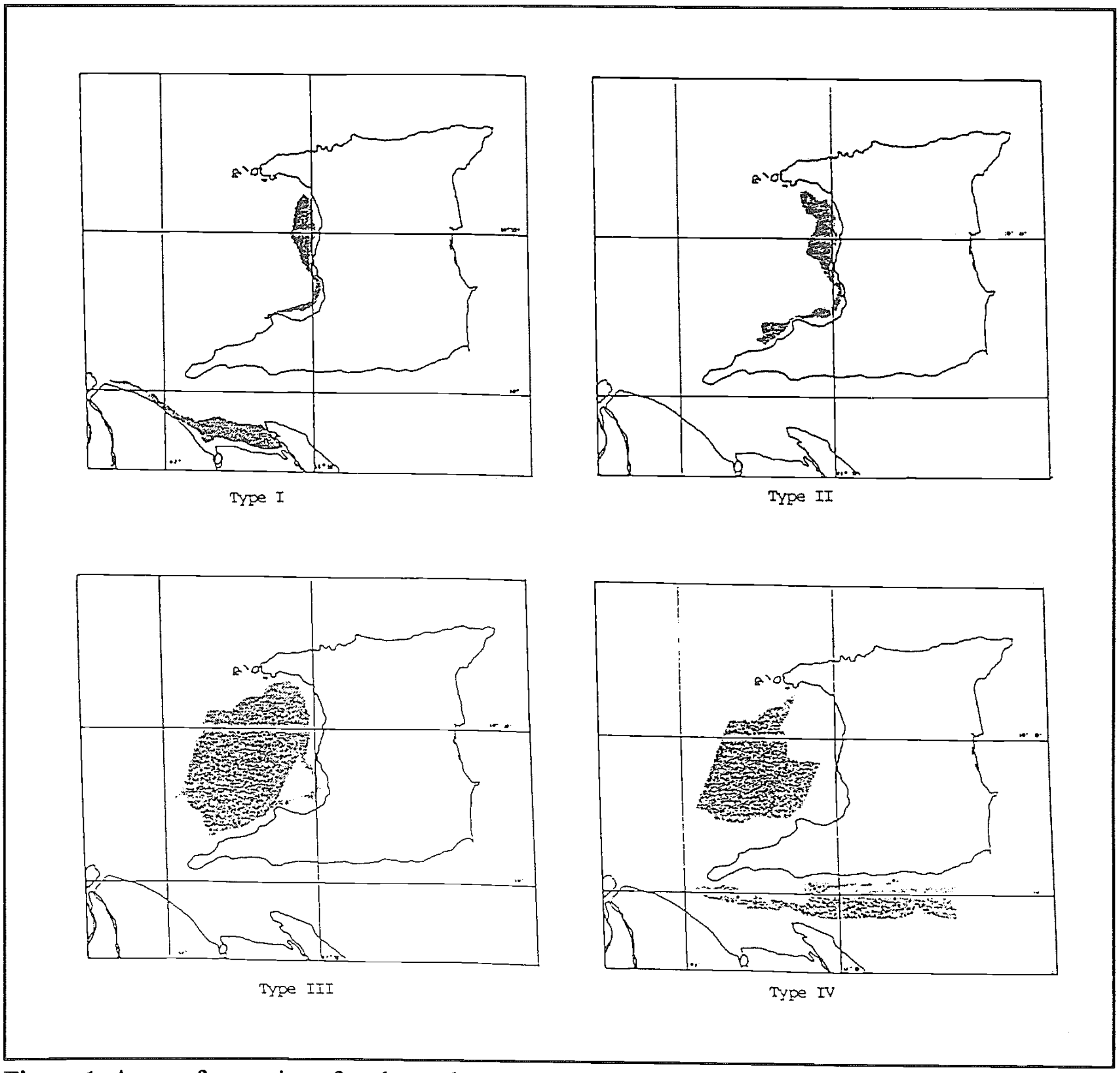

Figure 1: Areas of operation of each trawler type.

Vessels operating in the coastal waters of Trinidad trawl both day and night, while Type I vessels trawling in the Orinoco Delta usually trawl only during day-light hours. When catch rates are favourable for Type II vessels, two crews may operate the same vessel sequentially. Table 4 gives an indication of the fishing patterns of the different vessel types.

Table 4: Fishing pattern of each trawler type

TRAWLER CATEGORY	DEPTH FISHED (m)	AVG DURATION OF TRIP	AVG # FISHING DAYS/MONTH/VESSEL	AVG # OF HAULS/DAY	AVG DURATION OF HAUL (HOURS)	AVG VESSEL SPEED (KNOTS)
I	1.2-3.6	12 hrs	8	6	1.5	1
II	1.8-18	12 hrs	13	5	2	1
III	9-41.4	15 hrs	16	2 - 4	4	2
IV	9-58	17 days	17	2 - 4	4	3
Source: Interviews with Type I and Type II Fishermen. Extrapolation from Trawler Logbooks.						

The minimum size of the mesh used in the trawl gear generally a limits the size of shrimp harvested. There is however the incidence of tiny individuals being captured when trash and other obstacles prevent their escape. In the artisanal shrimp fishery, limited sorting/grading activity occurs on board the vessels, thus an insignificant amount of shrimp is discarded. In the case of the semi-industrial and industrial trawlers, sorting takes place manually, thereby leading to the discard of those individuals which are difficult to procure. Generally these are of little economic importance and present no loss to the fisherman. The Trinidad and Tobago shrimp trawl fishery is ranked as having the highest recorded discard ratios by weight per landed target catch weight, i.e. discard ratio of 14.71 (FAO Fisheries Technical Paper 339, 1995).

Recent international developments including the use of Turtle Excluder Devices (TED's) and By-catch Reduction Devices (BRD's) have attempted to reduce the levels of by-catch harvested. In Trinidad and Tobago, the use of TED's is mandatory for all type III and type IV vessels while there has been a hint that BRD's be considered as being part of the trawl gear in the near future.

SHRIMP PROCESSING ACTIVITIES

Shrimp in Trinidad and Tobago are processed by a variety of privately-owned companies which have supplemented the role previously performed by the National Fisheries Company (NFC). This activity cannot be clearly differentiated into industrial shrimp processing and artisanal shrimp processing since catches from all classes of trawlers are used at the processing plants. This occurs because buyers visit all of the landing sites. As shrimp trawling activity is mainly seasonal, processing also follows this trend, thus processing plant are largely temporary establishment. Only about sixteen (16) processors/exporters operate full-time.

Apart from these individual processors, some degree of processing occurs at the Orange Valley Fishing Complex where vessel owners and retailers employ personnel on an ad hoc basis to peel of shrimp before retailing.

Shrimp is graded according to an existing size regime, prior to selling and are frequently sold according to species since some degree of sorting is done on board the vessels; this grading according to size, indirectly leads to some degree of species differentiation.

Table 5: Number of shrimp per pound in the shrimp categories utilised by processors.

CATEGORY	SMALL (PER LB)	MEDIUM (PER LB)	LARGE (PER LB)	EXTRA LARGE (PER LB)
Heads on	66.90	41.65	16.40	0.15
Heads off		42.67	26.41	0.25

MARKETING FOR THE INDUSTRIAL & ARTISANAL SHRIMP FISHERY

On the local markets, the products targeted are fresh-chilled shrimp, peeled and breaded shrimp, shrimp patties as well as shrimp fingers. Exports are mainly in the form of fresh-chilled shrimp or frozen shrimp though a small proportion of the exports is in the forms of heads-off and peeled product. Statistics obtained from the Tourism and Industrial Development Company indicate that for the first three-quarters of 1995, exports totalled 422,065 kgs with an F.O.B. value of $15,127,850.67. These figures were affected by the imposition of an embargo on the export of shrimp to the United States of America from May to August, 1995. Corresponding export figures for the years 1992 to 1994 were 435,810 kgs., ($7,184,321.69), 404,571 kgs. ($11,395,960.36) and 322,892 kgs. ($16,036,660.27).

The traditional export markets for shrimp are the United States of America, the United Kingdom and Canada. One effect of the temporary embargo was for the exporters to secure alternative markets which included islands of the English-speaking Caribbean as well as the French Departments of Guadeloupe and Martinique. The lucrative export market created an upward movement of the retail price on the local market to $10.00 per kilo for small-medium shrimp and $22.00 for large "cork" shrimp.

Local wholesale prices are set by bidding at the major landing sites, while buyers visit the beaches at out-lying districts where they purchase the catch either for the local retail market or for export.

RESULTS OF EXPLOITATION

CATCH/EFFORT STATISTICS, ECONOMIC ASPECTS

Landings and effort data are collected by the Fisheries Division for the following landing sites: Orange Valley, San Fernando, Otaheite, Bonasse, Fullerton and Icacos. Estimates of total shrimp catch for Type I, II and III vessels, along with the number of trips and catch per unit effort (CPUE) values are given in Table 6 for the years 1991 - 1993.

No comparative catch/effort data are available for the Industrial (Type IV) fleet. Landings of shrimp and finfish by-catch at Sea Lots by the Type IV fleet are available from the Kwo Jeng Trading Company (formerly NFC), however Type IV vessels may sell parts of their catch at other ports or tranship shrimp at sea. A logbook programme for these vessels and for the semi-industrial (Type III) fleet was introduced in November 1991, in an attempt to obtain more accurate catch/effort data. Extrapolations from the data collected so far for Type IV vessels indicate an annual catch of 1,000 tons of shrimp and 300 tons finfish by-catch from an average of 300 trips per year, giving a CPUE of 3.3 tons shrimp/trip and 1 ton by-catch/trip.

ASSESSMENT OF THE RESOURCES

THE SAMPLING PROGRAMME OF THE TRAWL FISHERY

The Sampling Programme of the trawl fishery commenced in March 1991 under the Government of the Republic of Trinidad and Tobago (GORTT)/Food and Agriculture Organization of the United Nations (FAO)/United Nations Development Program (UNDP) Project TRI/91/001, entitled "Establishment of Data Collection Systems and Assessment of Fisheries Resources". This on-going Sampling Programme has been documented by Lum Young and Maharaj (1992).

As part of the Sampling Programme, shrimp from the different trawler fleets are being sampled for length frequencies on a weekly basis at specific sites in the Gulf of Paria. The landing sites/beaches currently covered are Waterloo, the Orange Valley Wholesale Fish Market, the San Fernando Fish Market, the Otaheite Fish Market, Bonasse, Fullerton and Icacos at a target rate of two (2) vessels per beach per week when catch is sorted and four (4) vessels when catch is unsorted.

Table 6: Catch weights, fishing efforts, cpue, prices and total revenue for trawlers (1991-1993).

YEAR	ITEM	SPECIAL FISHING AREA	OTHER ARTISANAL TRAWLERS	TYPE III (SEMI-INDUSTRIAL)	TYPE IV (INDUSTRIAL)	TOTAL
1991	Shrimp landings (t)	288	362	162	1,000	1,912
	Shrimp revenue ($TTM)	4.5	2.3	2.0	12.0	20.8
	By-catch landings (t)	*	190	174	300	664
	By-catch revenue ($$M)	*	0.5	0.6	1.1	2.2
	Trips	5,478	11,523	3,911	300	21,212
	Shrimp CPUE (kg/trip)	52.57	31.42	41.42	3,333.33	3458.74
	By-catch CPUE (kg/trip)	-	16.49	44.49	1,000	1060.98
1992	Shrimp landings (t)	168	286	145	n/a	599
	Shrimp revenue ($TTM)	2.7	2.4	1.8		6.9
	By-catch landings (t)	*	171	261		432
	By-catch revenue ($$M)	*	0.4	1.0		1.4
	Trips	3,330	11,294	3,986		18,610
	Shrimp CPUE (kg/trip)	50.45	25.32	36.38		75.77
	By-catch CPUE (kg/trip)	-	15.14	65.48		80.62
1993	Shrimp landings (t)	272	282	125	n/a	679
	Shrimp revenue ($TTM)	4.5	2.1	1.9		8.5
	By-catch landings (t)	*	98	248		346
	By-catch revenue ($$M)	*	0.2	1.0		1.2
	Trips	4,793	10,065	3,619		18,477
	Shrimp CPUE (kg/trip)	56.75	28.02	34.54		84.77
	By-catch CPUE (kg/trip)	-	9.74	68.54		78.28

* = negligible values, n/a = data not available

The Industrial Trawl Fishery

Type IV vessels were sampled at the National Fisheries Company (NFC) compound up to 1992. The sample size for each of the categories "medium", "large", "extra large", "headless (large)" and "headless (extra large)" was 10 lbs while that for the "small (hoppers)" and "small (mixed)" categories was 2 - 3 lbs.

The samples in each category were sorted by species and sex. For whole shrimp, the carapace length of each shrimp was measured (to the nearest millimetre). For headless individuals, tail lengths were measured. These measurements, in addition to the sample weights and catch weights for each category were recorded on voice-activated tape recorders and later transcribed on to tally forms.

Nothing was produced at the NFC in 1993 and 1994 and sampling was terminated. In 1994 the company assets were bought over by the Taiwanese KWOJENG Co. Ltd.

The Semi-industrial Trawl Fishery

Type III vessels are sampled at the Orange Valley Wholesale Fish Market. As far as possible, unsorted catches are sampled (with four vessels being targeted weekly) from which a random sample of 10 lbs is taken. If catches are sorted (two vessels are targeted weekly) (usually two commercial categories - medium and large browns), random samples of 10 lbs of each category are obtained. Samples are sorted by species and sex and carapace lengths are measured and recorded on voice-activated recorders.

The Artisanal Trawl Fishery

Type I and Type II vessels are sampled at San Fernando and Otaheite. Type II vessels are also sampled at Waterloo while the Type I vessels fishing in the Orinoco Delta are sampled at Bonasse, Fullerton and Icacos. Shrimp may be landed unsorted or in categories of "small", "medium" and "cork" (large). Sorted and unsorted catches are sampled out as described for the Type III vessels. Only 3 lbs of the "small" category are sampled. If "medium" on a particular beach is comparable to "small" at the NFC compound, then 5 lbs of shrimp are sampled.

TREATMENT OF LENGTH-FREQUENCY DATA

The length-frequency data collected at the NFC compound, the semi-industrial and the artisanal beaches are transcribed onto tally forms as indicated and filed by trawler type and fishing area. All data are converted into carapace lengths using conversion factors worked out by the Trawl Fishery Assessment Team. Tally data are added and summarised into monthly length frequencies.

Unsorted Catches

For unsorted catches, the length frequencies are simply added across the weekly sampling frequencies to give a monthly length-frequency distribution.

Sorted Catches

The length-frequency distributions for each category of a sorted catch are first raised to the total landing of the particular category. The length-frequencies for the different categories are then combined to provide a complete profile for the catch sampled. Complete (raised) profiles may then be added to the profiles of samples of unsorted catches for the month to give a monthly length-frequency distribution.

At present, all the monthly length frequencies are entered into FISAT (Food and Agriculture Organisation of the United Nations) files to be used in subsequent analyses. Length frequency distributions for the artisanal and semi-industrial fleets for 1993 and the industrial fleet for 1992 are graphically represented in Figures 2-6.

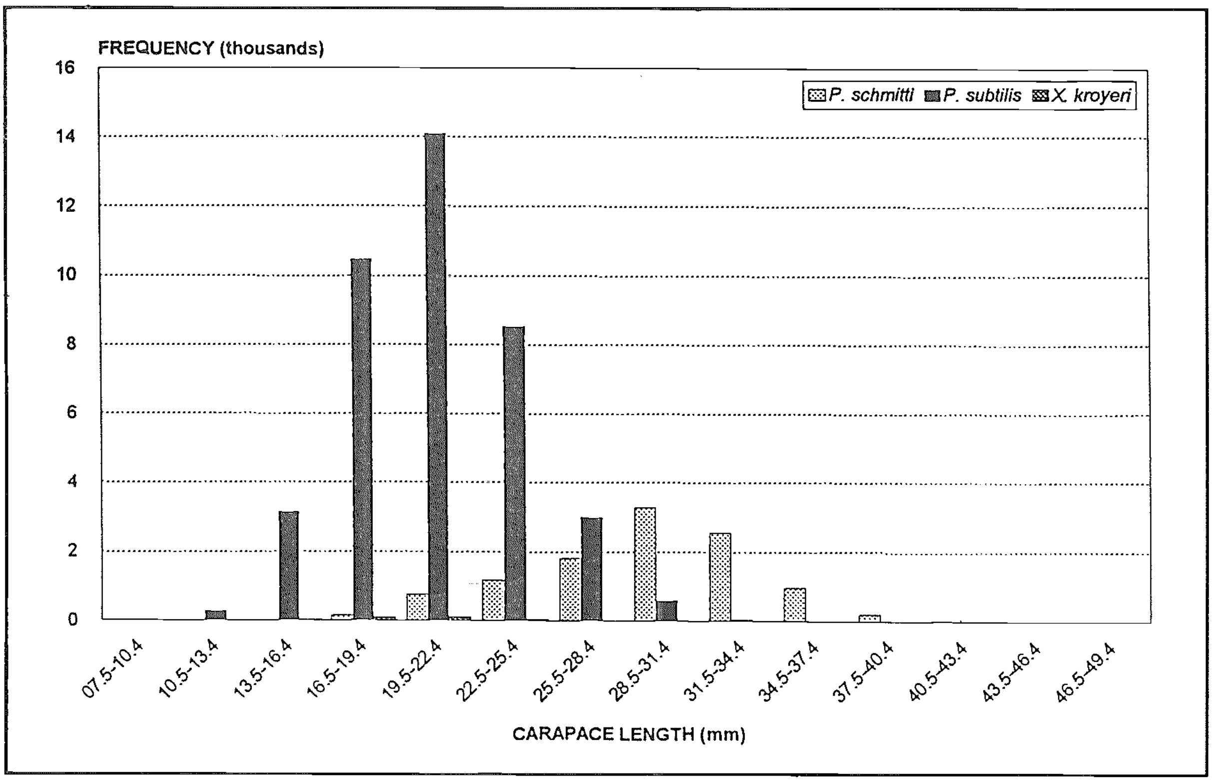

Figure 2: Length frequency distribution for artisanal fleet in the "Special Fishing Area" - 1993.

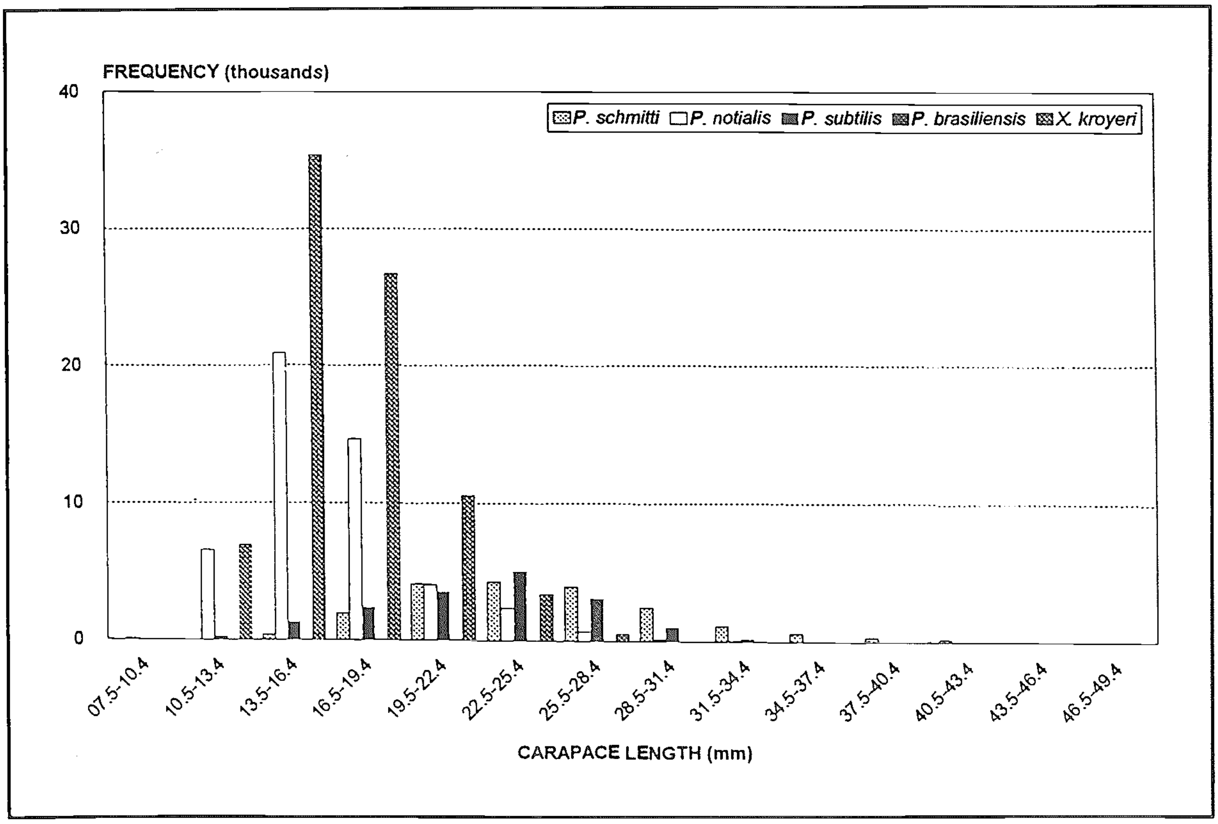

Figure 3: Length frequency distribution for artisanal fleet in the Gulf of Paria - 1993.

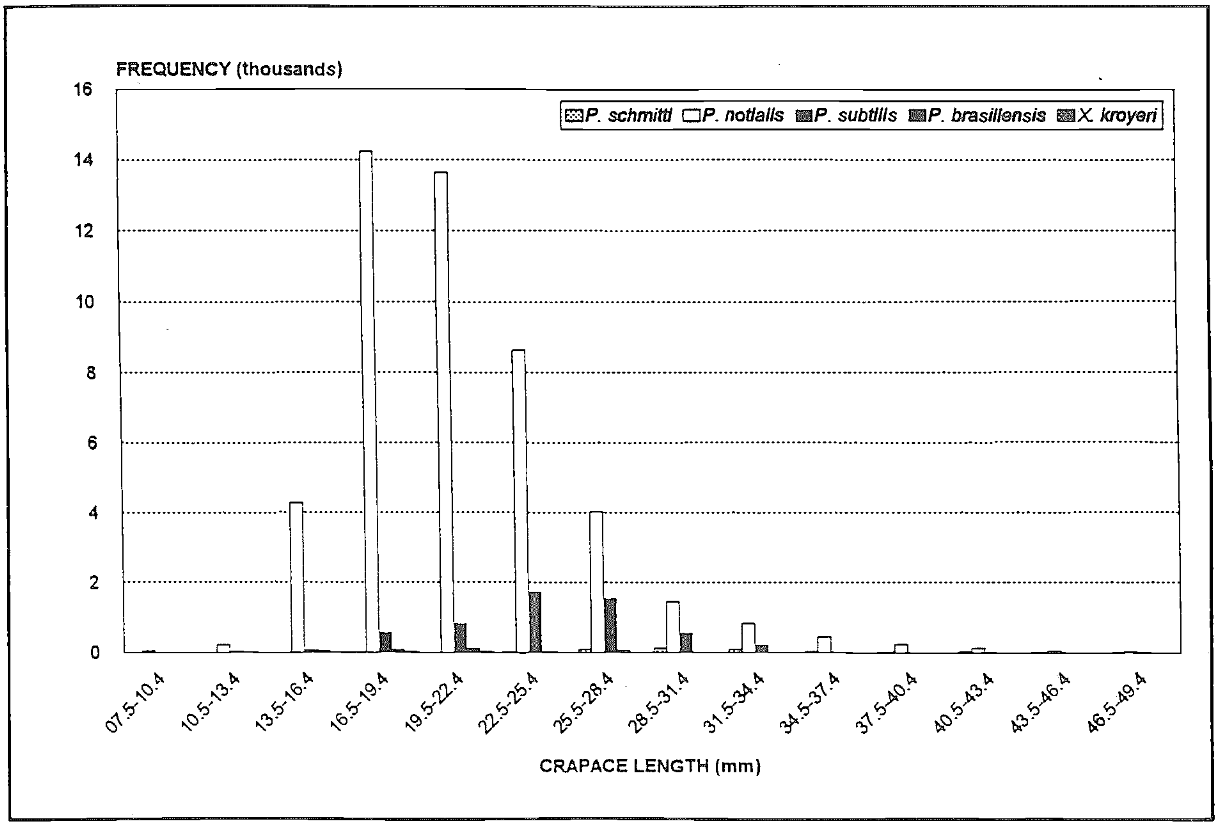

Figure 4: Length frequency distribution for semi industrial fleet in the Gulf of Paria - 1993.

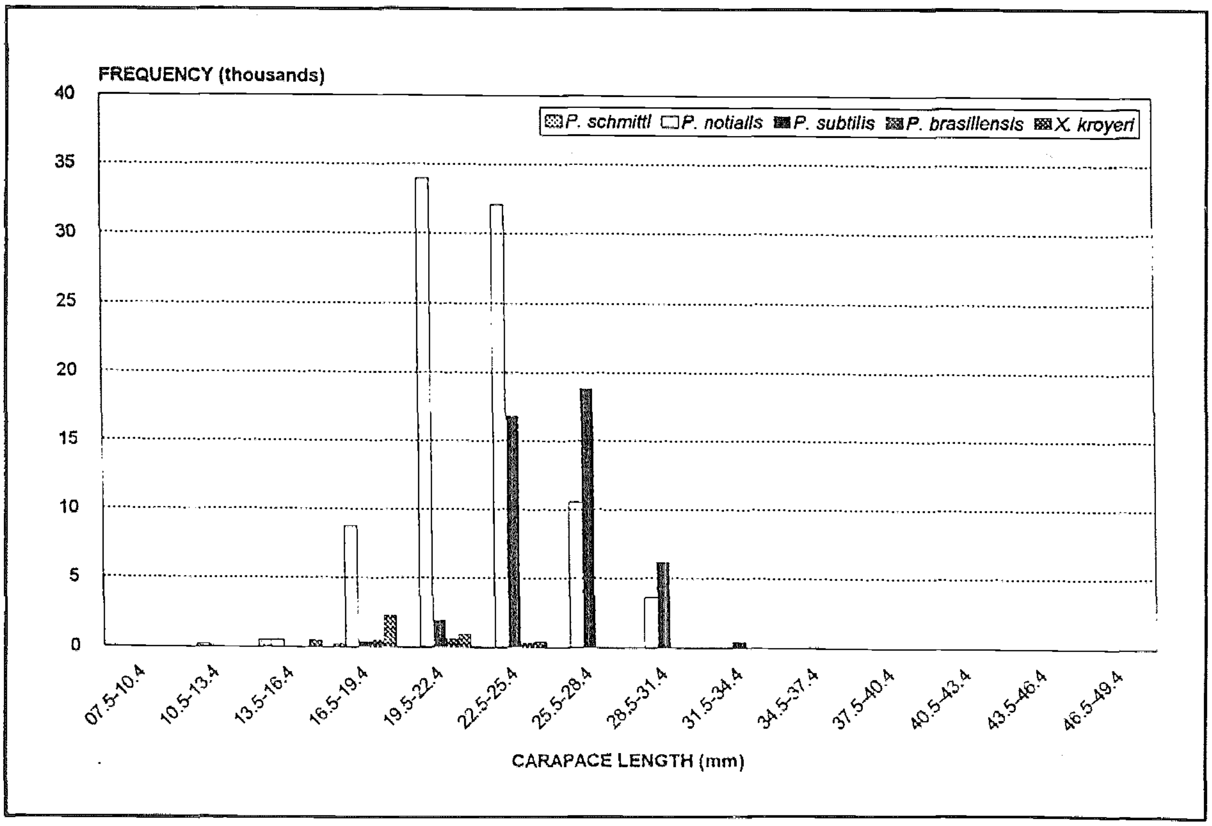

Figure 5: Length frequency distribution for industrial fleet in the Gulf of Paria - 1992.

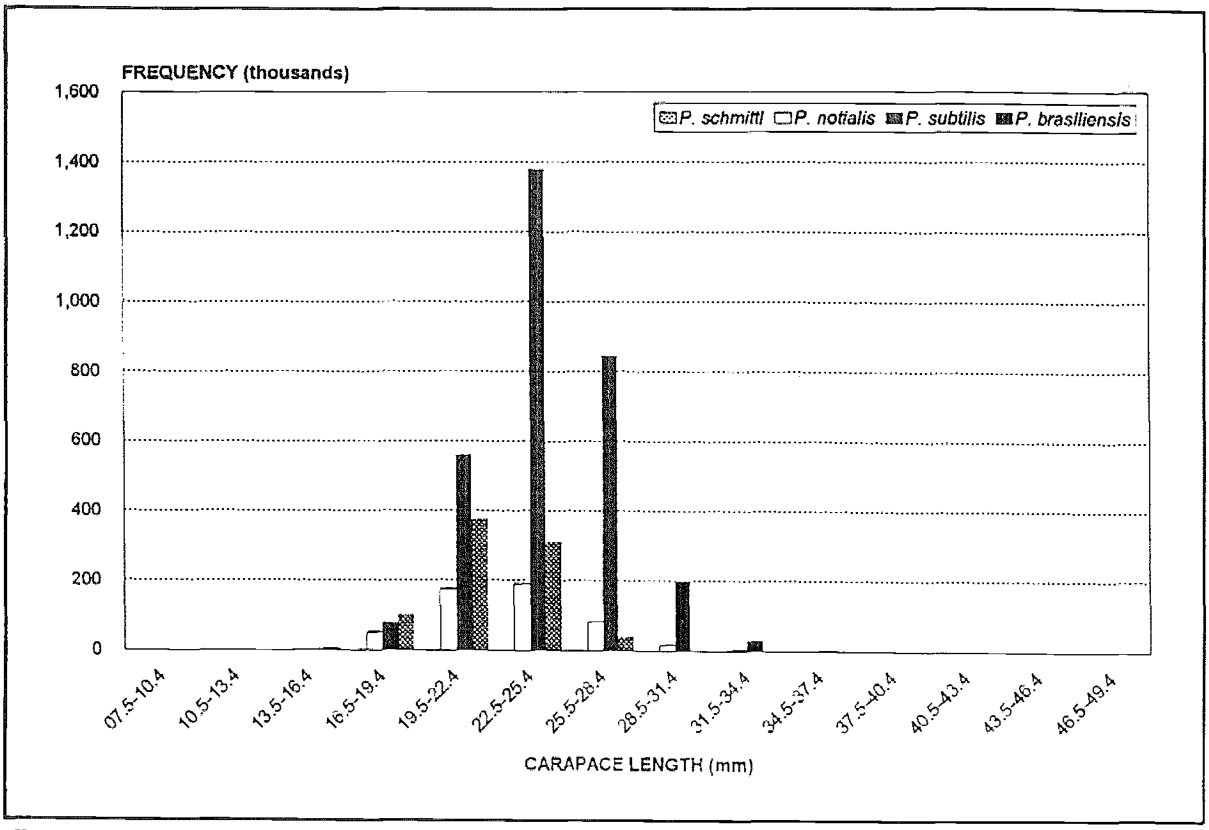

Figure 6: Length frequency distribution for industrial fleet in the Columbus Channel - 1992.

The length frequency summary for the inshore, artisanal (Type II) catches in the Gulf of Paria reveals that *Xiphopenaeus kroyeri* was the dominant species taken. These catches also comprised large amounts of *Penaeus notialis* and smaller amounts of *P. schmitti* and *P. subtilis*. *P. notialis* was the dominant species taken in the semi-industrial (Type III) catches in the Gulf of Paria with smaller amounts of *P. subtilis* also being landed. The "Special Fishing Area" catches comprised mainly 2 species, *P. subtilis* and *P. schmitti*, with the former being more dominant.

With respect to *P. subtilis*, the modal length class was 22.5 - 25.4mm for both the artisanal and semi-industrial fleets in the Gulf of Paria while it was less (19.5 - 22.4mm) in the "Special Fishing Area". For *P. notialis* in the Gulf of Paria catches, the mode was 13.5 - 16.4mm for the artisanal fleet and 16.5 - 19.4mm (larger) for the more offshore semi-industrial fleet. In the case of *P. schmitti*, the mode was 22.5 - 25.4mm for the artisanal vessels in the Gulf and 28.5 - 31.4mm (larger) in the "Special Fishing Area". For *X. kroyeri* taken by artisanal vessels in the Gulf, the modal length class was 13.5 -16.4mm.

The length frequency summaries for 1992 revealed that *P. notialis* and *P. subtilis* were the dominant species taken in Type IV catches in the Gulf of Paria. In the Columbus Channel, *P. subtilis* formed a major component of the catch, with *P. brasiliensis* being taken in smaller amounts.

For *P. subtilis*, the mode was 25.5 - 28.4 in the case of the Type IV's in the Gulf of Paria. For *P. notialis* the modes were 19.5 - 22.4 and even larger in the Columbus Channel (22.5 - 25.4).

SPECIES AND SEX COMPOSITION AND DISTRIBUTION IN COMMERCIAL (SIZE) CATEGORIES

Sample weight estimations were done for all monthly length frequencies using FISAT. Species and sex composition (as a percentage by weight) are available by fleet. The combined results obtained from the 1991 to 1994 data are shown in Table 7. In general, the sex ratio (male:female) is 1:2 for *P. notialis* and 1:1.5 for the other four (4) penaeid shrimp species. Observations on the species composition and distribution in commercial (size) categories are given below for each of the industrial, semi-industrial and artisanal trawl fisheries.

The Industrial Trawl Fishery

The Type IV vessels operating offshore in the Columbus Channel (Areas 8 and 9) land approximately 51% *P. subtilis*. *P. brasiliensis* is also abundant in the catches with some *P. notialis* also being landed. No *X. kroyeri* is landed.

The Type IV vessels operating offshore in the Gulf of Paria (Areas 10 and 11) land approximately 60% *P. notialis* and 31% *P. subtilis*, these species occurring in the medium, large and extra large categories. Small amounts of *P. brasiliensis* occur in all categories. *P. schmitti* is rare and *X. kroyeri* is absent from the catches.

The Semi-industrial Trawl Fishery

The Type III vessels operating nearshore in the Gulf of Paria land approximately 74% *P. notialis* and lesser quantities of *P. subtilis* and *P. schmitti*. All sizes of these species are landed, although only *P. schmitti* occurs in the extra large category. Neither *P. brasiliensis* nor *X. kroyeri* is landed.

The artisanal trawl fishery

The Type II vessels operating inshore of the southern Gulf of Paria (Area 10) land fair amounts of *P. notialis* and *P. schmitti*. Substantial amounts of *X. kroyeri* are also landed. The Type II vessels operating in the northern Gulf of Paria (Area 11) land approximately 29% *P. notialis*, with *P. schmitti* being most abundant. Some *P. subtilis* and *X. kroyeri* are also landed.

The Type I vessels operating inshore of the southern Gulf of Paria (Area 10) land more or less equal quantities of *P. notialis*, *P. subtilis* and *P. schmitti* with lesser amounts of *X. kroyeri*. The Type I and Type II vessels operating in the Orinoco Delta ("Special Area") land approximately 48% *P. schmitti* and 52% *P. subtilis*.

The artisanal fleet lands juveniles of *P. notialis* and *P. subtilis* and all sizes of *P. schmitti*. *P. brasiliensis* rarely occurs in the landings.

Table 7: Species and sex composition (% by weight) by fleet and by area based on data from 1991 to 1994 (data not available beyond 1992 for Type I in area 10, and Type IV).

		TYPE I	TYPE I & II	TYPE II		TYPE III	TYPE IV	
SPECIES	SEX	AREA 10	SPECIAL AREA	AREA 10	AREA 11	AREA 10 & 11	AREA 8 & 9	AREA 10 & 11
P. notialis	♂	6	0	8	10	26	6	16
	♀	19	0	16	19	48	11	45
	♂ and ♀	25	0	24	29	74	16	60
P. subtilis	♂	13	19	7	2	10	19	12
	♀	20	33	10	3	7	32	19
	♂ and ♀	34	52	17	5	17	51	31
P. schmitti	♂	12	22	9	24	4		
	♀	17	26	16	33	5		
	♂ and ♀	29	48	25	57	9		
P. brasiliensis	♂		0	0	0	0.5	10	3
	♀		0	0	0	0.5	22	5
	♂ and ♀		0	0	0	0	32	8
X. kroyeri	♂	4	0	13	2	0		
	♀	9	0	21	7	0		
	♂ and ♀	13	0	34	9	0		
TOTALS		101	100	100	100	100	99	99

KNOWLEDGE OF THE RESOURCE (RECRUITMENT, NURSERIES, POPULATION DYNAMICS, ETC.)

The nature of the shrimp trawl fishery in Trinidad and Tobago dictates that activities in the inshore waters by the artisanal vessels, impinge upon the catches of the semi-industrial and industrial vessels which trawl in the offshore waters. Juveniles hatched in the brackish-water mangrove swamp nurseries migrate from the coastal waters and are harvested sequentially and spatially, first by the artisanal vessels and then by the Type III and Type IV crafts. Since the resources of the Guyana-Brazil Shelf shrimp fishery have been identified as belonging to one stock (which is carried by currents northward along the north-east coast of South America) then recruitment and population dynamics of the local shrimp trawl fishery are also affected by the activities within neighbouring trawl fisheries.

Previous to 1992, not much work was done locally with regard to the recruitment, nurseries and population dynamics of the penaeid shrimp species. Table 8 shows the information obtained about the shrimp resources from surveys carried out locally. Stock assessment parameters for *P. schmitti*, *P. notialis*, *P. brasiliensis*, *P. subtilis* and *X. kroyeri* have been compiled from a literature search (Lum Young, 1992a).

Table 8: Information obtained about the shrimp resources from surveys carried out locally.

STUDY AREA	TIME PERIOD	HEADING	INFORMATION OBTAINED	REFERENCE
Inshore waters of the 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 (1987)
		Length at First Maturity	• *X. kroyeri* females: 8.1 - 8.5 cm (total length) • Smallest mature male was 6.3 cm.	
		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 (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 (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.	
Inshore Gulf of Paria, Trinidad near Orange Valley	Aug 1986 - May 1987	Species Composition	• *P. schmitti*, *P. notialis* and *P. subtilis* dominated the shrimp catches. • *P. schmitti* was most abundant from September to October and very low from November to May. • *P. notialis* was highest in the catch from January to May and lowest from October to January. • The quantity of *P. subtilis* in the catch fluctuated with highest levels occurring from November to May. • *X. kroyeri* appears sporadically in the catches being highest from August to January and almost absent from mid January to May.	Maharaj (1989)
		Impact of Environmental Factors	• There was an increase in shrimp catches in the dry 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.	Amos (1990)
		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	
		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 is usually caught close inshore by the Type I and Type II trawlers. Relative Contribution by Weight of Penaeid Shrimp Species 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 (1990)

Table 8: Information obtained about the shrimp resources from surveys carried out locally.

STUDY AREA	TIME PERIOD	HEADING	INFORMATION OBTAINED	REFERENCE
Nearshore Gulf of Paria, Trinidad	Jun 27 - Jul 27 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 a 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.	Amos (1990)

Subsequently, preliminary work was conducted to obtain information on the resources upon which the shrimp trawl fishery is based. Two studies were conducted, one based upon the five major species occurring in the Trinidad and Tobago trawl fishery, the other upon the Orinoco Delta shrimp fishery which is exploited by Type I shrimp trawl vessels.

In 1992, morphometric relationships between weight at length and between weight and length types were determined for the five commercially important shrimp species (Lum Young et al, 1992a). Both predictive and functional regressions were performed on data collected over a five month period from January to June 1992. Morphometric relationships were established by sex (separately and combined) for the following:

1. Total weight (W_{tot}/g) on total length (L_{tot}/mm).
2. Total weight (W_{tot}/g) on carapace length (L_{car}/mm).
3. Tail weight (W_{tail}/g) on tail length with telson (Tl_{tl}/mm).
4. Tail weight (W_{tail}/g) on tail length without telson (TL/mm).
5. Tail weight (W_{tail}/g) on carapace length (L_{car}/mm).
6. Tail weight (W_{tail}/g) on total weight (W_{tot}/g).
7. Tail length (L_{tot}/mm) on carapace length (L_{car}/mm).
8. Rostral length (L_{ros}/mm) on carapace length (L_{car}/mm).
9. Tail length with telson (Tl_{tl}/mm) on carapace length (L_{car}/mm).
10. Tail length without telson (TL/mm) on carapace length (L_{car}/mm).

Table 9 gives some of the results.

Table 9: Estimates of the constants for two important morphometric relationships (functional regression).

SPECIES	$W_{tot} = aL_{car}^{b}$			$L_{tot} = a+b\ L_{car}$		
	a	b	r	a	b	r
P. schmitti	9.0690	3.0434	0.9825	17.4523	4.0990	0.9729
P. notialis	17.3640	2.28824	0.9954	12.5459	4.1484	0.9881
P. subtilis	18.7599	2.7570	0.9743	21.1481	3.8775	0.9743
P. brasiliensis	9.0777	2.9582	0.9815	6.0072	4.3636	0.9857
X. kroyeri	41.6606	2.4164	0.9892	20.5410	3.6886	0.9730

A preliminary stock assessment of the two (2) dominant species *P. subtilis* and *P. schmitti* exploited by the shallow water shrimp trawl fishery in the "Special Fishing Area" adjacent to the mouth of the Orinoco River, (Venezuela) was also conducted in 1992 within the FAO/UNDP TRI/91/001/TR9 project (Lum Young *et al*, 1992b). The analysis was based on length frequencies collected in the 1990/91 fishing season.

The length frequency data for the landings from this "Special Fishing Area" suggest that *P. schmitti* remains in the fishery till the end of life, while *P. subtilis* migrates offshore at intermediate sizes. It is believed that this fishery is based principally on the progeny from spawning in the previous Autumn. Estimates for the von Bertalanffy length at age constants were determined by extrapolation from literature values, and these were used in the Pauly equation to estimate natural mortalities. The growth and mortality parameters upon which the assessment is based are hence provisional and need to be refined. The results of the assessment must therefore be considered to be very preliminary. The two species were found to have similar growth and natural mortality rates. Total mortalities were obtained from catch curve analysis of length frequency distributions.

Modifications of the Thompson and Bell (1934) model were used to estimate likely yields, catch rates, mean individual weights and exploited biomass from a range of annual fishing efforts. In the case of *P. subtilis*, the numbers of shrimp migrating off the fishing ground were also estimated. The length-based yield models for *P. schmitti* and *P. subtilis*, are in Appendices 1 and 2 respectively. The variation in annual recruitment during recent years was determined by simulation. This involved estimating the recruitment necessary in each year to achieve the observed yields from the observed efforts. Table 10 gives the estimated numbers of zero-age recruits.

The principal finding from this preliminary assessment was that, with the exception of years when the shrimp are particularly abundant, the potential effort of 70 vessels (estimated at 7,000 trips for a season) would be adequate and often excessive to that required to fully utilize the resource (i.e. to achieve MSY). Furthermore, additional fishing effort might result in increased yield from this fishery but can result in less migration of shrimp to the fishing grounds in the Columbus Channel, and hence to a reduction of yield to the industrial trawlers.

Table 10: Estimated number of zero-age recruits.

YEAR	NUMBER OF RECRUITS (MILLIONS)		
	P. schmitti	*P. subtilis*	TOTAL
1990/91	31.69	95.43	127.12
1989/90	40.95	105.88	146.83
1988/89	18.78	59.02	77.80
1987/88	51.02	105.76	156.78
1986/87	38.80	102.36	141.16

ECONOMIC ASPECTS

There has been an observed increase in the economic importance of the shrimp trawl fishery over the last few years. This has been due to the great demands from the markets in North America, resulting in increased local and foreign prices. Table 11 shows the revenue (FOB values) earned from shrimp exports and their destination for the years 1992-1995.

Table 11: FOB values (TT$).

DESTINATION	1992	1993	1994	1995
Antigua	1,277,795.63	70,309.85	44,979.90	19,438.71
Aruba		2,018.89		
Austria		1,920.00		
Barbados	173,447.86	259,774.63	637,215.72	711,156.27
British Virgin Islands		11,193.75		
Canada	450,209.10	154,756.98	330,997.18	45,665.10
Colombia	37.52			
Dominica	1,000.00			
Germany		160.00		
Grenada	77,266.82	130,186.12	172,593.70	137,083.00
Guadeloupe	14,785.49	6,100.00		2,880.40
Guyana		3,000.00	1,000.00	
Jamaica	123,888,86	1,352,066.16	3,079,993.20	2,953,345.69
Japan			838.10	
Malta	250.00			
Martinique	998,702.26		358,807.80	
Netherland Antilles	20,839.95	110,234.38		7,000.00
Puerto Rico	7,500.00	922,098.93		
St. Kitts/Nevis	127,184.62	2,750.00	31,702.24	7,681.06
St. Lucia	357,042.04	454,526.08	978,450.17	340,124.15
St. Vincent	192,415.52	200,004.81	210,945.95	101,754.05
Stores & Bunkers	18,924.00	15,296.00	11,660.00	6,050.00
Switzerland			540.00	
US Virgin Islands	24,299.09	20,440.87	14,159.95	7,740.90
United Kingdom	2,217.10		14,950.63	1,300,380.24
United States	4,466,515.83	7,614,815.05	10,147,825.73	9,487,551.10
Venezuela		64,307.86		
TOTAL	$ 7,184,321.69	$ 11,395,960.36	$ 16,036,660.27	$ 15,127,850.67
Source: Trinidad and Tobago Tourism and Industrial Development Company Limited.				

The Fisheries Division now has the responsibility for approving all export license applications for fin-fish, shellfish and other associated marine and fresh-water organisms. Data related to species, quantity and values have been obtained from these applications.

The average ex-vessel price of shrimp and associated by-catch was obtained from the Economics, Statistics and Marketing Unit of the Fisheries Division. The price per kilogram of shrimp and by-catch by each vessel type was calculated and is presented in Table 12, for the years 1991-1993. Recent by-catch figures for the Type I vessels based upon the Orinoco Delta shrimp fishery are unavailable, but the revenue ranged from $TT417 to $TT7,386 between 1987 and 1991.

Table 12: Value (TT$) of shrimp and by-catch from trawlers 1991-1993.

YEAR	ITEM	SPECIAL FISHING AREA	OTHER ARTISANAL TRAWLING	TYPE III	TYPE IV
1991	Price per kg shrimp	15.66	6.35	13.35	12.00
	Price per kg by-catch	-	2.63	3.45	3.67
1992	Price per kg shrimp	16.07	8.39	12.41	
	Price per kg by-catch	-	2.34		-
1993	Price per kg shrimp	16.54	7.45	15.20	
	Price per kg by-catch	-	2.04	4.03	-

SECONDARY RESOURCES

SEA-BOB

There are approximately twenty (20) inshore (Type I) vessels that trawl for bait for the long-line fishery. These vessels target the sea-bob, *Xiphopenaeus kroyeri*. Type I trawlers fishing in the Orinoco Delta land very little by-catch and indications are that small shrimp (mainly sea-bob) are discarded by these vessels.

DEEP WATER SHRIMP

Information on this resource was obtained through the surveys of the *RV Dr. Fridtjof Nansen* in 1988 (Inst. Marine Research, 1989). The following was reported.

In all surveys some test hauls with bottom trawl were made for deep sea shrimp on the slope which in the southern part extends 30 - 40 nm outside the edge of the shelf before 700 - 800 m is reached. The results of these fishing experiments are summarized in Table 13 showing total catch rates and by species for the forms judged to be of commercial interest. There were some minor bycatches of non-commercial species mostly *Nematocarcinus* and *Glyphocrangon* species. The most important species are scarlet shrimp *Plesiopenaeus edwardsianus* and royal red shrimp *Pleoticus robustus*, the latter caught together with other commercial sized species of Solenoceridae.

The mean catch rates are low, but there are a few higher individual catch rates which may indicate patchiness or seasonal aggregations. One should note the variation of depth ranges for some of these species. A trawl fishery was not recommended, based on the relatively low catch rates.

Table 13: Trinidad, east coast. Tests for deep water shrimp, 20 hauls (190 - 800 M). Catch Rates in kg/hr and main depth (m).

SPECIES	MEAN CATCH	HIGHEST	INCIDENCE	DEPTH
All commercial shrimp	9	39, 16, 12	20/20	
Plesiopenaeus edwardsianus	2	6, 5, 5	11/20	600-700
Pleoticus robustus a.o.	3	27, 8, 7	11/20	300-500
Penaeopsis serrata	3	13, 12, 8	11/20	300-500
Acanthephyra sp.	0.6	5, 3, 3	5/20	700-800

FINFISH

Significant quantities of finfish and crabs are exploited incidentally in the demersal trawl fishery. However, some authors (Manickchand-Dass and Julien, 1983; Fabres, 1989) claim that certain species of fish may be targeted according to market demand, or during the wet season when shrimp abundance decreases.

A survey of the Type II fishery was carried out by Maharaj (1989) between August 1986 to May 1987. Some seventy (70) species of finfish by-catch from forty (40) families and several species of portunid crabs were identified. Approximately eighty percent (80%) of the finfish by-catch was composed of sub-adults and juveniles of the following families: Ariidae, Carangidae, Clupeidae, Engraulidae, Gerreidae and Sciaendae. Species of commercial importance (i.e. marketable for consumption) carangids, sciaenids and lutjanids, accounted for only 15-33% of the total finfish catch. Length ranges of the most abundant and commercially important species of by-catch caught during this survey are given in Table 14. It was estimated that in 1986, 94.13% of the total By-Catch of Type II vessels were discarded.

In a one (1) month study of the commercial Type III trawl fishery, Amos (1990) reported twenty-five (25) species of finfish by-catch from fourteen (14) families. A list of the most abundant and commercially important by-catch spp. recorded is given in Table 15. The percentage by weight of discards to the total finfish catch was calculated as 59.67% (SD 11.67).

Length frequency analyses for two of the most commercially important and abundant species, *Micropogonias furnieri* and *Cynoscion jamaicensis*, indicate that for both species 95 % of the individuals caught were immature.

Table 14: Length ranges of the most abundant and commercially important finfish species (Type II Trawl Survey).

FAMILY	SPECIES	LENGTH MIN (cm)	LENGTH MAX (cm)
Ariidae	*Arius sp*	26	122
Bothidae	*Cyclopsetta sp*	39	113
Carangidae	*Caranx sp*	40	120
	Chloroscombrus chrysurus	38	142
Centropomidae	*Centropomus ensiferus*	141	190
Clupeidae	*Harengula sp*	59	140
Cynoglossidae	*Symphurus sp*	100	160
Engraulidae	*Anchoa sp*	40	95
	Cetengraulis edentulus	75	150
Gerreidae	*Diapterus rhombeus*	25	120
	Eucinostomus sp	30	135
Lutjanidae	*Lutjanus sp*	52	200
Portunidae	*Callinectes sp*	25	102
Sciaenidae	*Cynoscion sp*	60	260
	Macrodon ancylodon	117	190
	Micropogonias furnieri	90	275
Trichiuridae	*Trichiurus lepturus*	250	796
Source: Maharaj, 1989.			

Table 15: Percentage contribution by weight of the most abundant and commercially important finfish (Type III Trawl Survey).

FAMILY	SPECIES	% CONTRIBUTION BY WEIGHT
Carangidae	*Caranx hippos*	2.7
	Chloroscombrus chrysurus	10.0
	Trachinotus carolinus	6.8
Clupeidae	*Harengula clupeola*	2.2
	Opisthonema oglinum	1.6
Cynoglossidae	*Cyclopsetta sp*	1.7
	Symphurus sp	1.5
Gerreidae	*Diapterus rhombeus*	15.9
	Eucinostomus argenteus	8.5
Lutjanidae	*Lutjanus sp*	7.0
Polynemidae	*Polydactylus virginicus*	1.2
Sciaenidae	*Cynoscion jamicensis*	12.6
	Micropogonias furnieri	5.4
Trichiuridae	*Trichiurus lepturus*	1.4
Triglidae	*Prionotos punctatus*	9.7
Portunidae		8.9
Source: Amos, 1990.		

Analysis of logbook data collected from Type IV vessels for the period November 1991 - April 1992 indicate that of the total by-catch 64.8% was discarded. The percentage contribution by weight of the different species of by-catch landed is given in Table 16.

Table 16: Percentage contribution by weight of by-catch species landed by Type IV vessels.

FAMILY	SPECIES	% CONTRIBUTION BY WEIGHT
Ariidae	*Arius sp*	0.2
Carcharhinidae		1.6
Carangidae	*Caranx hippos*	0.02
	Chloroscombrus chrysurus	0.5
	Selene sp	0.2
Ephippidae	*Chaetodipterus faber*	0.7
Gerreidae	*Diapterus rhombeus*	3.0
Haemulidae	*Haemulon sp*	0.2
Lutjanidae	*Lutjanus sp*	6.3
Pomatomidae	*Pomatomus saltator*	0.08
Sciaenidae	*Cynoscion sp*	36.8
	Ophioscion sp	37.0
Scombridae	*Scomberomorus brasiliensis*	0.2
Source: Logbook returns for Type IV vessels (November 1991 - April 1992).		

SURVEYS ON SHRIMP AND RELATED RESOURCES

PAST SURVEYS

A number of trawl surveys have been implemented in the coastal waters of Trinidad and Tobago since 1944. The surveys resulted from a variety of objectives- exploratory fishing, gear trials, simulated production fishing and formal systematic sampling. During these surveys, a variety of trawl designs (with variations in gear rigging) were utilised. The fishing power of vessels varied significantly. These surveys are listed in Table 17, with the relevant references.

From 1957-1976, the United States (Bureau of Commercial Fisheries and National Marine Fisheries Service) *RV Oregon and RV Oregon II* also made a number of monitoring surveys in North-east South America, from Trinidad and Tobago to Brazil (Table 18).

Table 17: Past trawl surveys in the area of Trinidad and Tobago (1944 - 1988).

SURVEY YEAR	VESSEL	REFERENCE
1944	No. 305	Whiteleather & 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 Marine Research (1989)

Table 18: Summary of *RV Oregon I* and *RV Oregon II* cruises (1957 - 1977).

NUMBER	CRUISE PERIOD	SURVEY AREA: T'dad/ V'zuela	SURVEY AREA: Guyana	SURVEY AREA: S'name	SURVEY AREA: French Guiana	SURVEY AREA: North Brazil	SHRIMP: Explor.	SHRIMP: Product.	FINFISH: Explor.
OREGON									
47	3 Nov - 19 Nov (1957)	X	X	X	X	X	O		
53	26 Aug - 25 Sep (1958)	X	X	X	X		O		
84	18 Feb - 25 Mar (1963)	X	X	X	X		O		O
87	17 Sep - 4 Nov (1963)	X					O		
94	24 Aug - 8 Oct (1964)	X					O		
107	15 Feb - 1 Apr (1966)	X					O		
OREGON II									
8	25 Apr - 17 Mar (1969)	X	X	X	X		O	O[1]	O
13	15 Nov - 27 Nov (1969)				X		O	O[1]	
38	21 Jun - 4 Jul (1972)		X	X	X		O		
49	26 Jun - 13 Feb (1974)		X	X	X		O	O[1]	
58	5 May - 18 May (1975)				X	X	O		
66	15 May - 28 May (1976)	X	X	X	X	X	O	O	
84	14 Nov - 2 Dec (1977)		X	X	X	X	O		O

[1] Continental slope surveyed.

In 1994, the Fisheries Division, under the FAO/UNDP Project INT/91/007, conducted a series of socio-economic surveys in the Orange Valley and Otaheite communities. The components of this survey were:

a) The local knowledge survey,

b) The community survey,

c) The household survey,

d) The rural profile survey.

The results of these surveys are to be used to facilitate the implementation of the integrated coastal fisheries management approach to the shrimp trawl fishery. The surveys were structured to obtain responses on the perception of the fisherfolk on the present status of the fishery, past trends, factors mitigating against its growth and the desired direction in which development should proceed.

PRESENT AND PLANNED SURVEYS

Programmes initiated in 1992 to obtain data from each vessel type are on-going, with sampling being conducted weekly at all of the major landing sites for shrimp. This provides raw data for catch and effort as well as other resource assessment studies. Trinidad and Tobago is presently the headquarters for the CFRAMP Shrimp and Groundfish Resource Assessment Unit. Under this, project proposals have been developed to update and enhance current data collection activities.

The major objectives of the project are:

i) To develop an improved method of data collection.

ii) To implement a log-book system for the semi-industrial and industrial trawl fleet.

iii) To implement a biological sampling programme.

iv) To acquire economic data on all components of the trawl fleet in order to provide the parameters for the running of the BEAM 4 model.

v) To continue a community survey of the trawl fishery dependent communities located on the south-west peninsula, as a follow-up to the community survey component of the recently concluded FAO/UNDP Project INT/91/007.

MANAGEMENT

Directed by the Government's outlined objectives, the Fisheries Division continues to adopt the policy of sustainable management of the shrimp trawl fishery. There has also been an initial thrust towards community-based management whereby the co-operation of all stake-holders has been solicited in the management initiative. This approach is expected to achieve adherence to new and previous legislation through subtle persuasion.

The decision to limit the numbers of Type III and Type IV vessels is still in effect while defined areas in which the different types of vessels can operate have been introduced. Specifications related to gear type, including the use of TED's by the semi-industrial and industrial fleets, also serve as effective management tools. Type I vessels which participate in the Orinoco Delta fishery under the Trinidad and Tobago/Venezuela Fishing Agreement, are also guided by specific guidelines of operations. The Draft Policy Directions for Marine Fisheries of Trinidad and Tobago in the 1990's (prepared by the Fisheries Division with assistance from FAO under Project TCP/TRI/2352[A]) includes a range of management options for the local shrimp trawl fishery.

LICENSING POLICY

A system presently exists for the registration of all commercial vessels while there is the proposal for the introduction of a new licensing and registration system for local boat owners and vessels under a Caribbean Fisheries Resource Assessment Management Programme (CFRAMP) sponsored programme. A Government decision to maintain the status of the semi-industrial and industrial fleet at its then present level was implemented in 1988 and is still being observed.

Under the terms of a bi-lateral fishing agreement, the Venezuelan Government grants permits annually for seventy (70) Type I vessels to participate in its Orinoco Delta trawl fishery. The last negotiated agreement has expired, and at present no such agreement exists.

REGULATIONS

Regulations exist for the control of trawling in waters under the jurisdiction of Trinidad and Tobago. These relate to depth and areal Restrictions, and mesh regulations. These regulations entitled "The Fisheries (Control of Demersal [Bottom] Trawling Activities) Regulations, 1991" were adopted under the Fisheries Act, (Chapter 67:51).

These regulations specify the following in relation to where trawling may be permitted:

(a) within territorial waters outside two (2) nautical miles off each of the north and south coasts of Trinidad.

(b) within the Gulf of Paria

- outside the one (1) fathom depth contour for the artisanal (ie. Type I and Type II trawlers)
- outside the four (4) fathom contour for the non-artisanal trawlers of 180 horsepower of less (ie. Type III trawlers)

and,

- outside the eight (8) fathom contour for the non-artisanal trawlers of greater than 180 horse power (ie. Type IV trawlers).

No demersal trawling is permitted off the East Coast of Trinidad, nor twelve (12) nautical miles off Tobago. The Regulations have been extended since 1993 and are still in force.

The Regulations also specify the minimum mesh sizes permitted in the cod-ends of the trawl nets. Stretched mesh sizes must not be less than 7.5 cm (3 in) when trawling for fish, or 3.5 cm (1.5 in) when trawling for shrimp.

When chafing gear is used, it is required that it be of netting material of stretched mesh size not smaller than specified for cod-ends. The chafing gear must also cover no more than twenty-five (25) percent of the cod-end.

Under the terms of the last Trinidad and Tobago/Venezuela Fishing Agreement, a maximum of seventy (70) Type I trawlers are permitted to fish in the coastal waters of the Orinoco Delta. Under this agreement, it is specified that the vessels be constructed of wood or fibreglass, not exceeding twelve (12) metres in length, and have engines whose combined horsepower is not greater than 110 HP. No outboard engine may exceed 60 HP. The fishing period is confined to December 1st to June 30th. Provisions contained in "The Fisheries (Conservation of Marine Turtles) Regulations 1994" dictate the specifications for the construction and rigging of the devices to trawl gear.

The maximum storage capacity of the vessels is specified as 500 kg (net). The trawl nets must be of the artisanal type, with the headrope lengths not exceeding fifteen (15) meters, and have a cod-end minimum mesh size 1.75 centimetres (between knots). Only one (1) net may be used at any time. The maximum crew size is four (4) persons including the skipper.

Resulting from the requirement to export shrimp to the USA, the 1990 enactment by the US Congress (at the request of the United States shrimping industry), the adoption of Turtle Excluder Devices (TEDS) was accepted by the Trinidad and Tobago Government. As a result all Type III and Type IV trawlers are required to use TEDS on a permanent basis.

ENFORCEMENT

The responsibility for enforcement of regulations for national vessels in waters under the jurisdiction of Trinidad and Tobago lies with the Trinidad and Tobago Coast Guard. There is also an environmental lobby within the country, growing in importance, that monitors the operations of commercial fisheries, particularly trawling. Reports of alleged contraventions are reported to the Fisheries Division, the Coast Guard, and frequently to the media. Officers of the Fisheries Division and Forestry Division along with the Coast Guard officers are empowered to carry out the provisions of certain pieces of fisheries related legislation. In the coastal waters of the Orinoco Delta, the Venezuelan National Guard is the main enforcement agent. Contraventions are mainly for trawling in the areas not legally designated.

REVISION OF FISHERIES LEGISLATION

The existing legislation has been found to be inadequate as a legal basis upon which a modern fisheries management system can be structured. In response to this, the government is currently revising the fisheries legislation, bringing it in line with its formulated policy for marine fisheries.

In March 1994 under project TCP/TRI/2352 - "Marine Fisheries Policy and Legislation", technical assistance was provided by the FAO for the preparation of a Marine Fisheries Policy through a three week mission by an FAO Technical Advisory Team consisting of a Fisheries Economist/Planner and a consultant

Fisheries Biologist who worked with the Fisheries Division on the formulation of a document titled "Policy Directions for Marine Fisheries of Trinidad and Tobago in the 1990's". This document was the subject of three national consultations in 1995 and was reviewed in light of comments received and discussions held with the fishing industry and other agencies with an interest in marine fisheries.

In June 1995, a draft Fisheries Management Act was prepared with the assistance of the FAO Legal Department. The Act provides the framework for the management of both local and foreign fishing activity in the waters under the jurisdiction of Trinidad and Tobago. One of the major objectives as outlined in the National Marine Fisheries Policy was to provide for a move from a system of uncontrolled, free access to the fisheries resources to a system of controlled access dependent upon the preparation of Fisheries Management Plans based on the best available scientific and socio-economic information. The revised legislation was also intended to take into consideration the Government's participation in international agreements and national responsibilities for management of the resources of the Exclusive Economic Zone. The Act in its draft form remains to be finalised after a period of consultation and amendment.

DESCRIPTION OF THE GROUNDFISH FISHERY

FISHING ZONES

The sites of major groundfish fishing activity are the west (Gulf of Paria) and south (Columbus Channel) coasts of Trinidad, with minor activity occurring on the east and north coasts.

The substrate of the Gulf of Paria is generally fine mud with areas of shell debris and sand while the Columbus Channel is featureless with a fine mud substrate (Hodgkinson-Clarke, 1990). The west and south coast are shallow with maximum depths of 40 and 54 meters respectively (British Admiralty Chart no. 493).

The north and east coasts are more varied in topography, being rocky with some banks, shoals and sponge beds. These coasts have maximum depths up to the shelf break (90-100 meters) outside of which the continental slope descends to depths of several thousand meters. The continental shelf extends to 27 n. miles north and 35 n. miles east of Trinidad (Fridtjof Nansen Survey, 1988)

FLEET/GEAR

The vessels targeting groundfish are pirogues 6-10 meters long. They are constructed of wood, fibreglass or fibreglass coated wood. These vessels may use one or two outboard engines ranging in horsepower from 15 to 235, the average being 45-75 HP (Henry and Martin, 1992). There is no mechanisation of operations, however, most vessels carry ice chests for storage of catch. Vessels are privately owned with some persons owning more than one.

Table 19 shows the numbers of fishing vessels which operate gears to capture groundfish.

Table 19: Number of vessels with primary fishing method.

ISLAND	MONO (P)	MONO (D)	MULTI (P)	MULTI (D)	BANKING	LONGLINE (D)	BEACH SEINE
Trinidad	38	124	198	18	198	58	23
Tobago	46	6	1	2	35	1	34

Mono = monofilament gillnet, Multi = multifilament gillnet, P = pelagic, D = demersal

Source: Fisheries Division Census, 1991

While groundfish capture by trawling is probably the highest of any gear, the main fishing method targeting groundfish is monofilament demersal set gillnets, known locally as; "transpearing", "monoflemming", or "white net". Other gears which also capture groundfish include demersal longlines or "palangue", banking, beach seine, fishpots, and multifilament gillnets or "fillet", which though set on the surface may also catch groundfish due to deployment at shallow depths. Most fishing is done in depths between 9-14 meters.

The main landing sites from which these gears are operated are indicated in Table 20.

Table 20: Major beaches operating gears targeting groundfish.

BEACH	RANK
Erin	1
Icacos	2
Moruga	3
Sea Lots	4
Bonasse/Maracas	5
Guayaguayare*/Las Cuevas	6
Ortoire/Blanchisseuse	7
* - It should be noted that at Guayaguayare during "crop" time (Jan-July), activity targeting Carite increases drastically, through the migration of boats from other sites, to make this site one of the most important overall. This fact is not documented, as no statistics are collected from this beach.	
Source: Fisheries Division Census, 1991.	

The monofilament gillnet takes a greater percentage and variety of species as bycatch than the multifilament gillnet. This is due to both its demersal deployment and the fact that the monofilament net has a higher hanging ratio, and therefore entanglement ability, than the multifilament net (Hodgkinson-Clarke, 1990).

Monofilament nets may be fished both day and night, and are set demersally in two ways: (1) with both ends anchored, or (2) one end anchored and the other attached to the boat by the cork or float line. Multifilament nets are fished at night, except during bright moonlight, at the surface of the water. They may be free drifting or attached to the boat at one end. Gear characteristics for monofilament and multifilament gillnets are shown in Table 21.

Table 21: Gear description for gillnets.

NET TYPE	MESH SIZE	TWINE GAUGE	WEIGHT	MESH DEPTH	LENGTH
Nylon Mono- filament	114mm/4.5" 102mm/4.25" 95mm/3.75"	9, 10, 12, 15, 18 (10 most used)	5-8 bales per net (50 or 25 lb bales)	100 mesh/50lb 50 mesh/25lb	450-1098m
Nylon Multi- filament	114mm/4.5" 102mm/4.25" 95mm/3.75"	12, 15	3-6 bales per net (50 or 25 lb bales)	100 mesh/50lb	732-1190m
Source: Henry and Martin (1992).					

The target species for the gillnet is carite (*Scomberomorus brasiliensis*), the bycatch landed includes the following:

Kingfish *Scomberomorus cavalla*

Salmon *Cynoscion jamaicensis*, *Cynoscion* spp., *Macrodon ancylodon*

Croaker *Micropogonias furnieri*

Blinch	*Diapterus* spp.
Grunt	*Haemulon* spp., *Genyatremus luteus*, *Orthopristis* spp.
Brochet	*Centropomus* spp.
Cavalli	*Caranx hippos*
Redfish	*Lutjanus* spp., *Rhomboplites aurorubens*
Catfish	*Arius* spp.

On the west coast, some fishermen target mullet (*Mugil* spp.) for salting.

Nominal statistics from enumerated beaches indicate that for both multi- and monofilament gillnets, croaker is the most important species landed by weight and value, followed by catfish, blinch, salmon, redfish, and grunt, in that order. In banking, redfish is most important, followed by croaker, grouper, salmon, and catfish, respectively.

Table 22 shows the percentage contribution of individual groundfish species to the total catch weight and value, by gear, of all groundfish for 1994, it also shows the contribution made by groundfish species to the total catch by gear of all species:

Table 22: Percentage contribution of groundfish species to total groundfish catch weight and value, by gear.

SPECIES	BANKING		FILLET		MONOFILAMENT	
	Weight	Value	Weight	Value	Weight	Value
REDFISH (*Lutjanus* spp.)	63	82	1	2	3	13
SALMON (*Cynoscion* spp.)	2	2	2	4	5	8
CROCRO (*M. furnieri*)	17	6	85	85	61	53
GROUPER (Serranidae)	15	9	0	0	0	0
BROCHET (*Centropomus* spp.)	1	0	1	1	4	7
BLINCH (*Diapterus* spp.)	0	0	3	4	13	13
GRUNT (*Haemulon* spp.)	0	0	0	0	3	3
CATFISH (Ariidae)	2	0	8	3	10	4
% Contribution of groundfish landings to total catch of all species by gear	65	78	23	12	50	35
(Fisheries Division Nominal Statistics, 1994)						

Since the introduction of the monofilament gillnet, its use has become widespread. It was preferred to the multifilament net for several reasons;

- it can be fished both at day and night - day fishing reducing chances for piracy,
- it generally returns higher overall catches than the multifilament,
- the webbing is lighter, allowing larger nets to be made from the same weight of net.

A local knowledge survey conducted in 1994 on the west coast under the project INT/91/001, revealed however that fishermen now view the monofilament net as a threat to the Gulf of Paria. They feel that 'ghost fishing' by lost or abandoned nets, capture of juvenile fish, and destruction of the seafloor by this gear, is negatively affecting the fisheries resources of the Gulf of Paria.

Table 23: Periods of peak activity for monofilament, multifilament and banking.

GEAR	COAST	PEAK PERIODS
Monofilament Gillnet	North	No Data
	East	July-January
	South	August-February
	West	July-January
Multifilament Gillnet	North	December-March
	East	June-September
	South	July-October, December-January
	West	June-November
Banking	North	August-November
	East	October-December, March to May
	South	May-September
	West	July-January
Source: Fisheries Division Statistics, 1993 (unpublished data)		

CATCH WEIGHT AND VALUE

In 1994, groundfish landings comprising six groups of species, from three gears combined (monofilament, multifilament and banking), contributed a total of 956,998 kilograms to the total catch estimates of all gears and species, at an estimated value of TT$ 4,196,137.00. This represents an overall contribution of 12.57% (by weight) and 6.62% (by value) to the total annual production for 1994.

The six groups analyzed were blinch, brochet, catfish, croaker, grunt and salmon. The average price per kilogram for each group was as follows;

Salmon	$7.12
Brochet	$6.62
Blinch	$4.59
Croaker	$4.18
Grunt	$3.90
Catfish	$1.97

Of the total estimated catch and value of groundfish for 1994, croaker was most important, contributing 65% (Wt.) and 63% (Val.) to the total. The other groups contributions were as follows;

	% by Wt.	% by Value
Blinch	11	11
Salmon	9	15
Catfish	9	4
Brochet	4	6
Grunt	1	1

Table 24 gives the raised estimates for catch and value for groundfish from the three gears combined, by month, for 1994.

Table 24: Estimated catch (kg) and value (TT$) for groundfish in 1994 (raised by total units/coast):- monofilament, multifilament and banking combined.

MONTH	BLINCH		BROCHET		CATFISH		CROAKER		GRUNT		SALMON		TOTAL	
	Wt	Val	Wt	Val	Wt	Val	Wt	Val	Wt	Val	Wt	Val	Wt	Val
Jan	15301	68547	1671	10710	6756	8296	40068	192681	2816	10958	4036	32664	70648	323856
Feb	4223	17652	3399	22772	3968	5921	34925	154662	0	0	16896	135321	63410	336328
Mar	1748	8896	680	5272	3595	4568	26253	136383	3466	15021	9250	74772	44992	244912
Apr	794	4227	740	5467	2704	4055	22934	103790	3099	12240	2053	10880	32323	140659
May	7264	29711	678	4663	1107	1451	15299	73011	731	2937	2750	13716	27830	125489
Jun	6438	28776	1038	6496	2411	3279	69887	270244	428	1370	4512	28974	84713	339139
Jul	11691	54129	452	2922	8685	11950	73804	294241	400	2082	5059	34906	100091	400229
Aug	1830	6605	1892	13602	8597	11951	96732	505163	1165	3845	6398	40397	116614	581563
Sep	19146	74862	6029	36440	14951	63504	155734	512066	162	354	14788	92408	210811	779634
Octo	15537	86694	3137	17392	66	144	14355	50355	858	1999	6676	36579	40629	193162
Nov	15236	73743	1854	11795	19298	31709	48080	197855	198	688	10489	84741	95155	400532
Dec	5688	27643	15060	105118	15306	25714	28700	132189	508	2502	4521	37468	69782	330634
TOTAL	104895	481486	36629	242650	87444	172541	626771	2622640	13832	53995	87427	622826	956998	4196137

PROCESSING AND MARKETING OF FISH

The processing of fish species harvested from the shrimp and groundfish fishery, occurs on a very limited scale. On board the industrial vessels, after the catch is sorted, the larger fin-fish of economically imported species are washed and stored on ice, according to species and size. No other processing occurs on board with the fish being sold as whole-fish to wholesalers. Prior to retailing, some processing may include the removal of gills and gutting. Generally, the local market is supplied with fresh iced fish while the foreign markets receive the chilled or frozen product. A recent development on the local market is the supply of dressed and filleted fish by fish shops. These business enterprises also produce fish-fingers, patties, fish stock and steaks for the local hospitality industry.

Increased markets overseas have generated development in processing of previously under-utilised species such as mullet and catfish, which are now being processed into salted fish for export to Venezuela. It has also been recently learnt that blinch is now being targeted for export to North America at a price of TT$ 4.00 per lb.

Supplies from the artisanal vessels are either sold by auction at the major landing sites to exporters and hoteliers or to retailers who supply the domestic market. These are sold as fresh on ice, gutted, dressed or sliced fish. For both the industrial and artisanal fish processing activities, the form in which the product is sold depends upon how long ago the fish has been harvested.

The individuals of greater economic importance belong to the following families: Carangidae, Sciaenidae, Lutjanidae and Gerreidae. The major export markets for these fish are similar to those for shrimp exports. Prices on both the domestic and foreign markets are not fixed, but are determined by the prevailing market forces. The average price range determined from exporter licence application forms is TT$8.00 per kilogram.

ASSESSMENT OF THE GROUNDFISH RESOURCES

Demersal resources were investigated with a demersal trawl survey programme conducted by *RV Dr. Fridtjof Nansen* in 1988 (Institute of Marine Research, 1989). The dominant family was Sciaenidae, followed by Lutjanidae. Tables 25 - 27 summarize the biomass estimates, catch rates and length ranges, respectively, by coast, for the main groundfish families.

Table 25: Overview of biomass estimates of groundfish by coast (t).

FAMILY NAME	NORTH COAST[1]	EAST COAST[2] 0-50m (t/nm²)	EAST COAST[2] Beyond 50m (t/nm²)	SOUTH COAST ("Joint Area")[3]	TOTAL[4]
Sciaenidae	3,550	6.4	0.6	5,500	9,050
Lutjanidae	400	1.4	0.6	450	850
Serranidae				200	200
Haemulidae		0.3	0.1	100	100
Other groundfish	750	1.8	1.8	2,000	2,750
Total	4,700	9.9	3.1	8,250	12,950

1 - Two of the catches beyond 50m were exceptionally large, and hence the biomass estimates may be overestimated if these high catches are not representative. The estimates might also reflect a seasonal situation as most of the sampling was done in November.

The dominant species in the 0-50m bottom depth zone were *Micropogonias furnieri* (whitemouth croaker), *Cynoscion jamaicensis* (Jamaica weakfish), *Peprilus paru* (American harvestfish), and *Lutjanus purpureus* (southern red snapper). The main species in the 50-100m bottom depth range were *Cynoscion jamaicensis, Ctenosciaena gracilcirrhus* (barbel drum), *Priacanthus arenatus* (Atlantic bigeye), and *Pristipomoides macrophthalmus* (cardinal snapper).

2 - Estimates on mean densities (t/nm²) are given by depth range. Absolute biomass figures for the whole shelf were not made since major parts of the east coast shelf are not suitable for trawling, and the estimated densities from the trawlable areas are not representative for the whole shelf.

In the 0-50m bottom depth zone the main species were *Stellifer microps* (smalleye stardrum), *Bairdiella crysura* (white corvina), *Micropogonias furnieri, Stellifer griseus* (grey stardrum), *Lutjanus synagris* (lane snapper), *Arius* spp. (catfish), *Cynoscion jamaicensis*, and *Lutjanus analis* (mutton snapper). The 50-100m depth range was dominated by *Cynoscion jamaicensis*, with some *Lutjanus analis* and *Ctenosciaena gracilcirrhus*.

3 - The dominant species were *Cynoscion jamaicensis, Micropogonias furnieri, Ctenosciaena gracilcirrhus, Macrodon ancylodon* (king weakfish), and *Lutjanus synagris*.

4 - Derived from north and south coast estimates.

Table 26: Overview of catch rate estimates of groundfish by coast (kg/hr).

FAMILY NAME	NORTH COAST[1]	EAST COAST2	SOUTH COAST ("Joint Area")[3]	TOTAL[4]
Sciaenidae	169	82	123	374
Lutjanidae	22	40	10	72
Serranidae	1	1	3	5
Haemulidae	0	6	3	9
Other groundfish	375	93	217	685
Sharks	43	10	10	63
Total	610	232	366	1208

1 - The trawl stations occupied in May and November only are used in this analysis. All trawl stations are pooled as the data are too limited to allow for analysis of seasonality. The few mostly unsuccessful hauls attempted in the outer part of the shelf have not been included. The sciaenids constitute the main group of demersal fish both in the shallow and deeper parts. They are followed by the lutjanids. The main commercial demersal species (lutjanids, serranids, scianids, haemulids) sum up to about 80 and 400 kg/hr for the 2 depth ranges while the corresponding figures for other, mostly non-commercial, demersal fish are 60 and 40 kg/hr.

Two of the catches beyond 50 m were exceptionally large and might indicate an overestimate in mean expected catch rates if these high catches are not representative.

Trawl stations occupied in May and November only were used in the analysis. *Mustelus canis* (smooth dogfish) was the dominant *Mustelus* species and *Rhizoprionodon porosus* (Caribbean sharpnose shark), the dominant *Rhizoprionodon* species.

2 - 3, 5, 6 and 11 random bottom trawl stations carried out in the respective 4 surveys are used in this analysis. The few stations in each survey do not allow for analysis by season, and all data are pooled.

Catches of demersal fish were lower in the deeper parts. In the 0-50 m bottom depth zone the total mean catch of demersal fish of 290 kg/hr consisted of 66% sciaenids, 14% lutjanids, 3% haemulids and 17% other fish. In the outer shelf the total mean catch was 84 kg/hr and comprised 20% sciaenids, 20% lutjanids and 60% other fish.

3 - 16, 18 and 15 successful hauls were made in May, August and November respectively and these were used to determine the mean. The majority of these stations was in the 0-50 m bottom depth zone and this is probably the reason why data were not analyzed separately for the 2 depth ranges. The sciaenids are the dominating group followed by lutjanids.

Yield-per-recruit (Y/R) analysis was conducted for the whitemouth croaker, *Micropogonias furnieri* (one of the more commercially important and abundant sciaenids), in Trinidad waters based on samples obtained by trawling between October 1977 and September 1982 (Manickchand-Heileman and Kenny, 1990). This analysis revealed that the maximum Y/R (175g) is already being obtained, and any increase in fishing mortality would result in overexploitation.

Table 27: Length ranges for selected demersal species by coast (cm).

FAMILY NAME	NORTH COAST	EAST COAST	SOUTH COAST ("Joint Area")
SCIANIDAE			
Microponias furnieri	33.0 - 55.0	26.0 - 48.5	23.0 - 51.0
Cynoscion jamaicensis	11.0 - 34.0		3.0 - 28.0
Ctenosciaena gracilicirrhus			7.0 - 18.0
Macrodon ancylodon			10.0 - 29.5
LUTJANIDAE			
Lutjanus synagris	11.5 - 25.0	8.0 - 42.0	6.5 - 46.0
Pristipomoides macrophthalmus			
STROMATEIDAE			
Peprilus paru	15.0 - 36.0		17.0 - 23.0
SHARKS			
Mustelus canis	35.0 - 61.0		
SIZE RANGE (KG)			
SHARKS			
Carcharhinus sp.			1.0 - 2.0
Rhizoprionodon sp.			0.6 - 1.3
Sphyrna sp.			1.0 - 10.0
Mustelus sp.			0.4 -0.8
Source: Institute of Marine Research, Bergen, Norway, 1988.			

The biological cycles of the commercially important sciaenids and lutjanids around Trinidad and Tobago are more commonly known. It has been suggested, according to length/weight relationships and von Bertalanffy growth constants, that the local population of *Cynoscion jamaicensis* is not an isolated one is probably linked with the Venezuelan population (Shim 1981).

Spawning patterns of *Micropogonias furnieri* show that spawning occurs fifteen times per year (Manickchand 1990). This research showed that the spawning potential ratio (ratio of spawning stock biomass per recruit in the fished to that in the unfished population) is below the critical level of 0.1. To ensure an adequate spawning stock level, fishing effort must be reduced by 47.5% and the age of first capture increased to three years.

Spawning occurs year-round but peaks in the dry season for *Cynoscion jamaicensis, Micropogonias furnieri* and *Lutjanus synagris* and in the rainy season for *L. vivanus* (Manickchand-Heileman and Julien-Flus 1990; Manickchand-Dass 1987).

Gear type analysis was conducted on the monofilament and multifilament nets used on the south coast of Trinidad (Clarke-Hodgekinson, 1990; 1994). Major differences in the fishing practices associated with each type of net were recorded. Catch rates for monofilament nets are higher than multifilament nets. Monofilament nets (3.75" - 5" stretched mesh size) are fished demersally and the species landed include many demersal species. *Cynoscion jamaicensis* and *Diapterus rhombeus* and lutjanids were the most important species in the monofilament by catch. Other species of commercial importance found were the haemulids, *Orthopristes chrysoptera* and *Haemulon bonariense* and the sciaenid, *Micropogonias furnieri*.

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APPENDIX 1

Spreadsheet Depiction of Length-based Yield Model for *P. schmitti*

Length Class (mm)		Time Interval (yr)	Fishing Mortality Coef.	Fraction Retained	Natural Mortality Coef.	Start Pop. No. ('000)	Mean Pop. No. ('000)	Catch No. ('000)	Mean Ind. Wt. (gm)	Catch Weight (tonnes)	Exploited Biomass (tonnes)
L1	L2	@t	F'	O	M'	N1.N2	N'	Cn	w	Cw	B
						Females					
0	2	0.026	0.1297	0.0000	0.0681	15.750	15.225	0	0.00	0	0
2	4	0.027	0.1354	0.0000	0.0711	14.713	14.202	0	0.03	0	0
4	6	0.029	0.1415	0.0000	0.0743	13.703	13.206	0	0.12	0	0
6	8	0.030	0.1483	0.0000	0.0779	12.721	12.239	0	0.32	0	0
8	10	0.032	0.1557	0.0000	0.0818	11.768	11.300	0	0.69	0	0
10	12	0.033	0.1639	0.0000	0.0861	10.844	10.391	0	1.27	0	0
12	14	0.035	0.1730	0.0000	0.0909	9.950	9.512	0	2.11	0	0
14	16	0.037	0.1832	0.0063	0.0962	9.086	8.658	10	3.29	0	0
16	18	0.039	0.1946	0.0123	0.1022	8.243	7.827	19	4.84	0	0
18	20	0.042	0.2076	0.0236	0.1090	7.424	7.017	34	6.83	0	1
20	22	0.045	0.2224	0.0451	0.1168	6.625	6.222	62	9.31	1	3
22	24	0.049	0.2396	0.0844	0.1258	5.836	5.429	110	12.35	1	6
24	26	0.053	0.2596	0.1524	0.1363	5.043	4.624	183	15.99	3	11
26	28	0.057	0.2832	0.2597	0.1487	4.229	3.792	279	20.31	6	20
28	30	0.063	0.3115	0.4063	0.1636	3.387	2.939	372	25.37	9	30
30	32	0.070	0.3462	0.5718	0.1818	2.533	2.108	417	31.21	13	38
32	34	0.079	0.3896	0.7226	0.2046	1.733	1.372	386	37.91	15	38
34	36	0.090	0.4455	0.8356	0.2340	1.066	799	297	45.52	14	30
36	38	0.105	0.5200	0.9084	0.2731	581	410	194	54.11	10	20
38	40	0.127	0.6247	0.9509	0.3281	276	180	107	63.74	7	11
40	42	0.158	0.7823	0.9742	0.4109	110	65	49	74.47	4	5
42	44	0.212	1.0474	0.9866	0.5501	34	17	18	86.37	2	1
44	46	0.322	1.5901	0.9931	0.8352	7	3	4	99.50	0	0
46	48	0.693	3.4198	1.0000	1.7962	1	0	0	113.93	0	0
48	49	8.711	43.0058	1.0000	22.6874	0	0	0	125.60	0	0
						0					
Totals								2,642		84	215
						Males					
0	2	0.023	0.1201	0.0000	0.0722	15.750	15.195	0	0.00	0	0
2	4	0.024	0.1261	0.0000	0.0758	14.653	14.112	0	0.03	0	0
4	6	0.026	0.1327	0.0000	0.0798	13.584	13.056	0	0.12	0	0
6	8	0.027	0.1401	0.0000	0.0842	12.542	12.029	0	0.34	0	0
8	10	0.029	0.1483	0.0000	0.0892	11.530	11.030	0	0.72	0	0
10	12	0.030	0.1576	0.0000	0.0947	10.546	10.062	0	1.33	0	0
12	14	0.032	0.1681	0.0000	0.1011	9.593	9.124	0	2.23	0	0
14	16	0.035	0.1802	0.0000	0.1083	8.671	8.218	0	3.48	0	0
16	18	0.037	0.1940	0.0028	0.1166	7.781	7.342	4	5.14	0	0
18	20	0.040	0.2102	0.0087	0.1263	6.921	6.495	12	7.26	0	0
20	22	0.044	0.2294	0.0267	0.1378	6.088	5.670	35	9.92	0	2
22	24	0.049	0.2523	0.0788	0.1517	5.272	4.844	96	13.17	1	5
24	26	0.054	0.2804	0.2106	0.1685	4.441	3.972	235	17.08	4	14
26	28	0.061	0.3156	0.4542	0.1897	3.537	3.008	431	21.72	9	30
28	30	0.070	0.3608	0.7219	0.2168	2.535	2.016	525	27.15	14	40
30	32	0.081	0.4212	0.8901	0.2531	1.573	1.168	438	33.44	15	35
32	34	0.097	0.5059	0.9619	0.3041	839	580	282	40.66	11	23
34	36	0.122	0.6336	0.9875	0.3808	381	240	150	48.87	7	12
36	38	0.163	0.8483	0.9960	0.5099	139	76	64	58.15	4	4
38	40	0.248	1.2879	0.9987	0.7741	36	15	20	68.55	1	1
40	42	0.534	2.7697	0.9996	1.6647	5	1	3	80.16	0	0
42	43	8.946	46.4409	1.0000	27.9128	0	0	0	89.57	0	0
						0					
Totals								2,295		68	165

Inputs:

Annual Fishing Effort		V	=	4,690
Catchability coef. (= F/trips)	-female	q	=	0.001053
	-male	q	=	0.001107
Recruit Number at zero age ('000)		R	=	31,500
Ann. natural mortality coef.	-female	M	=	2.6
	-male	M	=	3.1
Asymptotic length (mm)	-female	L(inf)	=	49.0
	-male	L(inf)	=	43.0
Curvature coefficient	-female	K	=	1.6
	-male	K	=	2.1
Length/weight constants	-female	u	=	0.000701
(when w in gm and L in mm)		v	=	3.116
	-male	u	=	0.000711
		v	=	3.132
Recruitment/selection ogive		O	=	see spreadsheet

Outputs:

Est. Catch weight	=	153	tonnes
Est. Mean individual weight	=	31.5	gm
Est. Catch rate	=	33	kg/trip
Est. Exploited biomass	=	380	tonnes

Equations:

@t = 1/K.ln((L(inf)-L1)/(L(inf)-L2))
F' = @t.V.q
M' = @t.M
N2 = N1.exp(-(O.F' + M'))
N' = (N1-N2)/(O.F' + M')
Cn = O.F'.N'
w = u.(L1^v + L2^v)/2
Cw = Cn.w
B = O.w.N'

APPENDIX 2

Spreadsheet Depiction of Length-based Yield Model for *P. subtilis*

Length Class (mm)		Time Interval (yr)	Fishing Mortality Coef.	Fraction Retained	Natural Mortality Coef.	Migration Coef.	Start Pop. No. ('000)	Mean Pop. No. ('000)	Catch No. ('000)	Migration No. ('000)	Mean Ind. Wt. (gm)	Catch Weight (tonnes)	Exploited Biomass (tonnes)
L1	L2	@t	F'	O	M'	Mg'	N1.N2	N'	Cn	D	w	Cw	B
							Females						
0	2	0.026	0.1272	0.0000	0.0698	0.2846	47.750	46.122	0	0	0.01	0	0
2	4	0.027	0.1328	0.0000	0.0729	0.2973	44.531	42.947	0	0	0.05	0	0
4	6	0.028	0.1390	0.0000	0.0763	0.3111	41.401	39.861	0	0	0.18	0	0
6	8	0.030	0.1458	0.0000	0.0800	0.3263	38.360	36.865	0	0	0.44	0	0
8	10	0.031	0.1533	0.0000	0.0841	0.3431	35.410	33.962	0	0	0.85	0	0
10	12	0.033	0.1616	0.0001	0.0887	0.3616	32.554	31.152	0	1	1.45	0	0
12	14	0.035	0.1708	0.0002	0.0937	0.3823	29.791	28.435	1	3	2.27	0	0
14	16	0.037	0.1812	0.0010	0.0994	0.4055	27.122	25.810	5	10	3.34	0	0
16	18	0.039	0.1929	0.0004	0.1058	0.4317	24.541	23.284	2	4	4.68	0	0
18	20	0.042	0.2062	0.0177	0.1131	0.4614	22.071	20.748	76	169	6.31	0	2
20	22	0.045	0.2215	0.0710	0.1215	0.4957	19.479	17.892	281	629	8.27	2	10
22	24	0.048	0.2392	0.2450	0.1313	0.5353	16.394	14.023	822	1.840	10.57	9	36
24	26	0.053	0.2600	0.5798	0.1427	0.5820	11.892	8.820	1.330	2.976	13.24	18	68
26	28	0.058	0.2848	0.8543	0.1563	0.6375	6.328	4.095	997	2.230	16.30	16	57
28	30	0.064	0.3149	0.9614	0.1728	0.7047	2.462	1.461	442	990	19.78	9	28
30	32	0.071	0.3520	0.9907	0.1931	0.7878	777	431	150	336	23.69	4	10
32	34	0.081	0.3991	0.9978	0.2190	0.8931	207	107	43	95	28.05	1	3
34	36	0.093	0.4607	0.9995	0.2528	1.0310	46	22	10	22	32.90	0	1
36	38	0.110	0.5449	1.0000	0.2990	1.2194	8	3	2	4	38.23	0	0
38	40	0.135	0.6669	1.0000	0.3659	1.4924	1	0	0	1	44.09	0	0
40	42	0.174	0.8597	1.0000	0.4717	1.9241	0	0	0	0	50.48	0	0
42	44	0.245	1.2117	1.0000	0.6649	2.7119	0	0	0	0	57.42	0	0
44	46	0.420	2.0715	1.0000	1.1366	4.6359	0	0	0	0	64.95	0	0
46	48	8.782	43.3591	1.0000	23.7917	97.0376	0	0	0	0	73.06	0	0
							0						
Totals									4,160	9,310		59	216
							Males						
0	2	0.022	0.1146	0.0000	0.0757	0.2718	47.750	45.988	0	0	0.00	0	0
2	4	0.023	0.1206	0.0000	0.0796	0.2861	44.271	42.554	0	0	0.04	0	0
4	6	0.025	0.1273	0.0000	0.0841	0.3020	40.882	39.211	0	0	0.14	0	0
6	8	0.026	0.1348	0.0000	0.0890	0.3198	37.585	35.961	0	0	0.35	0	0
8	10	0.028	0.1432	0.0000	0.0946	0.3398	34.384	32.808	0	0	0.71	0	0
10	12	0.029	0.1528	0.0002	0.1009	0.3625	31.281	29.754	1	2	1.26	0	0
12	14	0.032	0.1637	0.0007	0.1081	0.3884	28.277	26.797	3	8	2.04	0	0
14	16	0.034	0.1763	0.0037	0.1164	0.4183	25.370	23.923	15	37	3.07	0	0
16	18	0.037	0.1910	0.0182	0.1261	0.4532	22.532	21.048	73	173	4.41	0	2
18	20	0.040	0.2084	0.0851	0.1376	0.4944	19.631	17.815	316	749	6.08	2	9
20	22	0.044	0.2293	0.3186	0.1514	0.5440	16.114	13.295	971	2.304	8.13	8	34
22	24	0.049	0.2548	0.7016	0.1683	0.6045	10.826	7.546	1.349	3.200	10.58	14	56
24	26	0.055	0.2867	0.9220	0.1893	0.6803	5.007	3.060	809	1.919	13.47	11	38
26	28	0.063	0.3278	0.9835	0.2165	0.7778	1.699	949	306	726	16.83	5	16
28	30	0.074	0.3827	0.9967	0.2527	0.9080	461	235	90	213	20.71	2	5
30	32	0.089	0.4597	0.9993	0.3036	1.0907	99	45	21	49	25.13	1	1
32	34	0.111	0.5757	0.9999	0.3802	1.3659	16	6	3	8	30.13	0	0
34	36	0.148	0.7708	1.0000	0.5090	1.8288	2	0	0	1	35.74	0	0
36	38	0.225	1.1702	1.0000	0.7728	2.7764	0	0	0	0	42.00	0	0
38	40	0.485	2.5167	1.0000	1.6620	5.9711	0	0	0	0	48.94	0	0
40	41	8.129	42.1985	1.0000	27.8668	100.1188	0	0	0	0	54.54	0	0
							0						
Totals									3,958	9,390		43	162

Inputs:

Annual fishing effort (trip)		V	=	4.690
Recruit number at zero age ('000)		R	=	95.500
Catchability coef. (=F/day)	-female	q	=	0.001063
	- male	q	=	0.001107
Ann. natural mortality coef.	-female	M	=	2.7
	- male	M	=	3.4
Ann. migration coef.	- female	Mg	=	11.0
	- male	Mg	=	12.3
Asymptotic length (mm)	-female	L(inf)	=	48.0
	- male	L(inf)	=	41.0
Curvature coefficient	-female	K	=	1.7
	- male	K	=	2.3
Length/weight constants	-female	u	=	0.002150
(when w in gram and L in mm)		v	=	2.709644
	- male	u	=	0.001155
		v	=	2.907667
Recruitment/selection ogive		O	=	see spreadsheet

Outputs:

Est. Catch weight	=	102	tonnes
Est. Mean individual weight	=	12.6	gm
Est. Catch rate	=	22	kg/trip
Est. Exploited biomass	=	377	tonnes
Est. Migration Number	=	18,700	thousand

Equations:

@t = 1/K.ln((L(inf)-L1)/(L(inf)-L2))
F' = @t.V.q
M' = @t.M
Mg' = @t.Mg
N2 = N1.exp(-(O.(F' + Mg') + M'))
N' = (N1-N2)/(O.(F' + Mg') + M')
Cn = O.F'.N'
D = O.Mg'.N'
w = u.(L1^v + L2^v)/2
Cw = Cn.w
B = O.w.N'

National Report on the Shrimp & Groundfish Fisheries of Venezuela

L.A. Marcano[1], J.J. Alio[1], D.E. Altuve[1]

INTRODUCTION

This report describes the characteristics of the shrimp fisheries made by the Venezuelan industrial fleet in the Atlantic zone of the country (from Bocas de Dragon in the Gulf of Paria, the zone between the South of Trinidad and the Orinoco River delta, up to Boca Grande, Fig. 1). It is considered an addendum to the report previously presented in 1992 by Marcano *et al.* (1995). Shrimp resources in this zone are exploited by fishermen from Venezuela and Trinidad-Tobago. Only information from Venezuelan fishermen is presented. Preliminary information on the artisanal trawling fishery practiced by Venezuelan fishermen has been included.

At the present moment, the traditional trawling fishing grounds, located in the Gulf of Venezuela, Platform Unare - Píritu, and Northern Margarita Island and Sucre State (Fig. 2), are being exploited intensively, although the effort has decreased progressively in the last three years. It has been estimated that the effort level applied to the bottom resources, and mainly upon the shrimp resources, is beyond the one required to achieve the maximum sustainable yield (MSY), with the exception of the resources in the Atlantic zone where it is still below that required to reach MSY.

In view of this situation, the Atlantic zone has been considered as an alternative to increase the industrial development of the fishery, because of its lowest level of exploitation, high yields in fish resources, and the highest yields in shrimp resources, in comparison with the other areas exploited by the trawling fleet. At the present moment, a total of 107 vessels operate, at least once a year, in the Atlantic zone of Venezuela, based in Puerto La Cruz, Cumaná and Güiria (Marcano, 1995). This effort would be equivalent to that made by a fleet of 50 vessels operating in the area for 180 days per year.

DESCRIPTION OF THE SHRIMP INDUSTRY

FISHING ACTIVITIES

Fishing Zones

The fleet maintains the same operation areas as described in our earlier report (Marcano *et al.*, 1995). The area where the fleet operates is located in the Atlantic zone of Venezuela, between Bocas del Dragón in the Northern Gulf of Paria, to the Esequibo river in the South (Fig. 1), covering an area of 71,000 km². Although, the effort has reduced during the last three years, its distribution in the zone has shifted towards the south of the Orinoco River delta, where 33% of the total effort made in the zone is being applied (Table 6). The industrial fleet operates in the area during the entire year.

The artisanal shrimp fishery takes place in the northern Gulf of Paria, and in front of Pedernales, in the northern Orinoco River delta. The former fishery is performed by walking fishermen with beach seines, whereas the fishermen near Pedernales use small trawling nets, similar to the ones utilized by the fishermen from Trinidad-Tobago. The latter originated in 1992, and operates during the entire year.

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[1] FONAIAP, Venezuela.

THE FLEET

Vessels and Enterprises

The number of fishing enterprises continues to be high, although it decreased 22% during the last three years (from 97 in 1991 to 76 in 1994; Table 1). Likewise, the number of industrial trawling vessels decreased 20%, from 140 in 1991 to 107 in 1994. All vessels are based in the ports of Güiria, Cumaná and Punta Meta. The number of vessels in Güiria was reduced by 8 units, and by 9 in Cumaná, in relation to 1991. The number of vessels from Punta Meta is stable with 6 units (Tables 2, 3 and 4).

The structural characteristics of the fleet has maintain the proportions found in 1991, in spite of the reduction in number of vessels (Table 5).

Fishing Gear

Most of the vessels use the Florida type trawls. However, the fishing gear changed in ten (10) vessels (7% of the fleet), from the Florida Type trawl nets to fish trawl nets. Four of these vessels use a single net from the stern, while the other six use two nets from the sides of the boat.

THE FISHING STRATEGIES (OPERATIONS)

The number of trips per boat has decreased slightly for the vessels from the three base ports, although the duration of the trip has increased by three days for the fleet based in Cumaná, two for the fleet based in Güiria and four for the Punta Meta fleet (Tables 2, 3 and 4).

THE DISCARD

Sea bob, *Xyphopenaeus kroyeri*, which used to be discarded prior to 1991, are now landed. It is peeled in factories located in Güiria and sold in national markets.

During 1994, the by-catch accounted for 93% of the total catch in the nets. From this capture, 33% was sold in the local market and the rest (60% of the total catch) was returned, mostly dead, to the sea (Table 12).

ARTISANAL SHRIMP FISHERY

The artisanal trawl fishery in the area has had an early development. It operates in the Pedernales area and sells the catch to processing plants located in Güiria and Soro. There are around 25 wood vessels operating in the area, with outboard engines, with a length of 7 to 9 m.

PROCESSING ACTIVITIES

INDUSTRIAL SHRIMP PROCESSING

Shrimps from the industrial fleet are landed either whole or headless. Since 1989, the problem raised with the use of bisulfite as a shrimp preservative, induced some managers to request the removal of the heads on board. Once in the plant, the shrimps are classified by size according to the international market categories, and packed in 5 lb. boxes. Headless shrimp are exported to the North American market, while whole shrimp are exported to Europe. The small shrimp (penaeid and sea bob) are peeled are sold in national markets.

There are 13 processing plants for shrimp and fillet of fish, distributed as follows:

Locality	N° of Processing Plants
Puerto La Cruz	2
Cumaná	6
Soro	1
Güiria	4
Total	13

Approximately, 80% of the shrimp catch in Venezuela is Atlantic zone are smaller than the one from other fishing zones, most of it is sold in the Venezuelan market, either whole or peeled.

PROCESSING OF THE ARTISANAL CATCHES

The artisanal catch from the Northern Gulf of Paria, receives very little processing, except for the cleaning of the shrimps with sea water after the seines are brought to the beach. The artisanal trawl boats conserve the daily shrimp capture on ice. This catch is taken daily to a freezer facility in Pedernales, from where it is carried to the processing plants in Güiria or Soro.

CATCH AND EFFORT

EFFORT

The number of trips made by the trawling units has decreased in relation to 1991, from 1026 in 1991 to 527 in 1994 (a decrease of 41%). The greatest decreased was observed in the fleet of Cumaná, which reduced the number of trips by 46%. The other two fleets decreased the number of trips by 37%. The decreased observed in the fleets is due to the fact that the vessels also operate in other fishing areas (Platform Píritu-Unare and Northern Margarita Island and Sucre State).

Considering the days-at-sea spent by the trawling units in the Atlantic zone of the country, it has been found that the Cumaná and Güiria fleets decreased from about 100 days-at-sea per vessel in 1991 to 71 and 68 in 1994, respectively (Table 2 and 3). The vessels with the longest stay are still those from Punta Meta, which spend about 163 days-at-sea per vessel.

The total effort made in the area by all three fleets decreased by 32% for 1994, when it reached 8851 days-at-sea in comparison with the 13011 days-at-sea reported in 1991.

Considering the geographic distribution of the fishing effort during 1994, it can be observed that trawling was mostly performed in 3 of a total of 16 squares that were used by the fleets (Table 6). The effort in these three squares represented 65% of the total effort made by the fleets in the zone. The fishing square with the greatest effort was 09613, located South of Trinidad and North of the Orinoco River delta. This year the fleet operated in a wider area, increasing the trawling zone to 5 squares. The new squares are located in the Southern area of the Orinoco River delta, which is characterized by its abundance in fish resources, more than shrimp.

With respect to depth, during 1994 the fleet was most active in the depth interval of 11-20 fathoms (20-36 m), where 82% of the effort was made.

CATCH AND LANDINGS

Since 1991 shrimp capture shows a decreasing trend, when the landings went from 1433 mt to 692 in 1994, which represents a decreased of 52%. This probably follows from the observed reduction in the effort during the last three years in the area. The reduction affected the landings of white shrimp slightly more that those of brown shrimp (55% vs. 51%, respectively; Table 8).

The fleet from Güiria provided the greatest landings during 1994 (413 mt; 59%), followed by the fleet from Cumaná (175 mt, 25%) and the fleet from Punta Meta (109 mt; 16%, Table 9).

The distribution of shrimp capture by fishing area (squares) during 1994, shows a high concentration in the same 3 squares as formerly described for effort (Table 6). More than 70% of the landed shrimp was captured in squares 10611, 09613, 09614, 10621 and 10612. In particular, during 1991, the capture from square 09613 was 538 mt (36% of the total landing for that year), in response to the highest value of effort made by the fleet in that square. There was a small annual variation for the geographical distribution of captures.

The analysis of the geographical distribution of captures by shrimp species indicates that during 1992 white shrimps were most abundant in the squares 09613 and 09604, where more than 100 mt (55 %) were reported. Captures of brown shrimp during this year were highest in the same squares, which amounted to 713 mt (73%; Table 6). White shrimp catches were high in the Southern Orinoco River delta (08594) in front of Boca Grande.

Shrimps were mainly fished between 1 and 20 fathoms (Table 7), with the greatest captures in the interval 11-20 fathoms (790 mt, 68%). This pattern of distribution was similar for both shrimp species (638 mt or 65% for brown, and 152 mt or 85% for white shrimp).

CAPTURE PER UNIT OF EFFORT

A decreasing trend has been observed in the c.p.u.e. for shrimp in the zone since 1986, reaching the lowest, 78 kg/day, in 1994. This is the lowest c.p.u.e. value observed in the 22 year history of the fishery in the area (Table 8). This trend has been attributed to different factors, in particular a shift of the effort towards areas with greater fish density or a reduction in the recruitment of shrimp to the fishing areas where the industrial fleet operates. The latter could be caused by the increased activity of the artisanal trawling fleet which targets shrimp juveniles in a nearby area (Pedernales) during the last three years,.

Regarding the fishing effort, the industrial fleet allocated 37% of the total effort to new areas in the Southern Orinoco River delta, where fish are more abundant and shrimp densities are low. Thus, the calculation of the general c.p.u.e. for shrimp considers the total effort made in the area, regardless if it was oriented towards shrimp or fish, leading to an apparent decrease. In fact, if the c.p.u.e. for a typical shrimp area (fishing square 09613) is considered for the last four years, a stable trend around 140 kg/day is observed, with an increase to 210 kg/day during 1994.

The behavior of the c.p.u.e. for brown shrimp follow a similar trend as the general shrimp captures in the area, since this species represents 77% of the shrimp landings. On the other hand, c.p.u.e. for white shrimp is more stable around 20 kg/day, during the last 7 years (Table 8).

The areas of greater shrimp density are located in the Northern section of the Orinoco River delta (fishing square 09613; Table 6). Greater c.p.u.e. values can be found in other squares, but the effort made in them is very low. This suggests that the accessibility of the fleet to the shrimp resources depends on environmental conditions (for instance, the shifting depth in a particular fishing square during different years), limiting the exploitation of the areas with the highest shrimp densities.

The depth interval with the highest values of c.p.u.e. was 1-10 fathoms during 1994. However, the effort at that depth only reached 4%, whereas the effort in the interval 11-20 fathoms represented 82% of the total. Again, the limiting accessibility of the fleet to the fishing grounds in shallow area is impaired and would explain the low effort made in them.

ASSESSMENT OF THE RESOURCES

LENGTH FREQUENCY DISTRIBUTION BY SPECIES/SEX.

Penaeus subtilis

Brown shrimp is the dominant species in the landings of shrimp from the Atlantic zone of Venezuela. This species represents more than 80% of the brown shrimp complex and more than 70% of all the penaeid shrimp captured in the area. From samples taken in processing plants of Cumaná and Guiria, a size/frequency analysis was carried out. The total length (postorbital/telson length)interval for females was 71 - 137 mm, with an average of 97 mm and a mode of 80 mm (Fig. 3). Size interval for males was 57 - 178 mm, with an average of 95 mm and a mode of 97 mm (Fig. 4). Sex proportion was extremely biased (8.5:1 F/M).

Length/weight relationships (regression model type I) were calculated as follows:

Females: $W = 3.21 \times 10^{-5} \times TL^{2.8009}$ (N= 2863, r = 0.96, Fig. 5)

Males: $W = 2.59 \times 10^{-5} \times TL^{2.84678}$ (N= 336, r = 0.92, Fig. 6)

Penaeus schmitti

White shrimp represents 16 - 29% of the landings of shrimp in the Atlantic zone of Venezuela. The sampling for the size/frequency analysis were made, as with the previous species, in the facilities of processing plants of Cumaná and Guiria. The total length interval for females was 82 - 190 mm, with and average of 134 mm and a mode of 130 (Fig. 7). Size intervals for males was 91 - 190 mm, with an average of 96 mm and a mode of 120 (Fig. 8). Sex proportion was close to 2:1 (F/M).

Length/weight relationships were calculated as follows:

Females: $W = 1.03 \times 10^{-6} \times TL^{3.4147}$ (N= 960, r = 0.96, Fig. 9)

Males: $W = 1.19 \times 10^{-6} \times TL^{3.3948}$ (N= 525, r = 0.98, Fig. 10)

EVALUATION OF SHRIMP RESOURCES

This evaluation was performed using the exponential model of Fox. In this case, the evaluation was oriented towards shrimp because the landings coincide with the catch reported by the fishing enterprises. The fish catch was not considered in the analysis because the landings at the beginning of the fishery represented only a small proportion of the total capture. The Pearson correlation coefficient was 0.62 (N=22, $P < 0.05$). The maximum sustainable yield (MSY) was 1,446 mt, which is slightly higher than the one reported already by the general fleet operating in the area. Likewise, the optimal effort (16,293 days-at-sea) necessary to reach the MSY, is larger than the one made already by the fleet (Fig. 11).

The evaluation made for the brown shrimp indicates that the Pearson Correlation coefficient was 0.64 (N=22, $P< 0.05$) and, as in the estimates for general shrimp evaluation, the MSY (1076 mt) is slightly higher than actual landings in the area, with an optimal effort close to 14,000 days-at-sea, which resembles the one made already by the fleet (Fig. 12).

The general behavior of the shrimp fishery during the evaluated period suggest that the fishery is affected by the actual fisheries. However, the results should be considered as indicators of the actual condition of the resources, but not as a precise measure of the density of the stock. The latter is due to the fact that:

1. Under the denomination of shrimp and brown shrimp there are four and three species of shrimps, respectively. It is also possible that there were several different stocks for each species, with a different population dynamics.
2. This analysis does not contain information on the fishery activity developed by Trinidad & Tobago vessels operating in the common fishing area between the two countries.

SECONDARY RESOURCES

A decreasing tendency in by-catch landings was observed during 1991-94, principally due to changes in the level of the fishing effort. In spite of this, the c.p.u.e. has consistently increased, from 537 kg/day in 1991 to 766 kg/day in 1994 (Table 10).

Geographically, fish are distributed more homogeneously in the area than shrimp, with c.p.u.e. values near 500 kg/day (Table 11). In 1992, the new fishing areas explored by the fleet in the Southern Orinoco River delta showed the highest c.p.u.e. values. Furthermore, the yield in the depth interval 11-20 showed the highest values, 664 kg/day (Table 12). Nevertheless, the maximum yield of the non commercial by-catch was found in shallow waters (interval 1-10), which is a zone typically occupied by fish juveniles

The by-catch component recuperated and commercialized by the Venezuelan vessels in the Atlantic zone is integrated exclusively by fish. The main fish species in this capture are: croaker (*Macropogonias furnieri*), curvina (*Cynoscion* spp.), dog trout (*Macrodon ancylodon*); lean snapper (*Lutjanus synagris*), catfish (*Bagre bagre*; *Arius* spp.; *Cathorops* sp.), Atlantic moonfish (*Vomer setapinis*), Atlantic cutlassfish (*Trachurus lepturus*), sharks (*Rizhoprionodon* sp.; *Mustelus* sp.). They represent about 80% of the total by-catch landings. Dog trout is the most important species, representing 53% of the landings.

The non commercial by-catch was reduced 4% during 1994, and reached a value of 18,324 mt. This indicates not only that the catch rate for fish is increasing in the area, but also the commercial use made of this resources. Non-commercial by-catch yields were maximum near the mouths of the Orinoco River in its delta (fishing squares 09604, 09602, 09614, 09613 and 09592), with values around 1,000 kg/day (Table 11). A similar trend can be observed in the total biomass of the capture.

The quotient of total biomass/shrimp and non commercial by-catch/shrimp in the captures during 1994 maintained values close to the ones reported in 1991 (16:1 and 10:1, respectively) in the capture.

MANAGEMENT MEASURES

REGULATIONS

Since 1992, the law penalizing crimes against the environment is in effect in Venezuela. Two seasons were established by Presidential Decree No. 2667 of 26 Nov. 1992 (Aceta Official de Venezuela No. 35 103) to the shrimp trawling fisheries in the eastern region of the country: 16 May to 15 June; 16 Dec. To 15 Jan. The seasons apply only to the fishing between 3 and 12 miles from shore. The purpose of these two periods with no fishing is to decrease the effort level made by the fleet in those fishing zones where the resources show signs of over exploitation. The selection of the seasons was not related to the biology of the species.

In 1993, Resolution from Min. Agriculture - Fisheries and Aquaculture Division No. 067 from 05 Feb. 1993 required the use of TEDs in all shrimp trawl nets in Venezuela. Although the measure is not intended to the protection of the marine ground resources, it affects severely the landings of by-catch (Marcano & Alió, 1995).

FISHING AGREEMENTS

The new fishing agreement between the governments of Trinidad & Tobago and Venezuela is currently under discussion.

REFERENCES

Marcano, L. A. & J. J. Alió, (1995). The turtle excluder device TED and its impact upon the captures of the Venezuelan shrimp trawling fisheries. FONAIAP Tech. Rep., 4 p. Presented at: Conv. Conserv. Preserv. Marine Turtles Occid. Hemisph., Huatulco Oct. 1995, México.

Table 1: Distribution of the number of fishing enterprises and trawling vessels operating in the Atlantic zone of Venezuela, by base port, in 1994.

BASE PORT	NO. ENTERPRISES	NO. VESSELS
Güiria	18	50
Cumaná	52	63
Guanta	6	6
TOTAL	76	109

Table 2: Fishing effort by the trawling fleet based in Güiria, in the Atlantic zone of Venezuela. ("-" = data not available).

YEAR	BOAT-YEAR	BOAT-MONTH	No. TRIPS	DAYS AT SEA	No. TRIPS PER BOAT	DAYS PER TRIP
1973	91	207	211	4656	1.0	22
1974	43	64	93	1130	1.5	12
1975	62	176	430	3350	2.4	8
1976	48	190	300	3008	1.6	10
1977	57	208	338	3189	1.6	9
1978	25	145	249	2333	1.7	9
1979	21	144	296	2446	2.0	8
1980	22	179	356	3588	2	10
1981	30	189	336	3643	1.8	11
1982	33	171	259	3386	1.5	13
1983	39	213	271	3722	1.3	14
1984	28	-	-	-	-	-
1985	34	-	-	-	-	-
1986	28	108	135	1850	1.3	14
1987	30	143	205	3051	1.4	15
1988	31	276	362	4501	1.3	12
1989	35	303	369	3819	1.2	10
1990	56	294	415	3917	1.4	9
1991	58	359	504	4995	1.4	10
1992	47	263	381	3454	1.4	9
1993	68	358	358	4238	1.0	12
1994	50	238	319	3444	1.3	11

Table 3: Fishing effort by the trawling fleet based in Cumaná, in the Atlantic zone of Venezuela. ("-" = data not available).

YEAR	BOAT-YEAR	BOAT-MONTH	No. TRIPS	DAYS AT SEA	No. TRIPS PER BOAT	DAYS PER TRIP
1973	45	140	245	3552	1.8	15
1974	49	194	285	3422	1.5	12
1975	43	235	364	4362	1.5	12
1976	42	227	332	4267	1.5	13
1977	60	304	472	5767	1.6	12
1978	33	117	166	1923	1.4	12
1979	30	140	235	2433	1.5	10
1980	36	110	175	1799	1.6	10
1981	38	158	243	3027	1.5	13
1982	52	191	239	2734	1.3	11
1983	31	115	178	1752	1.5	10
1984	36	-	-	-	-	-
1985	32	-	-	-	-	-
1986	47	-	-	-	-	-
1987	64	219	279	3767	1.3	14
1988	67	164	183	2670	1.1	15
1989	100	242	306	4891	1.3	16
1990	72	378	482	6833	1.3	14
1991	72	345	460	6715	1.3	15
1992	68	301	311	5395	1.0	17
1993	67	349	424	7084	1.2	17
1994	63	222	250	4432	1.1	18

Table 4: Fishing effort by the trawling fleet based in Guanta, in the Atlantic zone of Venezuela.

YEAR	BOAT-YEAR	BOAT-MONTH	No. TRIPS	DAYS AT SEA	No. TRIPS PER BOAT	DAYS PER TRIP
1990	12	105	109	2502	1.0	23
1991	6	61	62	1301	1.0	21
1992	6	35	46	1103	1.3	24
1993	6	56	60	1440	1.1	24
1994	6	38	39	975	1.0	25

Table 5: Characteristics of the trawling vessels operating in the Atlantic Zone of Venezuela in 1989-94. ("N/I" = no information was available).

	1989	%	1990	%	1991	%	1992	%	1993	%	1994	%
LENGTH (m)												
11-15	0	0	1	1	0	0	0	0	1		0	0
16-20	21	16	13	9	20	15	15	12	18	13	16	15
21-25	78	57	88	63	78	57	63	52	73	55	52	48
26-30	32	24	31	22	30	22	38	31	34	24	34	32
31-35	1	1	1	1	1	1	2	2	3	2	2	2
N/I	3	2	6	4	7	5	3	3	8	3	3	3
POWER (hp)												
<250	0	0	1	1	0	0	0	0	0	0	0	0
251-400	17	13	18	13	18	13	12	10	14	10	16	15
401-550	44	33	40	29	30	22	28	23	36	27	30	28
551-700	37	27	42	30	44	32	40	34	41	30	25	23
701-850	32	24	30	21	34	26	35	29	35	25	29	27
>850	2	1	3	2	3	2	3	2	3	2	4	4
N/I	3	2	6	4	7	5	3	2	8	6	3	3

Table 5: Characteristics of the trawling vessels operating in the Atlantic Zone of Venezuela in 1989-94. ("N/I" = no information was available).

	1989	%	1990	%	1991	%	1992	%	1993	%	1994	%
B.R.T. (mt)												
50-100	31	23	27	19	32	24	33	28	36	26	24	22
101-150	50	37	57	41	50	36	38	32	42	31	33	31
151-200	30	22	30	21	31	23	28	23	29	22	28	26
201-250	16	12	14	10	11	8	15	12	15	11	16	15
251-300	4	3	5	4	4	3	4	3	5		4	2
301-350	1	1	1	1	1	1	0	0	1		0	1
351-400	0	0	0	0	0	0	0	0	0		0	0
N/I	3	2	6		4	7	5	3	2	9	6	3

Table 6: Catch (mt), effort (days-at-sea) and c.p.u.e. (kg/day) for penaeid shrimps (brown and white), by fishing square, reported by the trawling fleet operating in the Atlantic zone of Venezuela during 1989-94.

		10621	10612	10611	10602	09601	09602	09603	09604	09613	09614	10614	09592	08603	08594	08583	08582	TOT
1989																		
CATCH	Br	56	71	234	27	2	7	3	22	203	222	13						859
	Wh	15	20	40	11	--	5	--	7	47	74	8						228
	Tot	70	91	274	38	2	12	3	29	250	296	21						1087
EFFORT		492	992	2200	305	61	771	81	174	1618	1653	363	*	*	*	*	*	8701
CPUE	Br	112	71	106	88	33	9	41	124	125	134	37						99
	Wh	31	20	18	37	--	6	--	39	29	45	23						26
	Tot	31	91	124	125	33	15	41	163	154	179	60						125
1990																		
CATCH	Br	104	38	345	18	23	15	21	55	260	300	13						1191
	Wh	23	10	55	4	--	11	6	7	51	54	7						230
	Tot	127	48	400	22	23	26	27	62	311	354	20						1421
EFFORT		1458	663	3525	271	259	801	289	553	2120	3048	265	*	*	*	*	*	13252
CPUE	Br	71	57	98	67	87	18	73	99	123	99	50						90
	Wh	16	16	15	15	--	14	22	12	24	18	28						17
	Tot	87	73	113	82	87	32	95	112	147	116	77						107
1991																		
CATCH	Br	140	125	121	27	99	11	23	99	396	39							1078
	Wh	50	62	17	9	28	3	9	17	142	19							355
	Tot	190	187	138	36	127	14	32	116	538	58							1433
EFFORT		1691	2602	911	390	781	651	390	781	3903	911	*	*	*	*	*	*	13011
CPUE	Br	83	47	133	69	126	16	60	126	102	43							83
	Wh	30	24	19	22	36	4	22	22	36	21							27
	Tot	113	72	151	91	162	20	82	148	138	64							110
1992																		
CATCH	Br	31	36	10	15	22	13	13	87	626	33		12	10	45	22	5	980
	Wh	7	1	1	3	3	3	1	33	67	6		--	3	43	11	--	182
	Tot	38	37	11	18	25	16	14	120	693	39		12	13	88	33	5	1162
EFFORT		427	441	9	102	450	160	70	1212	3295	173	*	11	704	1940	432	556	9952
CPUE	Br	73	88	1111	147	49	81	186	72	190	190		1091	14	23	51	9	98
	Wh	16	2	111	29	7	19	14	27	20	35		--	4	22	25	--	18
	Tot	89	90	1222	176	56	100	200	99	210	225		1091	18	45	76	9	116

For identification of fishing squares see Fig. 1. ("Br"=Brown; "Wh"=White; "--"=no captures of that species; "*"=no fishing took place in that square).

Table 7: Catch (mt), effort (days-at-sea) and c.p.u.e. (kg/day) of shrimps by depth interval, from the trawling fleet in the Atlantic zone of Venezuela during 1994.

		DEPTH				TOTAL
		01-10	11-20	21-30	31-40	
CATCH	Br	185	638	49	108	980
	Wh	30	152	--	--	182
	Tot	215	790	49	108	1162
EFFORT		439	8193	952	368	9952
%		4	82	10	4	
CPUE	Br	421	78	51	293	98
	Wh	68	19	--	--	18
	Tot	489	97	51	293	116

"Br"=Brown; "Wh"=White; "--"=no captures of that species; "*"=no fishing took place in that square.

Table 8: Catch, effort and c.p.u.e. for brown and white shrimps, from the Atlantic zone of Venezuela.

YEAR	CATCH (mt)					EFFORT	C.P.U.E. (mt/day)		
	BROWN	%	WHITE	%	TOTAL	(days)	BROWN	WHITE	TOTAL
1973	1395	70	605	30	2000	8208	170	73	273
1974	666	95	35	5	701	4552	146	8	154
1975	1012	72	386	28	1398	7712	131	50	181
1976	1344	91	129	9	1473	7275	185	18	202
1977	2022	97	53	3	2075	6956	226	6	232
1978	792	97	26	3	818	4256	186	6	192
1979	810	86	130	14	940	4879	167	27	193
1980	733	76	227	24	960	5387	136	43	178
1981	853	93	66	7	919	6670	127	10	137
1982	809	69	371	31	1180	6120	132	61	193
1983	568	60	378	40	946	5474	104	69	173
1984	624	97	22	3	646	3305	188	7	195
1985	445	79	121	21	566	3223	138	38	179
1986	360	87	55	13	415	1850	195	30	225
1987	762	91	74	9	836	6719	113	11	124
1988	714	81	171	19	885	7175	100	24	124
1989	859	79	228	21	1087	8710	99	26	125
1990	1191	84	230	16	1421	13252	89	17	106
1991	1078	75	355	25	1433	13011	83	27	110
1992	780	84	182	16	1162	9952	98	18	117
1993	888	71	369	29	1257	12762	69	29	98
1994	531	77	161	23	692	8851	60	18	78

Table 9: Catch (mt) of shrimps (all species combined), reported by the trawling fleet operating in the Atlantic zone of Venezuela, by base port. The Guanta fleet started operations in the zone during 1990. ("--" = data not available).

YEAR	BASEPORT			TOTAL
	Güiria	Cumana	Guanta	
1987	475	361	--	836
1988	604	281	--	885
1989	644	443	--	1087
1990	878	322	221	1421
1991	867	318	248	1433
1992	639	362	161	1162
1993	734	354	169	1257
1994	413	175	109	697

Table 10: Catch (mt) of the main fish species landed by the trawling fleet operating in the Atlantic zone of Venezuela. (1987-1994).

SPECIES	YEAR							
	1987	1988	1989	1990	1991	1992	1993	1994
Croaker	620	922	870	818	745	611	840	488
Curvina	887	567	910	858	974	798	1226	733
Dog trout	446	535	1363	1927	2682	2574	4082	3610
Lane snapper	105	155	80	110	148	145	148	119
Cat Fish	113	165	27	456	519	257	436	230
Atlantic moonfish	164	136	195	518	449	291	526	266
Atlantic cutlassfish	38	20	52	159	140	--	221	125
Shark	223	235	314	219	170	153	196	130
Other	644	591	1574	2120	1165	1290	1665	1080
TOTAL	3244	3569	5630	7186	6987	6119	9340	6781

Table 11: Capture (mt), c.p.u.e. (kg/day) of fish, NCBC and total biomass (TB), by fishing square (zone), reported by the trawling fleet operating in the Atlantic zone of Venezuela during 1989 - 1994. ("*" = no fishing took place in that square).

		10621	10612	10611	10602	09601	09602	09603	09604	09613	09614	10614	09592	08603	08594	08593	08582	TOT
1989																		
CATCH	Fish	398	499	1889	161	51	349	80	108	618	1350	125	*	*	*	*	*	5630
CPUE		809	503	859	529	839	453	992	623	382	817	344						646
1990																		
CATCH	Fish	1623	652	1673	262	282	392	397	1462	993	899	227	*	*	*	*	*	7086
CPUE		798	983	475	967	1089	490	1374	264	468	295	857						535
1991																		
CATCH	Fish	878	1364	512	341	426	256	426	341	1960	511	*	*	*	*	*	*	6987
	NCBC	1063	603	121	106	96	56	182	954	10905	1060							15146
	T. B.	2111	2163	781	493	659	335	650	1421	13413	1640							23566
CPUE	FISH	508	528	573	901	559	409	1119	450	505	573							545
	NCBC	629	232	133	272	123	86	466	1222	2794	1164							1164
	T. B.	1248	831	859	1263	844	515	1667	1820	3436	1801							1819
1992																		
CATCH	Fish	236	459	10	60	306	156	79	709	1217	75	*	22	679	1510	210	391	6119
	NCBC	290	331	2	67	216	279	56	3460	3785	253		12	441	161	183	407	11043
	T. B.	564	827	23	145	547	451	149	4289	5695	367		46	1133	2859	426	803	18324
CPUE	Fish	553	1117	1111	588	680	975	1129	585	369	433		2000	964	778	486	703	615
	NCBC	679	805	222	657	480	1744	800	2855	1149	1462		1091	626	650	424	732	1110
	T. B.	1321	2012	2556	1422	1216	2819	2129	3539	1728	2121		4182	1609	1474	986	1444	1841

Table 12:Catch (mt), effort (days-at-sea) and c.p.u.e. (kg/day) of fish, non commercial by-catch (NCBC) and total biomass (TB), by depth interval, reported by the trawling fleet in the Atlantic zone of Venezuela during 1994.

		DEPTH (m)				TOTAL
		01-10	11-20	21-30	31-40	
CATCH	Fish	130	5444	411	134	6119
	NCBC	1333	9074	487	149	11043
	TB	1678	15308	947	391	18324
EFFORT		439	8193	952	368	9952
CPUE	Fish	296	664	432	364	615
	NCBC	3036	1108	516	405	1110
	TB	3822	1868	995	1063	1841

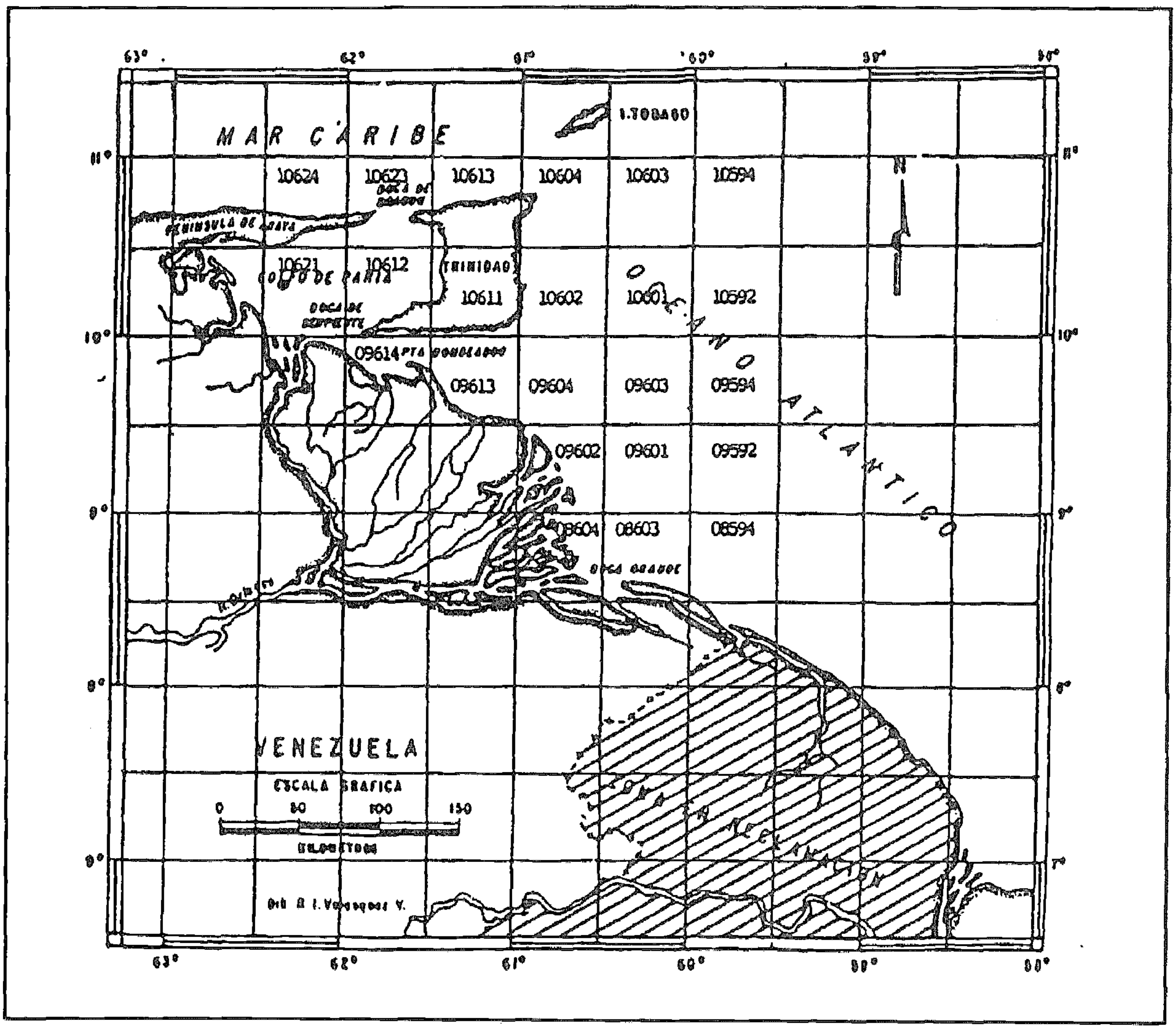

Figure 1: Atlantic zone of Venezuela, divided in fishing squares of 30 x 30 miles.

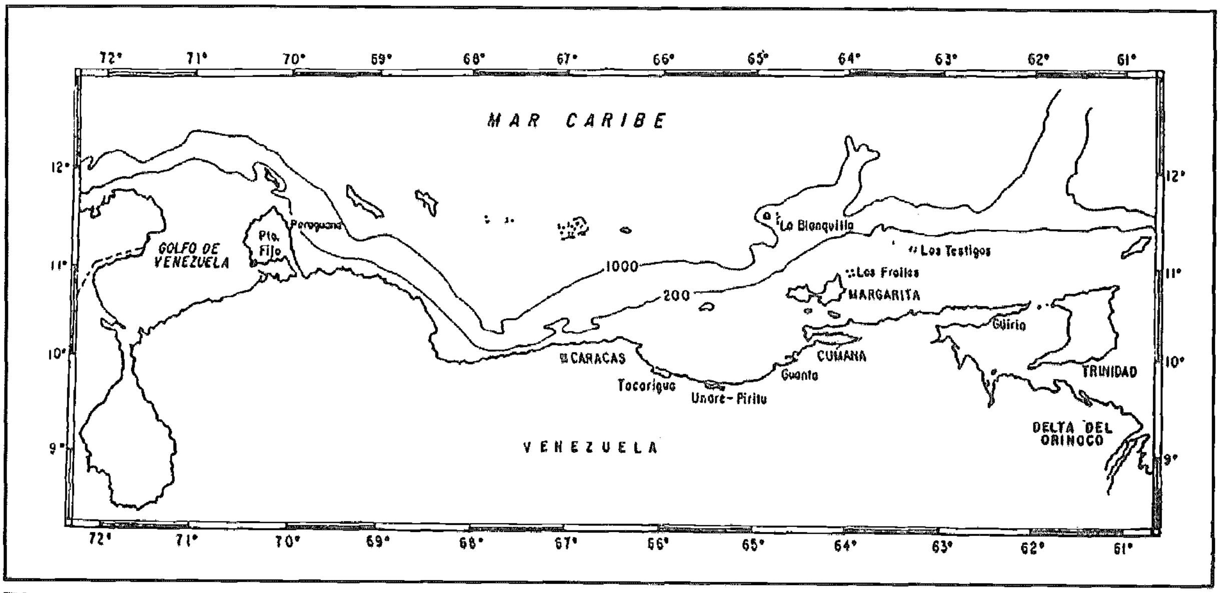

Figure 2: Marine coast of Venezuela, showing the major base port of the trawling fleet.

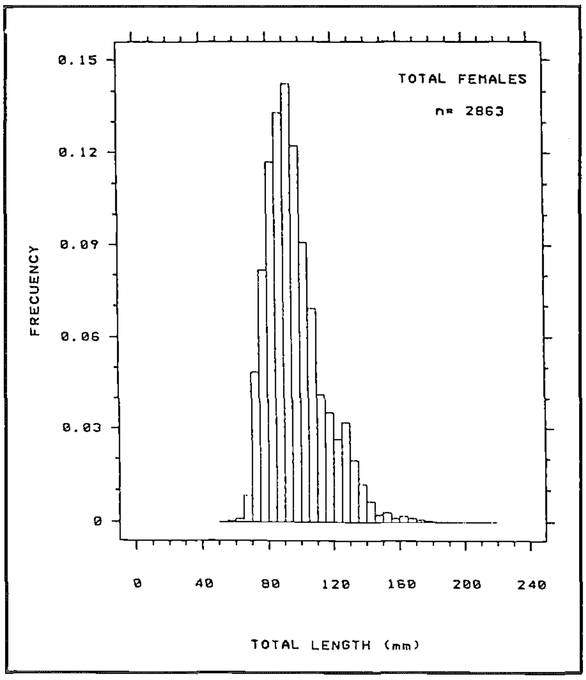

Figure 3: Length frequency histogram for female brown shrimp from the Atlantic zone of Venezuela.

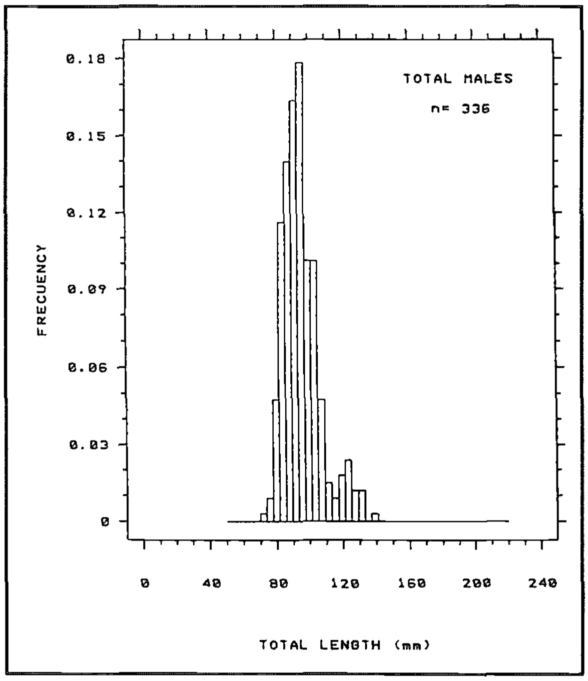

Figure 4: Length frequency histogram for male brown shrimp from the Atlantic zone of Venezuela.

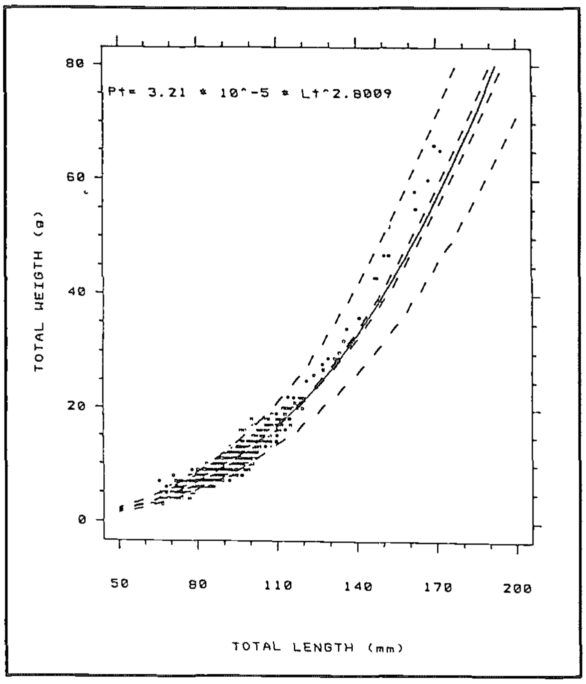

Figure 5: Total Length vs Weight Relationships for female brown shrimp from the Atlantic zone of Venezuela.

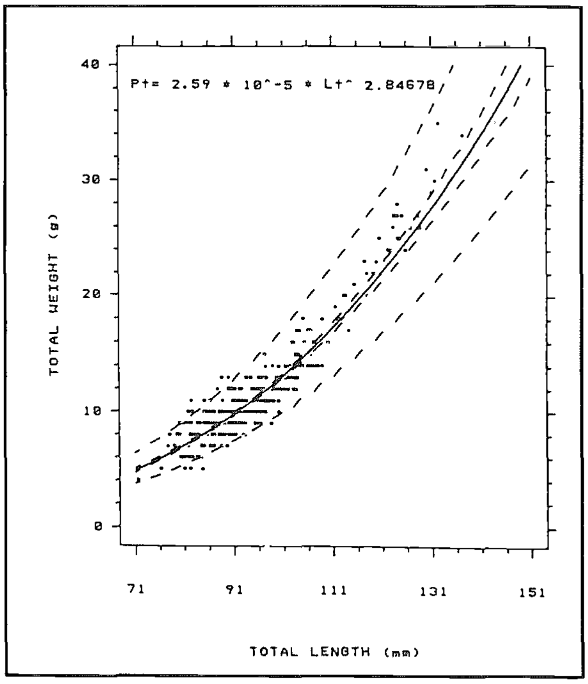

Figure 6: Total Length vs Weight Relationships for male brown shrimp from the Atlantic zone of Venezuela.

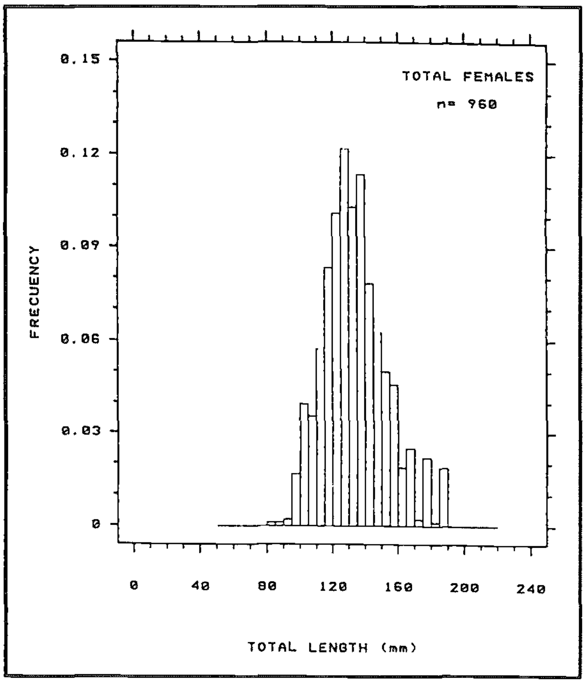

Figure 7: Length frequency histogram for female white shrimp from the Atlantic zone of Venezuela.

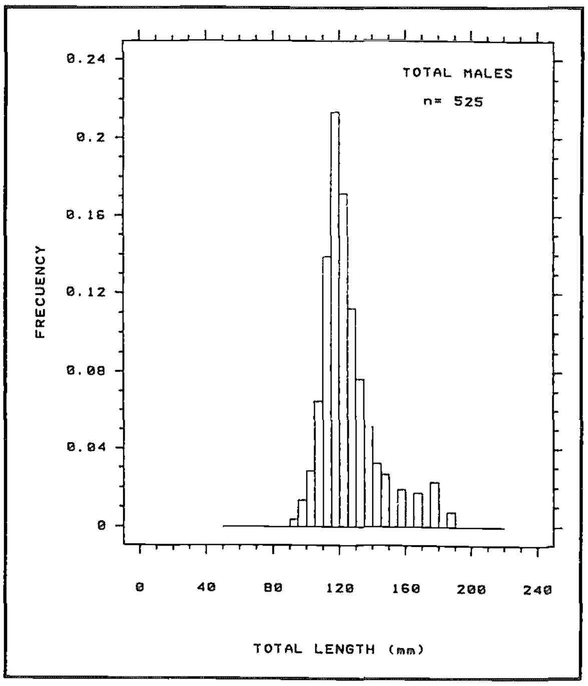

Figure 8: Length frequency histogram for male white shrimp from the Atlantic zone of Venezuela.

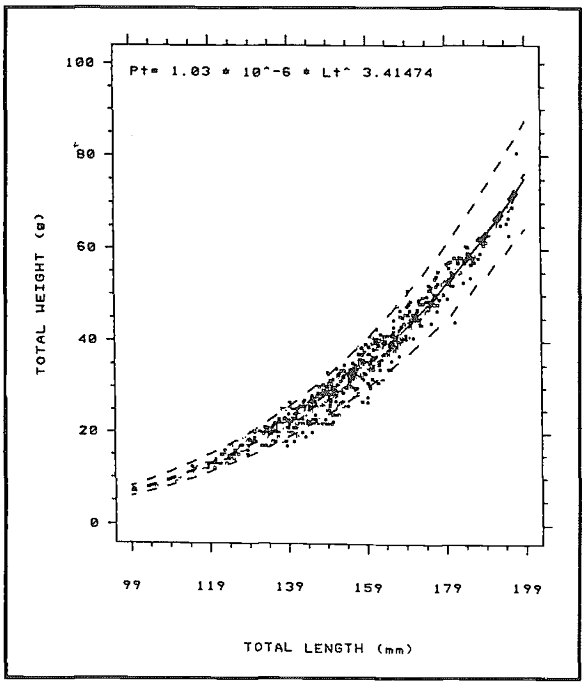

Figure 9: Total Length vs Weight Relationships for female white shrimp from the Atlantic zone of Venezuela.

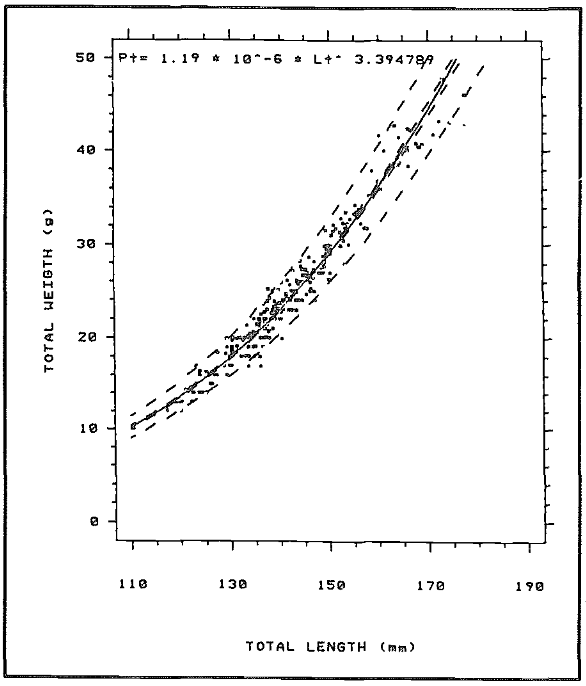

Figure 10: Total Length vs Weight Relationships for male white shrimp from the Atlantic zone of Venezuela.

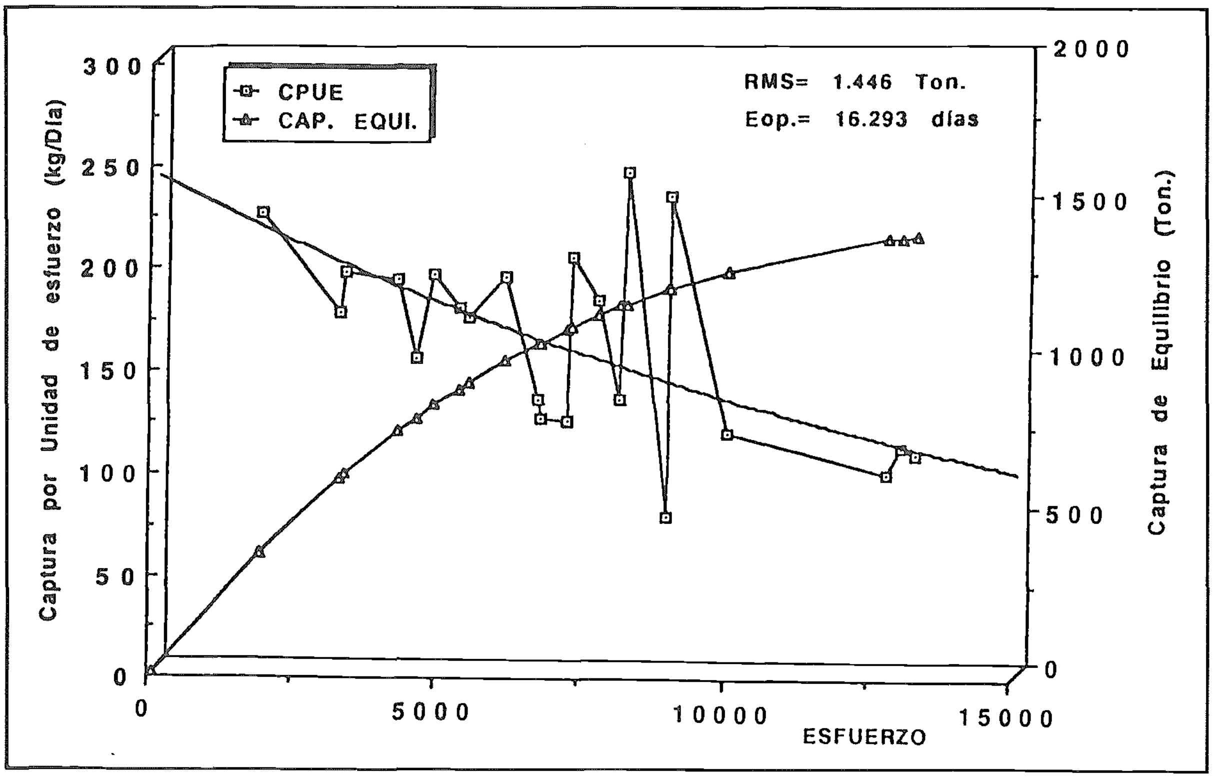

Figure 11: Relationship between cpue and fishing effort, showing the adjustment to the Fox model for the shrimp fishery in the Atlantic zone of Venezuela.

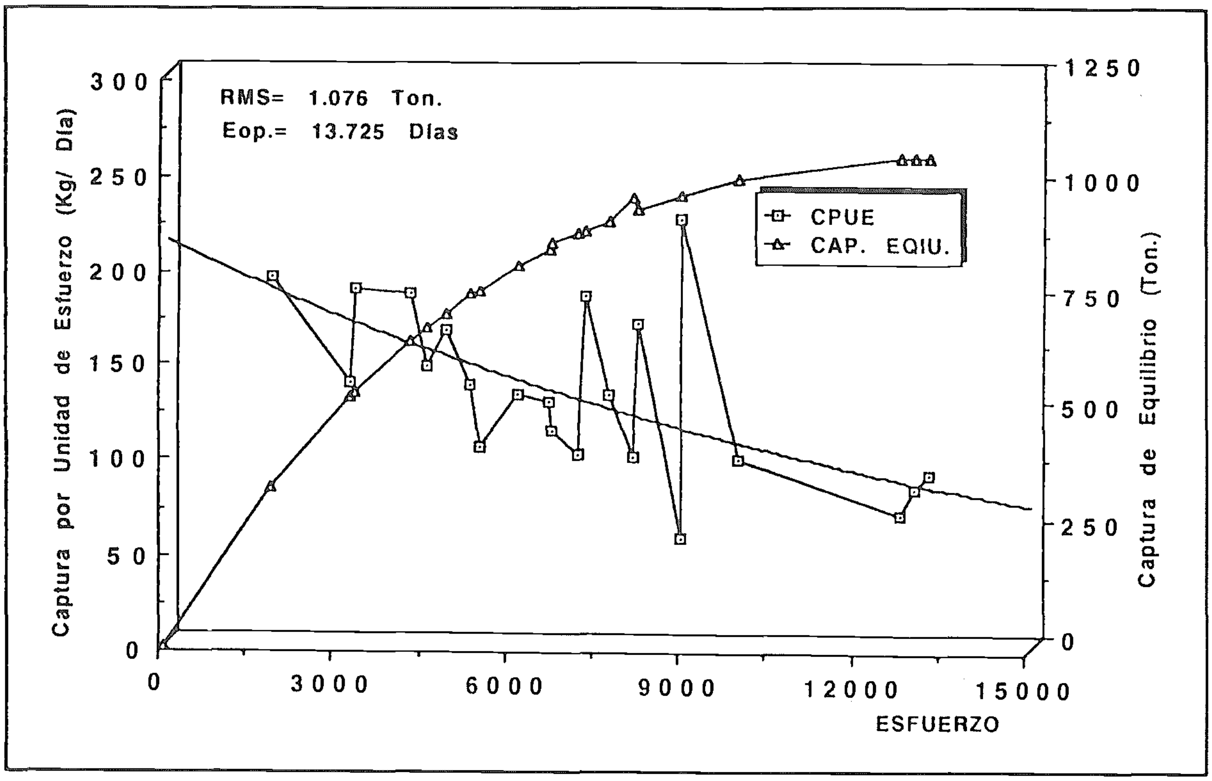

Figure 12: Relationship between cpue and fishing effort, showing the adjustment to the Fox model for the brown shrimp fishery in the Atlantic zone of Venezuela.

Crustacean Stock Assessment Techniques Incorporating Uncertainty

Nelson M. Ehrhardt[1] and Christopher M. Legault[1]

INTRODUCTION

Stock assessments of crustaceans are often more difficult than finfish stock assessments due to the combination of biological features such as relatively short life span, lack of hard parts that can be aged, discrete growth through molting, high natural mortality and high exploitation. Gears used to catch these species are often non-selective, with the exception of minimum sizes placed on trap fisheries. Crustaceans are also often landed according to commercial categories that are weight or size dependent upon only part of the animal, such as number of shrimp tails per pound, or size grades of crab claws. These categories may not even be consistent for different gears operating on a given stock. This aggregated landings data is usually measured in weight for a given period, for example, ten thousand pounds of 16-20 tails/pound shrimp during January 1994.

Many fisheries stock assessment techniques require numbers of animals caught, not yield, and thus the total landings in weight for each commercial size category must be converted to numbers of animals. Often these values are still on too course of a scale to allow a meaningful stock assessment and thus the animals are allocated to size intervals according to sampled or assumed size frequency distributions within each category.

Once the number of animals within given size intervals are known, a length-based cohort analysis (Jones, 1984) can be performed to estimate the fishing mortality rate and population size. One problem with this technique is the need to supply an external estimate of the fishing mortality rate for the largest (oldest) animals. In order to circumvent this problem, two tuning processes are presented in this document: one using external fishing mortality rate (or fishing effort and a catchability coefficient necessary to generate F estimates) and the other using an external biomass estimate. This tuning procedure creates more consistent population estimates over time than the untuned technique. Tuned length-based cohort analysis is further extended to incorporate uncertainty in parameters such as the growth function, natural mortality, and catch per size interval, such that the mean and variance of population size and fishing mortality rate are estimated.

Incorporation of uncertainty into the stock assessment of a species is important for many reasons. Specific areas of limited knowledge on the biology and population dynamics of crustaceans that have a major impact on the results can be identified thus allowing more efficient allocation of research effort and funding. A range of possible states of the stock and the resulting range of results under different management strategies provides a more solid basis upon which to base decisions. Most parameters in fishery assessment models are not known exactly, incorporation of the inherit uncertainty within the system allows more realistic analysis of the stock.

We present techniques for incorporating uncertainty into crustacean stock assessments in this paper, starting from the basic data collected through the description of the current state of the stock in terms of population size and fishing mortality rate. Results from simulated data sets, as well as applications of the

[1] University of Miami, Rosenstiel School of Marine and Atmospheric Science

methods to real data, are presented. FORTRAN source code and executables for the programs used in the examples are available upon request from the authors.

METHODS

CONVERSION OF LANDINGS BY COMMERCIAL SIZE CATEGORIES TO NUMBERS OF ANIMALS PER SIZE INTERVAL

The landings of crustaceans often occur by categories related to size or weight of part of the animal. For example, shrimp are often sorted by number of tails per pound, lobsters are often sorted by tail-weight classes, and crab claws are often sorted by the descriptive classes small, medium, large and jumbo. The total landings in weight for each category is the basic data collected in most crustacean fisheries, but is not directly useful in most stock assessment techniques. Thus the data must be converted to numbers of animals in size intervals landed during a given time period for use in length-based cohort analysis, for example. The steps required for this conversion are outlined in the following algorithm and then described in more detail.

Let $i = 1,...,m$ be the commercial size categories

$j = 1,...,n$ be distinct length intervals for the animals

Y_i = total landings in weight for each category

$P_{i,j}$ = proportion of animals in category i that are in length interval j

W_i = average weight of the sorted animal part in each category

G_i = number of animals caught in each category

C_j = number of animals caught in each length interval

Algorithm for deriving point estimate:

1. $G_i = Y_i/W_i$
2. $C_j = \Sigma\ G_i{*}P_{i,j}$

To Incorporate Uncertainty:

3. Assume or estimate distributions for Y_i and W_i

For each bootstrap or Monte Carlo simulation:

4. Choose at random Y'_i and W'_i from distribution of Y_i and W_i
5. $G'_i = Y'_i/W'_i$
6. Bootstrap the distributions of animals in each category to create $P'_{i,j}$
7. $C'_j = \Sigma\ G'_i{*}P'_{i,j}$
8. Repeat steps 4-7 many times

Point estimates of the number of animals landed within the categories (C_j) are quite straitforeward. The total landings (Y_i) are divided by the average weight (W_i) of animals within the category to generate the numbers caught in each category (G_i). Thus step 1 is to compute $G_i = Y_i/W_i$. This process can be improved if there is a large range of individual animal weights within the category, for example a designation containing from 1/21 to 1/16 pound shrimp tails. In this case, field sampling can generate the distribution of individual weights within the category. This distribution is used to separate the total landings into landings per individual weight according to the observed distribution of weights within the category. Each total landings value is then converted to numbers by dividing the landings by this individual weight in the same manner as step 1.

The landings per category in number (G_i) are next converted to landings by size interval (C_j) by multiplying the total number by the sampled relative frequency of sizes. Thus step 2 is to make $C_j=\Sigma G_i P_{i,j}$. This step is analogous to converting length frequencies to age frequencies using an age-length key. Berry (1969) followed this process to compute a point estimate of shrimp landings in number in order to estimate mortality rates.

The uncertainty of these point estimates cannot be computed directly due to the non-normal distributions often found during sampling. However, the computer-intensive resampling techniques of bootstrapping and Monte Carlo simulation can be used. The bootstrap technique was first described by Efron (1979) and assumes the data collected is representative of the population and thus can be resampled as if it was the population. Thus many data sets are created from the original data set by randomly choosing, with replacement, individual data points from the original data set. Each bootstrapped data set is then analyzed in the same manner as the original data set and the results recorded. After many data sets have been analyzed, the distribution, and thus variance, of the results can be created. The Monte Carlo technique is similar to the bootstrap, except that a distribution is assumed for the parameter and a value chosen from the distribution during each iteration. The bootstrap and/or Monte Carlo simulation are used within the algorithm to create many catch at size distributions according to the following steps.

The total landings in weight per category are often known and can be collected from processing centers, from tax data or from export statistics by government agencies. Artisanal or recreational (such as lobster) fishing can be an important component in crustacean fisheries and care should be taken to collect data from these sources as well as any large commercial sources. If the total landings per commercial size category are estimated, then the uncertainty associated with the numbers estimated by length interval can be carried through the assessment using the bootstrap or Monte Carlo procedure associated with the bootstrapping of the size distribution within categories. Thus step 3 is to assume or estimate distributions for Y_i and W_i.

Field sampling of landings is required in order to convert the total weight per category into numbers of animals per category or size interval. This sampling should occur each month to ensure correct assignment of total weight to size intervals. The sampling consists of collecting size information from many animals in each commercial size category such that the distribution of size within each category is created. In some cases animals must be measured before they are sorted, for example the carapace length of shrimp must be measured before the heads are removed and the tails sorted. This sampling creates the size distributions to be assumed or estimated in step 3 of the algorithm.

Within each bootstrap or Monte Carlo[2] iteration, randomly created or chosen values for the total landings in weight per commercial size category (Y'_i) and average weight per category (W'_i) are selected to estimate the number of animals caught in each category (G'_i). Thus, steps 4 and 5 of the algorithm are accomplished. Then, bootstrapped size distributions within each category ($P'_{i,j}$) are used to distribute the catch in numbers (G'_i) to catch at size (C'_j) amongst the size intervals according to the bootstrapped size distributions. This is accomplished in steps 6 and 7.

Creation of the bootstrapped size distributions can occur two ways, either within category or overall. Each category is treated independently for the bootstrapping under the assumption that sorting occurred correctly. If this assumption cannot be made, then bootstrapping should occur over all categories. Resampling of the observed size distributions occurs with replacement such that each bootstrap can contain multiple values from one animal and none from others. For example, assume there are five 1 cm size intervals within a category with the following frequency: 2, 4, 5, 6, 3. Then twenty animals would be

2 Bootstrap iteration is when resampling is from observed distributions. Monte Carlo iteration is when resampling is from an assumed theoretical distribution.

chosen at random with replacement from this distribution, recording the size of each animal that is picked to create a bootstrapped size distribution. If inaccurate sorting is suspected then the bootstrap can occur over the size intervals for all categories, that is, an animal is chosen at random, with replacement, from the entire sampled data. The form of the population distribution is not important, but without representative sampling, the bootstrap technique will fail to correctly estimate the variance.

Further stratification of the data may be desired to reduce some of the variability in the catch at size distributions. For example, if there are multiple types of gear or fishing areas, then each gear/area combination should be sampled separately to create the distributions of size intervals within categories. Note that this stratification allows combining data from sources with different grading systems (ie tails/pound and descriptive grading of small, medium and large), as long as the size intervals are consistent for all sources. The total landings by gear/area, or at least estimates of proportions of the total, are then required. Additionally, sexual dimorphism may require collecting different size distributions within categories for males and females. Additional sampling would then be required to estimate the sex ratio for each category and month. The iterative re-sampling needed to generate catch at size will follow the experimental sampling design.

The conversion of landings in weight by categories to numbers of animals per size interval is a simple process that can be made as complex as required by the fishery. Gear and area stratifications of the data, as well as sex ratios are easily incorporated, if sufficient data is collected to properly describe distributions.

All sources of uncertainty can be included to create bootstrapped estimates of catch at size. These bootstrapped catches can then form the basis for a stock assessment incorporating uncertainty using tuned length-based cohort analysis.

TUNED LENGTH-BASED COHORT ANALYSIS

Age-based cohort analysis was introduced by Pope (1972) as an approximation to virtual population analysis that is much simpler computationally. The catch is assumed to be caught instantly at the midpoint of the time period so that the exponential decline of the population throughout the time period is replaced by a step function with only natural mortality occurring throughout the period. Thus the number of animals in a cohort of age a (N_a) can be computed directly from the numbers at age a+1 given the catch at age (C_a) and natural mortality (M) using the following equation:

$$N_a = (N_{a+1}e^{\frac{M}{2}} + C_a)e^{\frac{M}{2}} \ . \tag{1}$$

Once the number of animals in the oldest age (a +1) is estimated, the number of animals in each younger age (a) is computed by successive backward applications of equation (1). If the oldest age is a plus group, the number of animals in the oldest age class can be estimated by group, the number of animals in the oldest age class can be estimated by

$$N_A = \frac{C_A}{(F/Z)_A} \ ; \tag{2}$$

where A is the oldest age and $(F/Z)_A$ is the ratio of fishing to total mortality for the oldest age, which must be supplied from outside sources. The total mortality rate for age a (Z_a) is estimated by

$$Z_a = -Ln(\frac{N_{a+1}}{N_a}) \tag{3}$$

and the corresponding fishing mortality rate at age (F_a) found by $F_a=Z_a-M$. Thus population size and fishing mortality rates can be estimated from catch data if the natural mortality rate and F/Z for the oldest age group are given.

Landings data by size instead of age can be used in cohort analysis under equilibrium conditions if a growth function is available to determine the amount of time spent in each size class (Jones, 1984). The basic cohort analysis equation using lengths is

$$N_j = (N_{j+1}e^{M\Delta t/2} + C_j)\ e^{M\Delta t/2}\ ; \tag{4}$$

where j=1,n are size intervals, N is population size in numbers, C is catch, M is natural mortality, and Δt_j refers to the time an individual requires to grow through size interval j. The Δt_j can be estimated from any growth equation appropriate for the given species. Although crustaceans grow in discrete steps by molting, traditionally the von Bertalanffy growth equation (von Bertalanffy, 1938) has been used because of data limitations. The von Bertalanffy growth equation is usually given in the form due to Beverton and Holt (1957)

$$L_a = L_\infty(1-e^{-K(a-a_0)})\ ; \tag{5}$$

where L_a is length at age a, L_∞ is the average maximum size at infinite age, K determines the rate of approach to the asymptote and a_0 is the theoretical age at zero length. This equation can be rearranged to give age as a function of length:

$$a = a_0 - \frac{1}{K}\ Ln(1-\frac{L_a}{L_\infty})\ . \tag{6}$$

Thus if L_j and L_{j+1} are the lower and upper size limits, respectively, of size interval j, then the time required to grow through size interval j can be expressed as

$$\Delta t_j = a_{j+1}-a_j = \frac{1}{K}\ Ln(\frac{L_\infty-L_j}{L_\infty-L_{j+1}})\ . \tag{7}$$

A common computational simplification used in length-based cohort analysis is to compute $\exp(M\Delta t_j/2)$ by replacing Δt_j by equation 7 such that it can be computed as

$$X_j = (\frac{L_\infty-L_j}{L_\infty-L_{j+1}})^{\frac{M}{2K}} \tag{8}$$

for each size interval, such that only M/K is required as a parameter instead of both M and K. Thus equation (4) becomes

$$N_j = (N_{j+1}X_j + C_j)\ X_j\ . \tag{9}$$

Thus, once the number in the largest, and therefore oldest, size interval is known, the numbers in each successively smaller size interval can be estimated through application of equation (9). As in the age-based cohort analysis, if the largest size interval is assumed to be a plus group, the number in the largest size interval (n) can be estimated by

$$N_n = \frac{C_n}{(F/Z)_n} ; \tag{10}$$

where again $(F/Z)_n$ is the ratio of fishing to total mortality for the largest, and therefore oldest, size group. If the approach used in age-based cohort analysis to estimate total mortality rates (Z_j) is followed in length-based cohort analysis, an estimate of $Z_j \Delta t_j$ will result due to the different growth rates at size. Instead, the total mortality rate for each size interval (Z_j) can be estimated by

$$Z_j = \frac{M}{1-(F/Z)_j} ; \tag{11}$$

where $(F/Z)_j$ is estimated from the number of animals caught divided by the number dying for each size interval, that is,

$$(F/Z)_j = \frac{C_j}{N_j - N_{j+1}} . \tag{12}$$

The fishing mortality rates per size interval (F_j) are then estimated as $F_j = Z_j - M$.

The population numbers in each size interval (N_j) computed using equation (9) refer to the number of animals attaining the size during the time period of the catch. However, an animal may attain the length at the start, middle or end of the time period. To estimate the standing stock, the average numbers in the sea per size interval ($\bar{N}_j$) can be computed under the assumption of steady state as

$$\bar{N}_j = \frac{N_j + N_{j+1}}{Z_j} . \tag{13}$$

Use of equations (9-13) can thus be used to convert the number of animals caught in size intervals into population estimates and fishing mortality rates given a growth curve, natural mortality, and F/Z estimate for the largest animals. These population and fishing mortality estimates are highly sensitive to the $(F/Z)_n$ value entered for the largest animals. If outside information is present, $(F/Z)_n$ can be chosen such that the estimated population size or fishing mortality rates most closely agree with this externally estimated index.

Two classes of outside information that may be used to tune length-based cohort analysis are: 1) the overall fishing mortality rate for the time period and 2) average population biomass during the time period.

The overall fishing mortality rate (F) can be estimated in two ways; 1) as the product of catchability (q) and effort (f) and 2) from a total mortality rate estimated by length-catch-curves and M. A brief description on the two estimation procedures are given below.

CATCHABILITY ESTIMATION

Catchability estimates can be derived from the Chien and Condrey (1985) method, a DeLury type model incorporating natural mortality. The Chien and Condrey method uses catch in numbers per unit effort (CPUE), cumulative catch in numbers (K) and average effort (f) data over a number of time periods to estimate catchability in the following process: for a number of successive time periods, CPUE is regressed against cumulative catch to yield a slope estimate q'. That is

$$CPUE_t = qN_0 - (\frac{1}{\bar{f}})(1 - e^{-(q\bar{f}+M)})K_t$$

Thus the slope of the the line is expressed by

$$q' = (\frac{1}{\bar{f}})(1 - e^{-(q\bar{f}+M)})$$

The catchability quotient is then estimated as

$$q = \frac{-1}{\bar{f}} [Ln(1 - |q'| * \bar{f}) + M] \ . \qquad (14)$$

The derivation of equation (14) assumes recruitment does not occur during the regressed range, an assumption that can be broken by many tropical crustacean species. Recruitment will cause the (K,CPUE) points to be moved up and to the right due to the catch of animals not in the cohort, thereby decreasing the slope of the regression line. If recruitment bias is evident in a given analysis, the effect can be corrected by not counting the smallest animals in the catch for later months during the time period in an attempt to follow a single cohort of animals or by truncating the regression's time period to those months when recruitment is low or nonexistent.

TOTAL MORTALITY ESTIMATION FROM LENGTH CONVERTED CATCH CURVE

In general, catch curve analysis applies when estimating total mortality rates (Z) as the slope of a regression line fitted to the natural log of the abundance in numbers of a given age t, on the age t. That is

$$\log_e N_t = a + Zt$$

Since crustaceans cannot be aged individually, then N_t in the above equation may be replaced by the number of animals in a given length class. This is achieved by dividing N in the length class by the time needed to grow through the length class. This time is defined by equation 7, given previously. Thus a length catch curve is given by

$$\log_e(\frac{N}{\Delta t}) = a + Zt'$$

where t' is the relative age of the animals at the mid-length of the class interval. This median age t' is computed from a von Bertalanffy growth function as

$$t' = \frac{\log_e(1 - \frac{L_t}{L_\infty})}{-K}$$

Once Z is estimated from the above procedure, the fishing mortality rate is estimated as the difference between the total mortality rate Z and the natural mortality rate M.

In the tuning of the length-based cohort analysis procedure, the overall fishing mortality rate derived in these manners should be compared to a weighted average of the fishing mortality rates from the length-based cohort analysis. The average population size in the size interval should be used as the weights for the averaging process if the overall F was derived using CPUE data reflecting average population sizes. The tuning process thus consists of changing the F/Z value for the largest animals until the weighted F estimate from the size intervals is equal to the overall F from q* f, that is,

$$\frac{\Sigma N_j F_j}{\Sigma N_j} = q*\bar{f} . \tag{15}$$

Alternatively, population biomass can be utilized for tuning. Population biomass estimates can be derived from non-equilibrium production models (see eg Prager, 1994; Yoshimoto and Clarke, 1993). Catch and effort data for the population pooled over all categories are used to estimate parameters causing changes in the surplus production of the stock over time. For example, Prager (1994) assumed the surplus production changes were derived from the differential equation

$$\frac{dB_t}{dt} = (r-qf_t)B_t - \frac{r}{\kappa}B_t^2 ; \tag{16}$$

where B_t is population biomass at time t, r is the stock's intrinsic rate of increase, κ the maximum population size or carrying capacity, q is catchability, and f is effort. Equation (16) can be integrated and solved for biomass at time t+δ given biomass at time t as

$$\begin{aligned} B_{t+\delta} &= \frac{\alpha_t B_t e^{\alpha_t\delta}}{\alpha_t + \beta B_t(e^{\alpha_t\delta}-1)} \quad for\ \alpha_t \neq 0 \\ B_{t+\delta} &= \frac{B_t}{1+\beta\delta B_t} \quad for\ \alpha_t = 0; \end{aligned} \tag{17}$$

where α_t=r-qf_t and β=r/κ. The predicted yield ($\hat{Y}_t$) during this time period is then given by

$$\begin{aligned} \hat{Y}_t &= \frac{qf_t}{\beta} Ln[1 - \frac{\beta B_t(1-e^{\alpha_t\delta})}{\alpha_t}) \quad for\ \alpha_t \neq 0 \\ \hat{Y}_t &= \frac{qf_t}{\beta} Ln(1+\delta\beta B_t) \quad for\ \alpha_t = 0. \end{aligned} \tag{18}$$

A Simplex search routine contained in the ASPIC computer program developed by Prager (op. cit.) is used to estimate r, κ, q, and the initial biomass B_1 which result in the minimal squared deviations between observed and predicted yield for each time period. Often a lognormal error structure is assumed in production modelling, such that the objective function to be minimized is

$$\Sigma\ [\ Ln(Y_t)\ -\ Ln(\hat{Y}_t)]^2$$

Once these parameters are estimated, population biomass for each time period (B_t) can be computed from successive applications of equation (17). Note that nonequilibrium production modelling also provides an estimate of catchability (q) which cannot be used directly in length based virtual population analysis because the production model q is based on weight while the LVPA q assumes population numbers.

The biomass from length-based cohort analysis is found by

$$\hat{B} = \Sigma \bar{N}_j \bar{\omega}_j ; \tag{19}$$

where $\bar{\omega}_j$ is the average weight for each of the size intervals.

The tuning process then consists of changing the initial F/Z for the largest animals until the biomass estimate from non-equilibrium production modelling is equal to the biomass estimated by length-based cohort analysis.

Tuning the length-based cohort analysis using either an overall fishing mortality rate or a biomass estimate will produce more consistent population size and fishing mortality rates in successive time periods relative to an analysis that does not use tuning. This is because time periods are treated totally separately in untuned length-based cohort analysis, while the index estimation procedure creates a linkage between time periods in the tuned analysis. The high sensitivity of length-based cohort analysis to the initial F/Z value entered for the largest animals requires additional information to prevent bias from propagating through the successive applications of equation (9). A calibration index provides a means to choose an appropriate F/Z value for the largest size interval. The results of the tuned length-based cohort analysis are only point estimates though, and should have levels of uncertainty associated with them to reflect the uncertainty inherit in the data collection and analysis.

Uncertainty can be incorporated into the tuned length-based cohort analysis through the bootstrap and Monte Carlo techniques. Xu and Chiu (1995) presented analytic variance estimates for untuned length-based cohort analysis using the delta method. Error structures for variables were assumed to follow normal distributions for use in the delta method. This approach is not possible when the length-based cohort analysis is tuned due to the minimization of residuals process. The inability to predict the relationship between the uncertainty in the tuning index value and the observed catch data prevents an analytical estimation of uncertainty.

The most simple case of bootstrapping the tuned length-based cohort analysis is to use the catch at size distribution bootstraps (C'_j) from the method described earlier. Thus the bootstrapped catch data would be used in the analysis in place of the point estimate for catch at size, with each bootstrapped catch distribution tuned to the index. Estimates of population size and fishing mortality rates at size (N_j and F_j respectively) would be produced for each bootstrap. These bootstrap N_j and F_j estimates can then be summarized in histograms to show graphically the uncertain state of the system.

Additional sources of uncertainty can be incorporated in the tuned length-based cohort analysis. For example, the natural mortality value is notoriously difficult to estimate and should usually have a distribution, or range, about its mean value to reflect this uncertainty. The growth curve used in the computation of time spent in each interval also can also be subject to uncertainty, most simply by choosing L_∞ and K from a bivariate normal distribution following Xiao (1994). If the natural mortality rate is estimated from the Pauly (1980) equation relating M to growth parameters and sea temperature, then M can be a variable dependent upon the random choices of L_∞ and K. The calibration index, or data used to create the index value, can also contain uncertainty that may be incorporated into the stock assessment.

The bootstrap or Monte Carlo simulation procedure would then consist of randomly choosing one value for each of the uncertain parameters, with covariances among parameters if possible, and running the tuned length-based cohort analysis recording the resulting N_j and F_j estimates for run. Again, the N_j and F_j distributions can be plotted as histograms to show graphically the uncertain state of the system. The progressive inclusion of uncertain parameters into the analysis and the resulting increases in the uncertainty of the results can be used to determine which parameters are most important in generating uncertainty in the stock size or fish mortality rate estimates.

APPLICATIONS

RE-CONSTRUCTION OF LENGTH FREQUENCIES

Data for the red shrimp fishery of Panama is used here to demonstrate an application of the algorithm to re-construct length frequencies in landings when landings are reported by commercial size categories. The algorithm is coded in the FORTRAN language in a program called CATLEN. An executable version of the program CATLEN is available from the authors upon request. The program requires two separate input files. The first file is time specific since it contains the information on landings by commercial size categories for a given time period (month or year). The information in the file is as follows:

```
Landings Red Shrimp Panama, July 1991
8   20
     17823      70.     61.     50.     0.
     39875      60.     51.     50.     0.
     35948      50.     41.     50.     0.
      7552      40.     36.     50.     0.
     46219      35.     31.     55.     0.
     73407      30.     26.     65.     0.
     64646      25.     21.     85.     0.
     12385      20.     16.     99.     0.
```

The first line is a title. The second line contains two numbers: the first corresponds to the number of commercial size categories to be included in the analyses (8 in this case) and the second is the number of bootstraps to be performed in the estimation of the length frequencies (20 in this case). The output will produce an average length frequency for the bootstraps indicated here. The third line and remaining lines (in this example there are 8 lines in total) will contain the catch in pounds per commercial size category in the first column, the commercial size category definitions in the second and third columns (note that catch and categories are entered from the smallest shrimp or largest tail count/lb to the largest shrimp or smallest tail count/lb), the sex ratio of females to males in the fourth column, and number of bootstraps to be performed with sex ratios in the fifth column.

The second file contains the information on size frequenciy distributions in each commercial size category. This file could be the same file used for any time period if no significant changes in biological condition of the tails are suspected through time. The information in the file is as follows:

```
SIZE DISTRIBUTIONS AT GRADES RED SHRIMP PANAMA
65  60. 1.0                                   !#size classes,smallest size (mm), size increment (mm)
     1      0      0      0      0      0      0      0     !females
     0      0      0      0      0      0      0      0
     0      0      0      0      0      0      0      0
     1      0      0      0      0      0      0      0
     0      0      0      0      0      0      0      0
     3      0      0      0      0      0      0      0
     5      1      0      0      0      0      0      0
     9      0      0      0      0      0      0      0
     4      4      0      0      0      0      0      0
    11      1      0      0      0      0      0      0
    27      1      2      0      0      0      0      0
    29      3      1      0      0      0      0      0
    16      7      2      0      0      0      0      0
    22      6      5      1      0      0      0      0
    16      6      7      1      0      0      0      0
    29      3      8      0      0      0      0      0
    27      9      6      1      0      0      0      0
    24      7      8      0      0      0      0      0
    20      8     18      1      0      0      0      0
    17     10     29      5      0      0      0      0
    25     13     24      6      0      0      0      0
     9     12     22      8      6      0      0      0
     9      5     24     13      4      1      0      0
     2      8     17      8      3      0      0      0
     3      4     15      7      3      0      0      0
     0      5      7     12      3      0      0      0
     1      2     11     14      7      1      1      0
     0      2      8     14     11      0      0      0
```

1	2	9	15	10	4	0	0	
0	1	3	9	12	7	0	0	
0	0	2	18	18	7	0	0	
0	0	0	13	8	3	1	0	
0	0	2	5	12	7	0	0	
0	0	0	6	10	11	2	0	
0	0	0	7	7	8	1	0	
0	0	1	3	12	17	5	0	
0	0	0	4	8	12	4	0	
0	0	0	2	9	16	4	2	
0	0	1	1	2	13	4	0	
0	0	0	0	4	6	7	1	
0	0	0	0	3	8	8	3	
0	0	0	0	0	5	10	2	
0	0	0	0	3	5	8	2	
0	0	0	0	2	1	5	6	
0	0	0	1	1	2	5	8	
0	0	0	0	1	1	12	12	
0	0	0	0	0	0	9	13	
0	0	0	0	0	0	10	8	
0	0	0	0	0	0	6	11	
0	0	0	0	0	0	4	7	
0	0	0	0	0	0	6	7	
0	0	0	0	0	0	1	2	
0	0	0	0	0	0	4	6	
0	0	0	0	0	1	0	0	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	0	3	
0	0	0	0	0	0	0	1	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	1	1	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	1	
1	0	0	0	0	0	0	0	!males
0	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
1	0	0	0	0	0	0	0	
0	0	0	0	0	0	0	0	
3	0	0	0	0	0	0	0	
5	1	0	0	0	0	0	0	
9	0	0	0	0	0	0	0	
4	4	0	0	0	0	0	0	
11	1	0	0	0	0	0	0	
27	1	2	0	0	0	0	0	
29	3	1	0	0	0	0	0	
16	7	2	0	0	0	0	0	
22	6	5	1	0	0	0	0	
16	6	7	1	0	0	0	0	
29	3	8	0	0	0	0	0	
27	9	6	1	0	0	0	0	
24	7	8	0	0	0	0	0	
20	8	18	1	0	0	0	0	
17	10	29	5	0	0	0	0	
25	13	24	6	0	0	0	0	
9	12	22	8	6	0	0	0	
9	5	24	13	4	1	0	0	
2	8	17	8	3	0	0	0	
3	4	15	7	3	0	0	0	
0	5	7	12	3	0	0	0	
1	2	11	14	7	1	1	0	
0	2	8	14	11	0	0	0	
1	2	9	15	10	4	0	0	
0	1	3	9	12	7	0	0	
0	0	2	18	18	7	0	0	
0	0	0	13	8	3	1	0	
0	0	2	5	12	7	0	0	
0	0	0	6	10	11	2	0	
0	0	0	7	7	8	1	0	
0	0	1	3	12	17	5	0	
0	0	0	4	8	12	4	0	
0	0	0	2	9	16	4	2	

0	0	1	1	2	13	4	0
0	0	0	0	4	6	7	1
0	0	0	0	3	8	8	3
0	0	0	0	0	5	10	2
0	0	0	0	3	5	8	2
0	0	0	0	2	1	5	6
0	0	0	1	1	2	5	8
0	0	0	0	1	1	12	12
0	0	0	0	0	0	9	13
0	0	0	0	0	0	10	8
0	0	0	0	0	0	6	11
0	0	0	0	0	0	4	7
0	0	0	0	0	0	6	7
0	0	0	0	0	0	1	2
0	0	0	0	0	0	4	6
0	0	0	0	0	1	0	0
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	3
0	0	0	0	0	0	0	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	1	1
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	0
0	0	0	0	0	0	0	1

The first line is a title. The second line contains three numbers: the first is the number of size classes included in each of the blocks of size frequency data corresponding to each sex (in this case in mm), the second number is the size (in this case in mm) of the smallest size clase in both blocks of data, and the third number is the size increment between size clases (in this case 1 mm). The next 65 rows (in this example) will contain frequencies corresponding to each size class within commercial size categories begining with size class 60 mm and at increments of 1 mm. The frequencies are in columns corresponding to each commercial size category. Thus, the first column corresponds to size frequencies in the smallest commercial size category (the one with the largest number of tails per pound) and the last column to the largest commercial size category (the one with the fewest number of tails per pound). Since in file 1 there were 8 commercial size categories given then in this file there will be 8 columns representing the length frequencies in each of the categories. Note that the first block of 65 rows corresponds to females while the second block of 65 rows corresponds to males. Therefore, there are 130 rows containing all the information on size frequencies corresponding to all the commercial size categories being analized (Note that an equal number of size classes and commercial size categories are included in each sex block, this is required even if no information is available for some of the size classes).

The output file contains information on the average frequency per size class as well as the standard deviation of the average frequencies. These average values are for the number of bootstraps specified in file 1. These average frequencies at size are for the total catch reported by commercial size categories in a given time period. The estimates are as follows:

LENGTH FREQUENCIES FROM COMMERCIAL CATEGORIES
Landings Red Shrimp Panama, July 1991
SIZE DISTRIBUTIONS AT GRADES RED SHRIMP PANAMA

LENGTH	AVE. # FEMALES	STD. DEV.	AVE. # MALES	STD. DEV.
60.00	1956.	1641.89	1332.	1410.03
61.00	0.	.00	0.	.00
62.00	0.	.00	0.	.00
63.00	2332.	2048.74	1831.	1748.10
64.00	0.	.00	0.	.00
65.00	4492.	2719.35	6490.	4133.03
66.00	17584.	12919.75	13020.	7181.61
67.00	17854.	5631.81	16200.	5947.72
68.00	40043.	17913.11	38526.	16974.75
69.00	29557.	12265.11	32102.	10663.10
70.00	70916.	18231.04	64035.	13284.42
71.00	93300.	21877.15	81104.	16772.63

72.00	101495.	25807.57	104220.	25467.80
73.00	110290.	27944.79	119538.	24354.02
74.00	104544.	26244.75	98714.	21085.53
75.00	105642.	23503.38	113069.	18882.25
76.00	145469.	30713.96	169740.	27391.80
77.00	134987.	35266.95	140099.	23678.09
78.00	164932.	27244.53	171909.	28079.46
79.00	227400.	31460.41	211675.	26493.46
80.00	257082.	36980.97	255032.	38132.92
81.00	235400.	26462.44	235224.	32931.64
82.00	175735.	29328.56	170337.	27058.11
83.00	163357.	32091.26	167819.	29845.61
84.00	120592.	25168.88	108972.	15746.45
85.00	94283.	26170.87	90418.	31204.95
86.00	125063.	25115.37	117373.	25538.04
87.00	119318.	19715.06	102510.	22691.64
88.00	153430.	25013.66	126130.	20587.05
89.00	164516.	27655.66	110551.	19813.75
90.00	202349.	31064.83	132485.	23726.92
91.00	91014.	16278.55	60092.	15672.34
92.00	147777.	30914.28	93701.	15940.30
93.00	187299.	38168.78	115758.	22921.40
94.00	132561.	29766.56	76205.	23101.02
95.00	281352.	58259.29	161671.	28541.07
96.00	208827.	33645.40	111531.	24002.23
97.00	256135.	34531.63	132907.	24706.87
98.00	160996.	29576.34	92470.	21350.71
99.00	146919.	29147.65	61245.	15601.20
100.00	200805.	52266.64	70434.	16906.22
101.00	143509.	33613.03	43325.	12868.83
102.00	160874.	29343.79	53914.	15086.09
103.00	94309.	29853.86	21881.	10466.07
104.00	88218.	23021.56	22419.	10201.05
105.00	177962.	47632.94	32613.	8963.22
106.00	130639.	33339.12	18397.	3398.22
107.00	133945.	36263.29	19975.	5824.15
108.00	90986.	23567.11	10691.	4195.95
109.00	59986.	22534.54	7560.	4768.03
110.00	80848.	23666.08	12046.	4339.57
111.00	16229.	10539.13	1938.	1590.25
112.00	55344.	14562.87	7206.	3516.71
113.00	11279.	9818.31	5310.	6418.89
114.00	2233.	1621.48	21.	22.82
115.00	2858.	2746.69	29.	26.61
116.00	6095.	3922.39	68.	45.52
117.00	1513.	1437.77	16.	19.32
118.00	0.	.00	0.	.00
119.00	15255.	11457.74	2303.	2120.61
120.00	0.	.00	0.	.00
121.00	0.	.00	0.	.00
122.00	0.	.00	0.	.00
123.00	0.	.00	0.	.00
124.00	2558.	2502.14	30.	27.62

USE OF LENGTH FREQUENCIES IN LENGTH CATCH CURVES

Plots of the log-converted catch in numbers per size class interval on median age obtained with the data generated for red shrimp in Panama are presented in figure 1. The regression range is for the points in the descending right limb of the distributions shown in the figure, and the slope of the estimated lines is an estimate of the total instantaneous mortality rate ($Z_{females}$=1.43; Z_{males}=2.43 in the example). Simple electronic spreadsheets can be developed to perform the above analyses. The shape of these distributions may change from month to month and between sexes since they depend on the recruitment rates experienced by the given class sizes as well as the selectivity pattern affecting each size class.

CHIEN AND CONDREY Q ESTIMATION

An application of the Chien and Condrey method to estimate the catchability coefficient q is shown here with data for the Pacific white shrimp fishery of Nicaragua (Ehrhardt and Perez 1996). Plots of the monthly CPUE on cumulative monthly catch in numbers are required for each biological year. These are presented in figure 2. Again, in this method the seasonal trends of recruitment may affect the ability to generate a decreasing trend in CPUE on cumulative monthly catches. In those cases it will not be possible to estimate a slope q' as required by the method. For those biological years that q' may be estimated, and instantaneous fishing mortality rate may be estimated as the simple product the the catachability coefficient times the fishing effort deployed during the period.

TUNED LVPA

The tuned length cohort analysis approach suggested in this paper is demonstrated with data for the pink shrimp of Florida (Ehrhardt, Legault, and Nance 1996). For this purpose, a LVPA computer program coded in the FORTRAN language was used. The program is available from the authors upon request. Another simple way to calibrate length cohort analyses is to develop an electronic spreadsheet in EXCEL and use the SOLVER Tool in EXCEL to make average F-values from cohort analysis converge to the external F-value provided for the calibration. Results of applying this technique to 380 months with length frequencies of total landings allowed the preparation of figures 3, 4 and 5. In figure 3, the fishing mortality rate in each month is depicted, while in figure 4 the recruitment (67+ tails per pound category) is shown by months and biological years, and finally in figure 5, the total stock abundance is given by each month.

BYCATCH ESTIMATION IN SHRIMP FISHERIES

In most fisheries on a worldwide basis, an incidental capture of non-target species and size groups occurs. These non-target species and age groups are collectively termed bycatch. Bycatch in shrimp fisheries are usually very significant and utilization of this bycatch may vary among different countries. However, shrimp bycatch most frequently affects juveniles of fish species which may be non-marketable fish. In this case, bycatch is usually discarded in great numbers. For example, the bycatch discards in the United States Gulf of Mexico shrimp fishery have been estimated at around ten billion fish per year, with most of the catch composed of groundfish species (Pellegrin et al. 1981).

Nichols *et al.* (1987) developed an algorithm to estimate total shrimp bycatch in number of fish by species caught in the U.S. Gulf of Mexico shrimp fishery. Briefly, a bycatch per hour of shrimp fishing effort is estimated for each fish species in each year (in the case of the Gulf of Mexico shrimp fishery for the years 1972 to date) based on a General Linear Model (GLM)(see McCullagh and Nelder 1995 for details on GLM's). The estimated bycatch rates are then multiplied by the total shrimp fishing effort deployed during the same year to estimate total annual bycatch.

Several stratifications are considered in this GLM to include data sources available for estimation, years, seasons, areas and depths differences in byctach. The general linear model is defined as:

$$Log(CPUE+1)_{ijklmn}=mean+dataset_i+year_j+season_k+area_l+depth_m+\epsilon_{ijklmn}$$

for each species, where *CPUE* is the catch rate in numbers of fish species caught in each trawl net per hour fishing, *mean* is the overall mean, *dataset* is a fixed effect term differentiating bycatch observations obtained aboard shrimp fishing vessels from those bycatch observations obtained aboard research trawlers, and the terms *year*, *season*, *area*, and *depth* are also fixed effect terms characterizing the spatio-temporal variability of shrimp bycatch. The error term is assumed to be random, independent, and normally distributed (i.e. lognormal) with equal variance throughout.

Predicted catch per net per hour is estimated for each defined stratum (cell) in the commercial shrimp fishery as:

$$CPUE = 10^{Log(CPUE+1)+1.1513*RMS} - 1$$

where *RMS* is the residual mean square from the log-linear regression model and the constant 1.1513 is a correction factor for estimations using log base 10 instead of the natural log.

Predicted catch rates per net-hour per cell are multiplied by the estimated shrimp effort in the corresponding spatio-temporal cell in a giving year. Note that CPUE's are estimated on a per trawl net basis. It has been assumed that in the U.S. Gulf of Mexico fishery an average of two nets per commercial shrimp vessel exists in the time series 1972-1995. Thus, total estimates of bycatch for species per year (j) are obtained as the sum of the commercial bycatch in all cells (strata) for that year multiplied by 2, as

$$Bycatch_j = 2\sum_k \sum_l \sum_m CPUE_{jklm} f_{jklm}$$

where f is the estimated total annual shrimp effort (hours of fishing) for area k, season l and depth zone m.

For bycatch estimation purposes, temporal variability of shrimp bycatch is accounted by including three seasons: 1 from January-April, 2 from May-August, and 3 from September-December. Also, the U.S. Gulf of Mexico has been divided into four main geographical areas: Area 1 covers the Texas coastline, Area 2 covers the Louisiana coast, west of the Mississippi river delta up to the border with Texas, Area 3 corresponds to the Alabama and Mississippi coast, and the northwestern coast of Florida; the Panhandle area, east of the Mississippi river delta, and Area 4 corresponds to the southwest Florida coast and the Lower Florida Keys. Two depth strata were defined using the 10 fathom depth as divider of the inshore and offshore regions.

The database for estimating shrimp bycatch in the Gulf of Mexico derives from several sources, however, two types of information form this database. These are: 1) direct measurements of finfish catch rates obtained by observers aboard commercial shrimp vessels, and 2) finfish catch rates obtained in research survey cruise programs.

In addition to the previous data sources, existing data from four other National Marine Fisheries Service (NMFS) observer projects are available and included in the database for estimating shrimp bycatch, these are data collected during sea turtle incidental catch and mortality studies, sea turtle excluder device evaluations, shrimp fleet discards assessments and shrimp bycatch characterization studies carried out in the U.S. Gulf of Mexico during the last 16 years.

Application of the above algorithm to the U.S. Gulf of Mexico shrimp database is shown in figure 6, where total finfish bycatch estimates and estimates for Spanish mackerel an red snapper are shown as examples.

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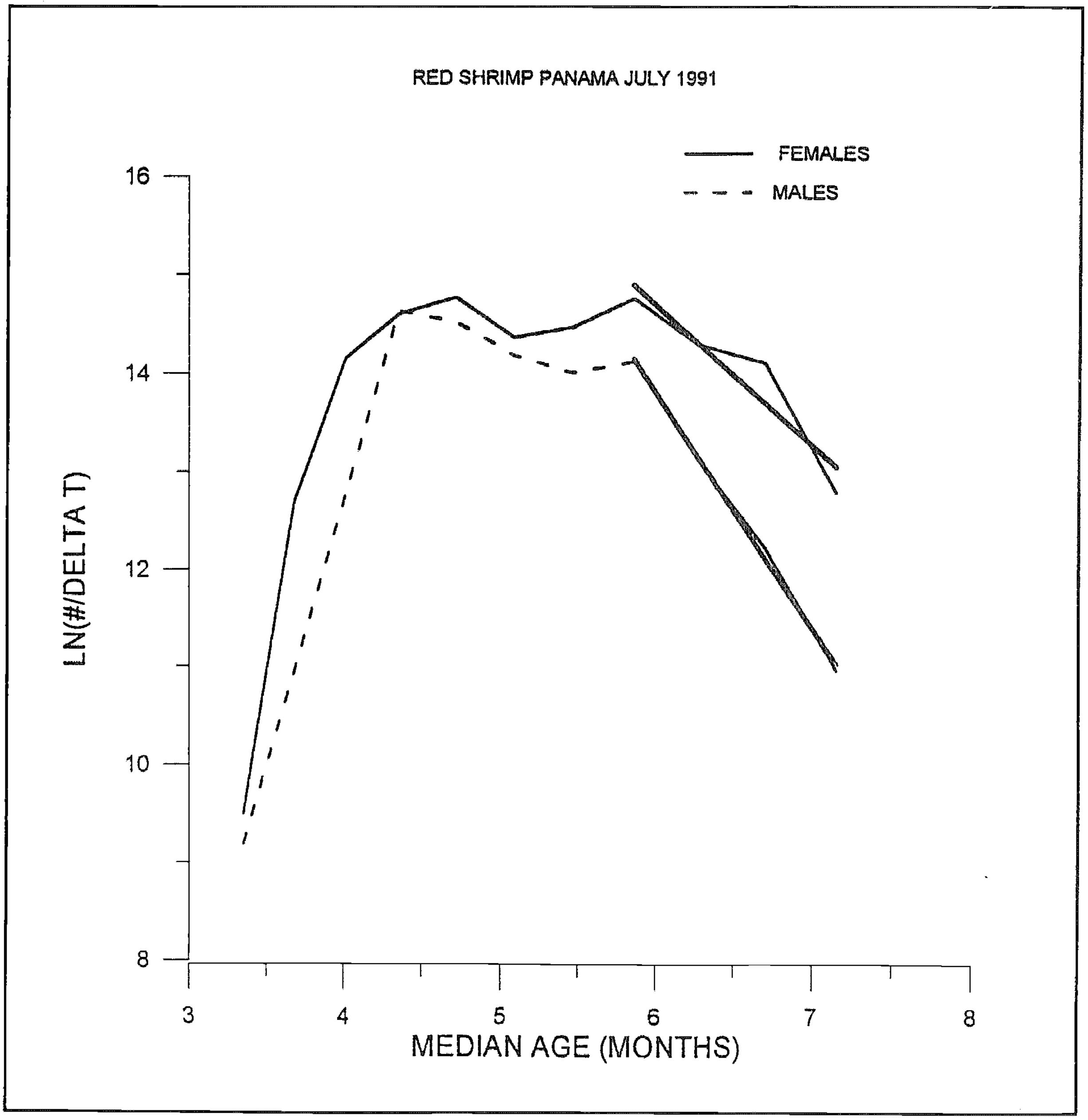

Figure 1: Plots of log-converted catch in numbers per size class interval on median age obtained with the data generated for red shrimp in Panama.

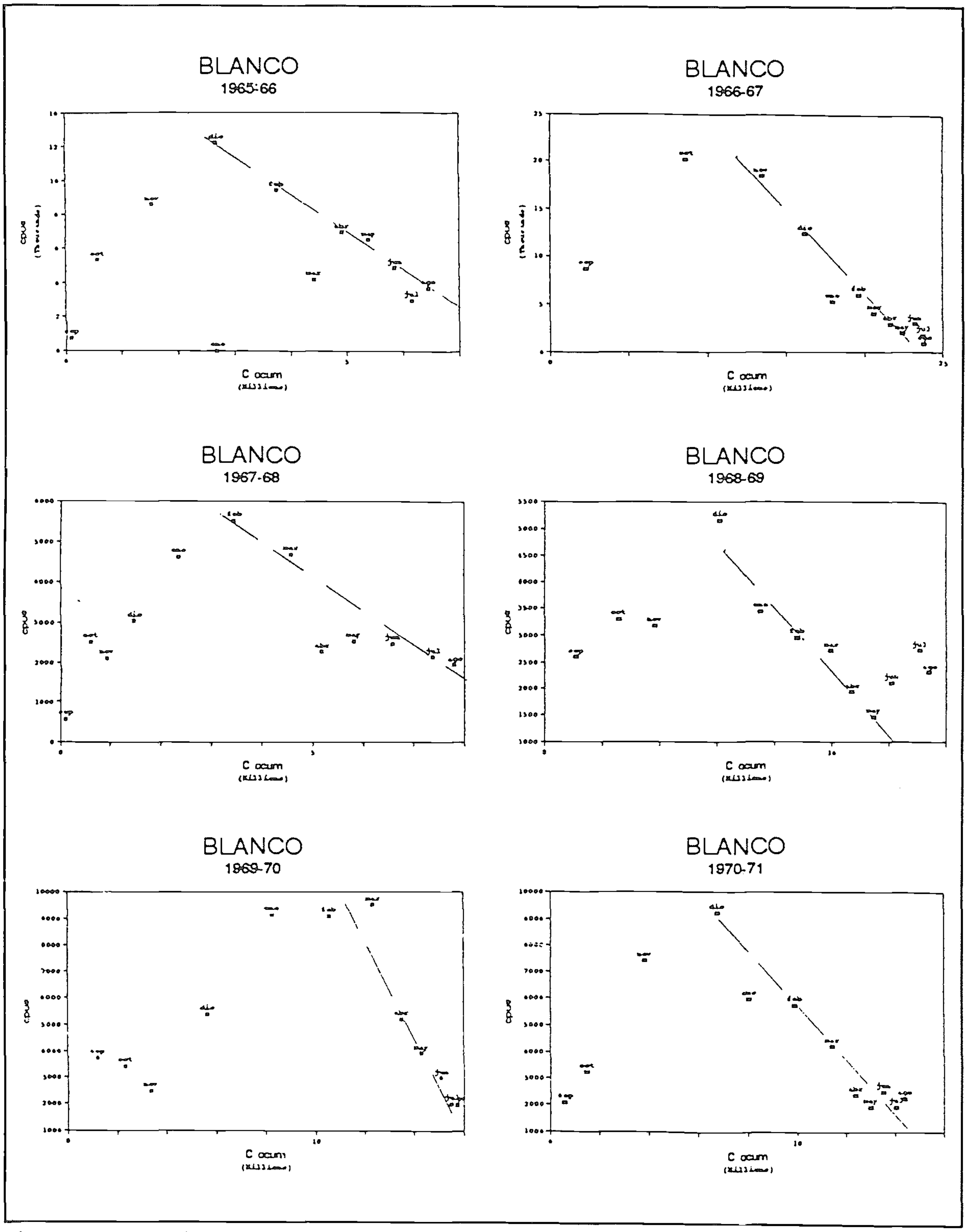

Figure 2: Plots of the monthly CPUE on cumulative monthly catch in numbers of Pacific white shrimp of Nicaragua as required for each biological year in the Chien and Condrey (1985) method.

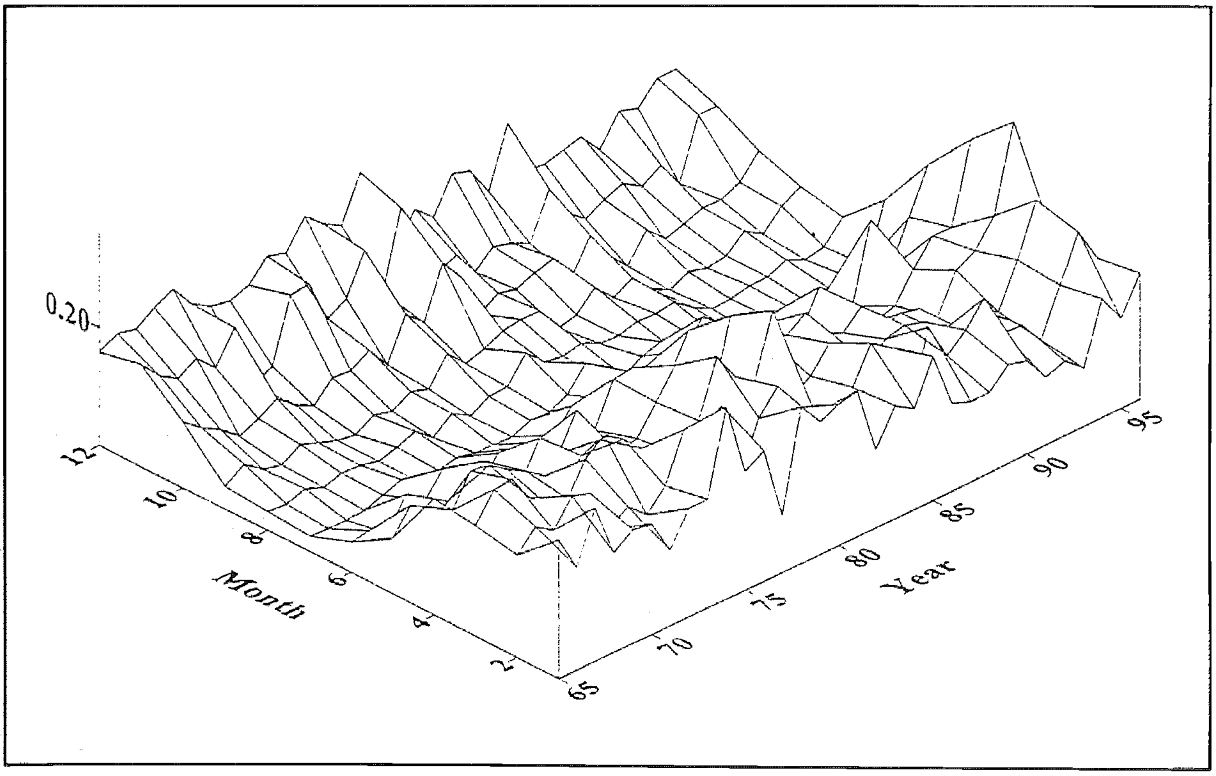

Figure 3: Monthly F-estimates from applying the calibrated length cohort analysis technique to 380 months with length frequencies in total landings in the Florida pink shrimp fishery.

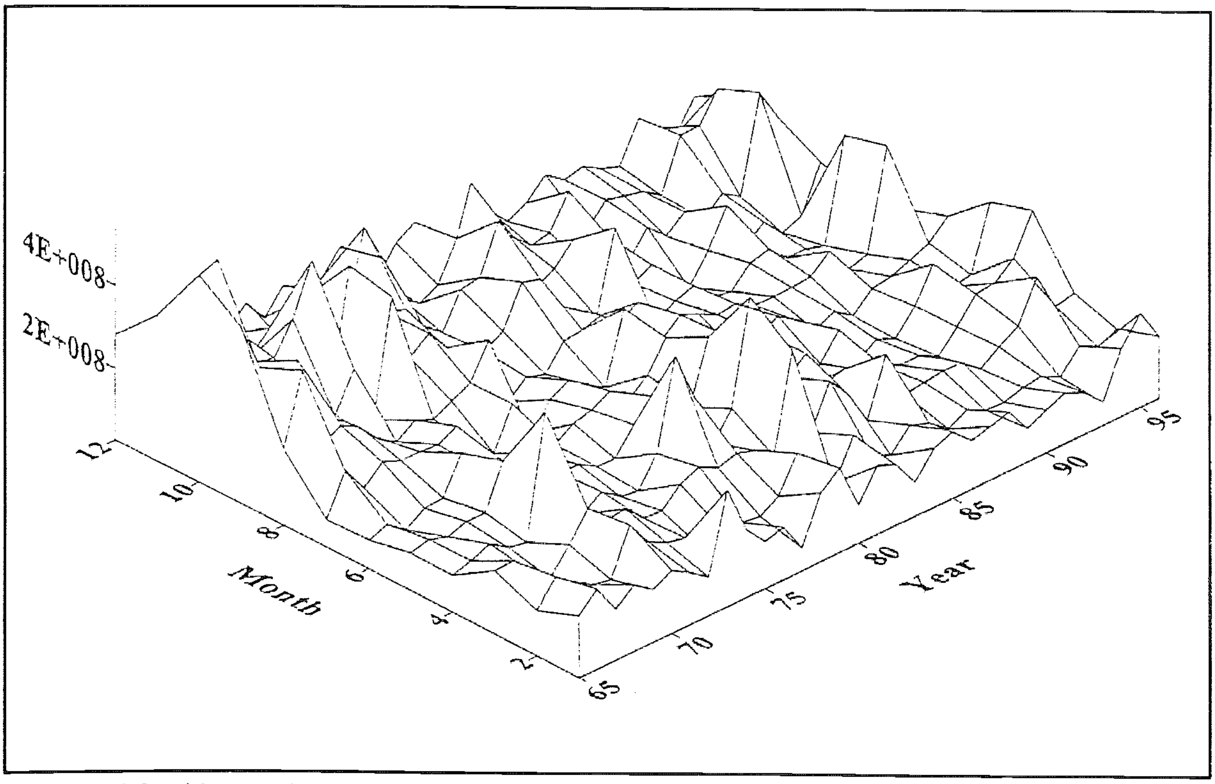

Figure 4: Monthly recruitment in numbers (67+ tails per pound category) from applying the calibrated length cohort analysis technique to 380 months with length frequencies in total landings in the Florida pink shrimp fishery.

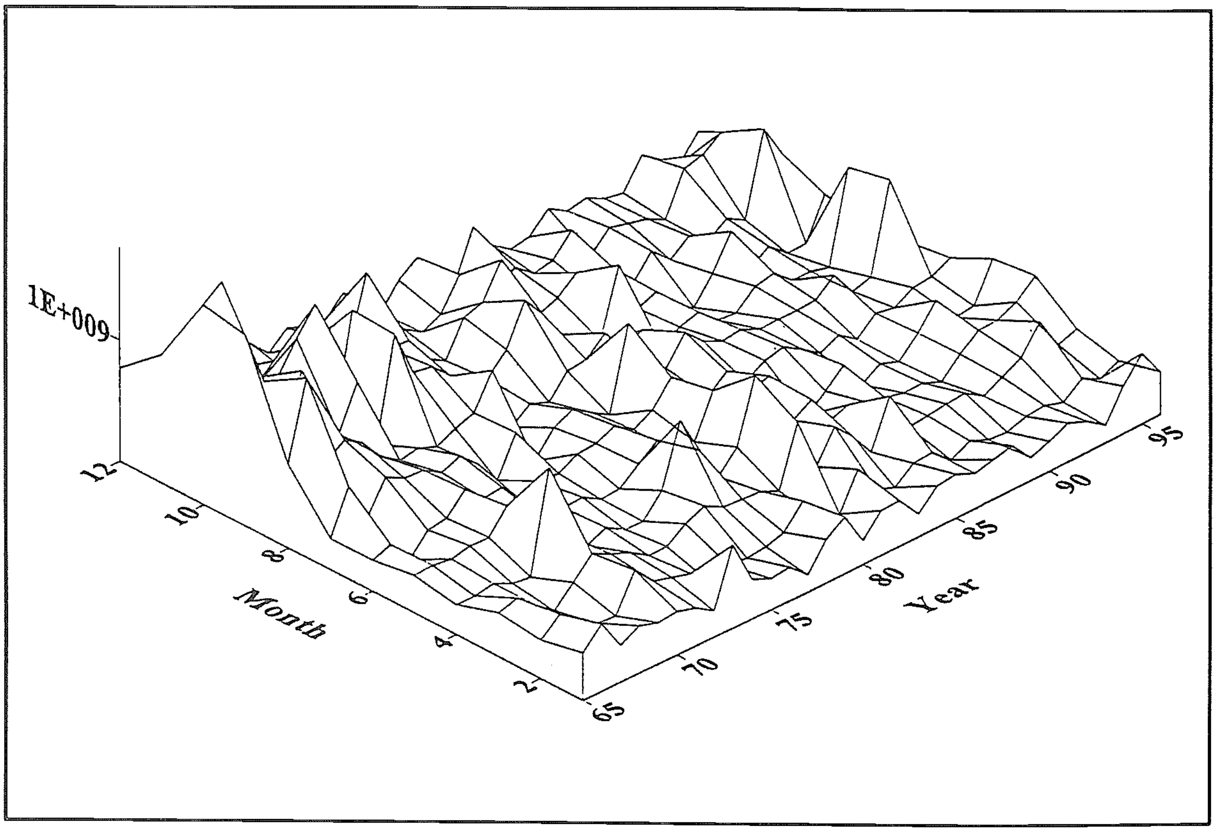

Figure 5: Monthly stock abundance in numbers from applying the calibrated length cohort analysis technique to 380 months with length frequencies in total landings in the Florida pink shrimp fishery.

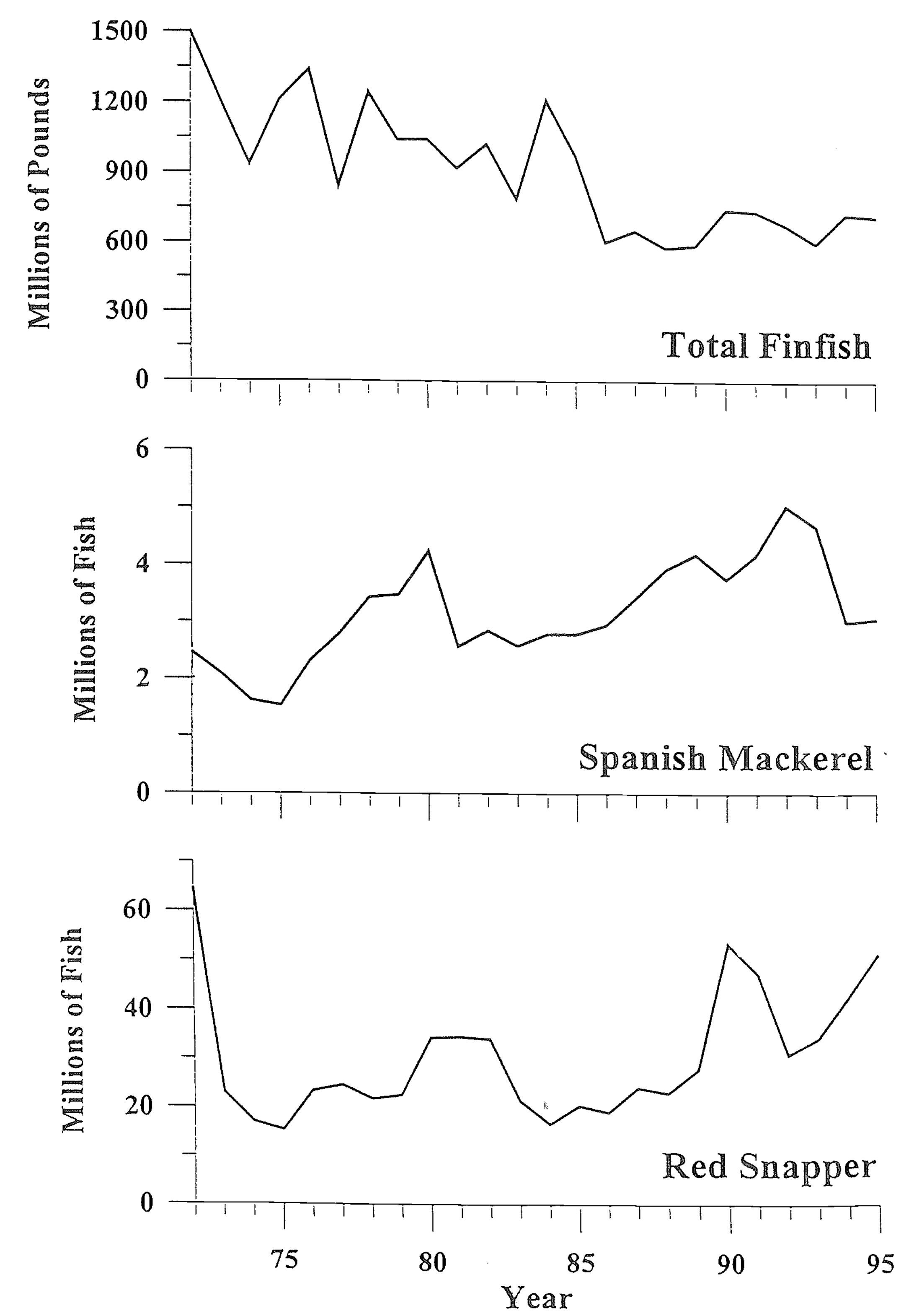

Figure 6: Shrimp bycatch estimates for total finfish (biomass), Spanish mackerel (numbers) and red snapper (numbers) in the U.S. Gulf of Mexico shrimp fishery.

Conceptual Framework for Shrimp & Groundfish Stock Assessment & Data Collection

A. Talbot[1]

INTRODUCTION

The main purpose of this summary report is to outline an approach to the Shrimp and Groundfish Assessment Subproject based on: the conceptual framework for shrimp and groundfish assessment; identification and description of the proposed stock assessment activities; description of proposed fishery assessment projects/activities that will be coordinated or undertaken by the RAU in order to address these needs. The conclusions and recommendations of the Subproject Specification Workshop and the Joint FAO/CARICOM Ad Hoc Shrimp Group Workshop will be integrated.

CONCEPTUAL APPROACH TO STOCK ASSESSMENT

FUNCTIONAL SPECIES GROUPS

The methods of determining optimal fishing effort and natural productivity for a particular stock are based on two 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 estimated, or 2) carry on a detailed scientific program in which the productivity of the stocks within habitat types are estimated from information on recruitment, growth, mortality and other life history parameters. The two approaches, namely fisheries monitoring and applied fishery science respectively, are not mutually exclusive, and most fishery research centers combine them according to the availability of fishing data and research opportunities.

The shrimp and groundfishes of the Guiana-Brazil continental shelf fall into several categories that will require different assessment approaches depending on their life-history, fishery and functional groups. The shrimp are obviously in one group, but even these are divisible into the large shrimps (Penaeidae) and small estuarine shrimps (seabob, whitebelly, etc.). Fishes can be classified into functional groups according to their anatomy and life-history characteristics. The demersal fishes live on near the bottom, but can swim and feed in the water column. This is a very diverse group, and can be further classified into 3-4 groups the omnivorous "mudeaters" (mostly catfishes of the family Ariidae), associated with mud bottoms as a consequence of their feeding habits and anatomy; the carnivores, only loosely associated with the soft-bottoms and probably as a primary predator of shrimps (the family Sciaenidae in general, including sea trouts, croakers, etc.); and the opportunistic bottom fishes, generally with down-turned mouths and often barbels (snooks, drums, etc.).Commercially important groundfish in the Guiana-Brazil continental shelf region include members of different families, the sciaenids, the catfishes, the snooks and the drums. Other than the fact that all of these families are exploited by the demersal shrimp trawl fishery, they have few similarities and should be treated separately for assessment and management purposes.

Therefore, four functional groups are targeted by the fisheries and fall under the responsibility of the RAU. Talbot *et al* (1996) gives a summary of the biology of the major commercial species in their functional groups. Talbot and Phillips (1995) give a summary of the status of the fisheries for shrimp and

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1 CFRAMP Shrimp & Groundfish Resource Assessment Unit, Trinidad & Tobago.

groundfish in the region. It is therefore recommended that a full stock assessment be done on one representative of each of the functional groups.

STATUS OF THE FISHERY SURVEYS AND ASSOCIATED FISHERY DATA

Shrimps of the family *Penaeidae* have been extensively studied worldwide and many parameters may be available from the literature. This is not so for most groundfishes, with the possible exception of *Micropogonias furnieri*.

There appears to be a great deal of information scattered throughout the region on the shrimp resource and its exploitation in general (Table 1). However, there have been very few attempts to pull all sources of data together and analyze them as such. Most of the catch and effort data relates to the industrial fishery, except in Trinidad where such data does not exist. The artisanal fishery, whether for shrimp or for groundfish, has received very little attention, except in Trinidad, and there is very little data to analyze. Suriname has some data available on by-catch and targeted artisanal groundfish fisheries.

Details of the status of historical data are given in Talbot and Phillips (1995). A thorough review of the life-history parameters derived for the penaeids of major economic importance has been produced (Lum Young *et al.* 1992). In this document, life-history data is resumed and organized in sections according to species. Charlier (1994) also reviews the status of stock assessment in the region and provides a thorough survey of available data and parameters estimated (status of present knowledge).

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 developed 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. This growth curve is similar to other growth curves for Penaeidae elsewhere, and may be accurate, but many of the assumptions should be tested.

The U.S. National Marine Fisheries Service (NMFS) (Galveston Laboratory) 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. 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. The status of knowledge of the different species targetted for biological data collection is given in Table 2. This table may be incomplete due to the absence of published results in the region. Some gray literature may still need to be uncovered.

The shrimp fisheries now appear to be in a state of economic or biological over-fishing. In light of this, recruitment over-fishing must become a focus of research activities (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 over-fishing"). Ideally, 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.

Table 1: Type of data available for shrimp stock assessment in participating countries and in the Guiana-Brazil continental shelf area. Data from Sur. Fish. (1994). A thorough review of the sampling programs in each country of the Guiana-Brazil continental shelf is presented in Charlier (1994). The equivalent table for groundfish is not presented as virtually every field is incomplete.

COUNTRY	LANDINGS (whole (W) or tails (T))	EFFORT			BIOLOGICAL		
		Vessels (with HP)	Days at sea (D) or trips (T)	Days at sea (D) or trip (T) per strata	Length frequency	Size category	Mortality (Z, F or M)
Venezuela	X	X	D,T		X	X	
Trinidad	X[1]	X[1]	D,T		X	X	
Guyana	X[2,3]	X	T			X	
Suriname	X (W,T)	X	T		X	X	
Guyane française	X (W,T)[4]	X_{HP}[4]	D	D		X	
Brazil	X (T)	X	D,T			X	Z,F,M
Jamaica	X[5]					X	
Belize	X	X				X	

NOTES: 1: Artisanal fishery only. 2: all large shrimp species combined. 3: Split into industrial and artisanal components. 4: Industrial only (artisanal negligible). 5: May not reflect actual fishery.

Table 2: Status of knowledge of the biology of the species targeted for biological data collection.

SPECIES	PRI. STAT.	BODY MORP.	L_∞	K	Z	F	M	AGE	GRO. RATE	LGT. MAT	FEED.
Penaeidae											
Southern white shrimp, *Penaeus schmitti*	1	X	X	X	X						
Southern pink shrimp, *Penaeus notialis*	1	X									
Redspotted shrimp, *Penaeus brasiliensis*	1	X	X	X		X	X				
Southern brown shrimp, *Penaeus subtilis*	1	X	X	X		X	X				
Seabob, *Xiphopenaeus kroyeri*	1									X	
Palaemonidae											
Whitebelly shrimp, *Nematopalaemon schmitti*	1										
Arridae **(catfishes)**											
Arius parkeri	1		X[1]								
Arius grandicassis	2										
Bagre marinus	3										
Bagre bagre	3										
Centropomidae											
Snooks (*Centropomus undecimalis*)	2										
Scianidae											
King weakfish (bangamary, *Macrodon ancylodon*)	1		X[1]								
Acoupa weakfish (gray snapper, *Cynoscion acoupa*)	2										
Jamaica weakfish (bashaw, *Cynoscion jamaicensis*)	2										
Green weakfish (trout, *Cynoscion virescens*)	2								X[2]		
Whitemouth croaker (*Micropogonias furnieri*)	2	X	X,X[1]	X			X	X	X	X	X
Shorthead drum (*Larimus breviceps*)	1										
Butterfish (*Nebris microps*)	2										

1: Maximum size captured. 2: Closely related species (*C. nebulosus*) in Florida. PRI. STATUS=Priority status, BODY MORP.=Body morphometrics, GRO. RATE=Growth Rate, LGT. MAT.=Lenth at Maturity, FEED.=Feeding.

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 disputed (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. If we assume that spawning takes place year-round as a null hypothesis, and assume that the quantity of available nursery habitat for juvenile and post-larvae shrimp fluctuates with the rainy season, the one would predict that the variation in total abundance would correspond to the rainy season cycle. This hypothesis can be verified using a remote-sensing approach to habitat mapping, where seasonal fluctuation in nursery habitat are noted.

Although surplus-production models (catch and effort models) have been used in the region, their success in determining optimum 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 in Trinidad. French Guiana have used yield-per-recruit models for their industrial fleet, but the results are difficult to apply in a regional context.

CONCEPTUAL STOCK ASSESSMENT FRAMEWORK

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.

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*) (Talbot *et al.* 1996) and the local characteristics of the shrimp fishery (Talbot and Phillips 1995). The shrimps are intricately dependent on the estuaries in which they reproduce and grow-out, yet there has not been much attention to this element in the management programmes. Shrimp are fast growing and essentially 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. Despite apparent very high fishing mortalities in some areas, 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.

The RAU has 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 in theory. 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. 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.

MODELS AND APPROACH TO STOCK ASSESSMENT

Firstly, it must be emphasized that the stock assessment of a species or fishery is an ongoing process. It is not desirable to collect data for a length of time (2 years or more) without undertaking parameter estimation and evaluation of the quality of the data during the sampling process. Within CFRAMP, while establishing data collection systems in participating countries, the countries should be strongly encouraged to begin stock assessments immediately with all available data. Several assumptions may be required, but this will help in determining required refinements to the sampling programs and data collection as well as determining the value of available data in a quantitative sense.

Due to the diverse nature of the functional species groups (marine and estuarine shrimp species, marine catfishes, sciaenids, etc.), a wide variety of stock assessment methods have to be examined, and data acquisition tailored to these methods. The existence of historical data and time-series will also bear an influence on what approach should be employed.

The most fundamental element of the stock assessment is the analysis of commercial landings, usually based on catch and effort data, although it might be argued that survey data are also fundamental. Several tools have been developed for the analysis of commercial data. Most assume that the average number of individuals is constant in a stock (clearly violated in the case of shrimps, may be more reasonable for finfishes), and that the habitat used by the stock is a constant area (the number of individuals per unit square is constant), that a unit of effort is a measurable, constant quantity.

The methods to be considered for the analyses are far ranging, beginning with the time-series of CPUE, which, assuming constant catchability, is related to population size. This method permits the evaluation of long-term trends in the fishery, but does not allow an evaluation of optimal use of the fleets. There are many variants of this technique, including statistical weighting by different methods, integration of various fishing technology and efforts, and standardization of effort. Integration of the capture from various sources of the fishery, including by-catch and capture of juveniles will on the other hand modify the estimates of capture. With this data, it is also possible to map the distribution of fishing effort and captures according to environmental factors or habitat parameters. This type of work can be done if no time-series exist, as will be the case in many fishery/species/country combinations.

Some of the important elements of catch-effort must be dealt with at this level. The high number of species in the catch must ideally be handled separately. This will cause some difficulties. Moreover, because of the existence of a commercial fishery operating in essentially the same areas as the artisanal fisheries, and because of the very high number of types of fishing gear, each with a different catchability coefficient for each species captured, it is often very difficult to obtain, for a given stock/species, a series of compatible and summable effort data against which the catch per unit effort could be plotted.

SURPLUS PRODUCTION MODELS

Slightly more complex are the surplus production models (e.g. Schaefer or Fox models). The objective of these models is to determine the optimum level of effort in order to maximize sustainable yields. The data requirements are light, since the models can be applied to catch per unit effort by species and the associated effort over a number of years. The availability of time-series remains to be determined for many species/countries. For surplus production models to work, sufficient variation in the effort vector is required so that the response variable (capture) has the opportunity to respond to variation in effort beyond all combined stochastic effects. This is a difficult assumption to meet in mature fisheries. However, this technique might be applied to new finfish fisheries that have a good time-series of landings and gear numbers in use. I am not aware of any time-series at present which meet these requirements, and application this method will not be a principal goal of the CFRAMP.

With this method, maximum sustainable yields are 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. Despite its severe limitations, holistic models must be used when catch and effort data is the only type of data available, and may nevertheless give valuable insight into the nature of the problem ("qualitative results").

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. Use of surplus production models is a first level of structured "stock assessment" analysis.

PREDICTION OR "ANALYTICAL" MODELS

Length frequency analysis of the commercial catch samples can be used to estimate growth parameters, using various cohort reconstruction methods with sampling over a single year. Mortality rates can also be estimated, using either methods adapted from the literature or from packages designed for this purpose (ELEFAN, FISAT, etc.). Catch predictions for changes in fishing patterns can be made based on the length-based versions of the Thompson and Bell model. This type of modeling approach is used in the BEAM series, but is complex to use. This method will be the primary focus of the Shrimp/Goundfish RAU.

If an historical time-series is available for catch and effort, length frequencies and other biological data, a more thorough modal-progression analysis can be done and yield sound results for short-lived species such as shrimps. Similarly, a cohort-based estimation of mortality rates is possible, particularly for short-lived species. Estimates of recruitment rates for each cohort are also possible using various length-based extrapolation methods (including cohort analysis). With the resolution of the length frequencies into modal groups corresponding to ages or cohorts, then age or length-based cohort analyses or Virtual Population Analyses (VPA) are possible. Yield-per-recruit models (including Thompson/Bell), although recommended, are very demanding in quantity and quality of data, and their evaluation of their usefulness must be counterbalanced with the costs involved and quality of data required in a sustainable sampling framework. Cohort analysis can be achieved with only one or two years of data, assuming that there is no variation in cohort strength. Ideally, the length of a time-series for any type of cohort analysis corresponds to the number of age groups or cohorts in the population. Therefore, for shrimp, only one year of data is required. For finfishes, longer time-series are desirable.

Use of yield-per-recruit models in mixed fisheries is also technically difficult to develop, as the Y/R functions must be transformed to incorporate comparable units.

If the fishery incorporates several levels of interaction among fleets fishing the same stock at different times of the life cycle or locations, then more sophisticated tools are required. These would be required to estimate mortality rates at different stages during the life cycle of the animal, such as provided by age or size-structured models. Predictive models can estimate length-based mortality rates from data collected on a monthly basis, and which output results for yield-per-recruit types of analyses.

The most important variation affecting yield is recruitment, and it is 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 most often been related to rainfall, river run-off or similar factors.

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 the level of fishing is not inferred 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) and sexes 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. We will ensure 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 or catch-by-length table, an instantaneous rate of fishing and natural mortality for one age or size-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. Total mortality rates must be estimated from the catch statistics or from direct observations (e.g. tagging data). We will be making extensive use of this subclass of model at the regional level, but may not be able to do so on a country basis where the technological, statistical and human resources (and time-series) do not permit it. 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, Cuba, Venezuela) that could be analyzed by the RAU and applied to local fisheries for comparison purposes.

When recruitment is continuous, or if the fishing fleet (effort) moves from one area to another to sequentially exploit cohorts/stocks from different nursery grounds, then these analyses of fishing mortality and VPA will be more complicated. It may be possible to "correct" for these errors by calibrating with the recruitment variability estimated from the monitoring of the near-shore and nursery fisheries.

For many species, there will be published information on age-length relationships, growth rates, mortality etc. However, and for several species, there will be no published life-history information. For these species, it is likely that some growth information will have to be acquired experimentally in order to calibrate length frequency analyses. This may be done on a very small scale, only for certain species of finfish, and for a limited time-period. Length frequency analyses and growth relationships would then be developed so that the wide range of age converted length-specific models could be applied to time-series data.

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 (BEAM I-IV) to speculate numerically on the level of interaction between artisanal and industrial fisheries.

Table 3 presents the advantages and disadvantages of each class of stock assessment model discussed above. These are not all-inclusive but rather represent a synthesis of the current thinking in light of the need for stock assessment in the general sense and management advice derived from the analyses.

Table 3: Pros and cons as well as data requirements for the various stock assessment methods proposed.

PROS	CONS
Surplus Production Models Data types required: Catch biomass) and effort for each fleet/fishery from landings	
- Light data requirements	- Long time-series required
- Easy methodology	- Sufficient variation in effort over the time-series
	- Integration of fleets difficult
	- Poor quantitative advice for management
Cohort, VPA and predictive (T/B) models Data types required: Total catch and effort, catch-at-length, natural and fishing mortality.	
- Integrates life history data which can be age or length-dependent	- Very demanding in quantity of data required
- Permits estimation of parameters by fleet	- Requires precise estimates of parameters
- 1 year of data is sufficient to apply model	- May ignore variation in recruitment variability if no time-series is available
- Multi-species/multi fleet analyses possible although complex	- Cohorts may not be discernible in the population
- Can incorporate food chain parameters	- Stock distribution must be known and used as unit of model
- Can be used for analysis of by-catch	- Ignores species interactions
	- Multi-species model give very different results than single species model

Table 3: Pros and cons as well as data requirements for the various stock assessment methods proposed.

PROS	CONS
Beverton/Holt yield-per-recruit model Data types required: Length at recruitment, length at infinity, natural mortality, K (VB "growth" parameter), length/weight relationship	
- Simpler than VPA or cohort analysis	- Series of assumptions used to simplify the method
- Can be used as a first estimate of MSY	- Other reservations as the cohort analysis class of models
- Only requires basic life-history parameters (L_∞, L_r, M/K ratio)	
Stock-recruitment relationship Data types required: Total catch or fisheries-independent estimate of adult abundance, time-lagged recruitment index, environmental data (optional but highly desirable).	
- Based on simple rationale	-Ignores yearly and seasonal fluctuations
- A central issue in all stock assessments	- Assumes enough variation in stock size has been recorded to observe co-variation in recruitment
	- Strong effect of environmental factors
	- Assumes existence of well defined cohort
	- Problable existance of an infinite number of models
	- long time-series required
	- Required biological knowledge of a species/stock is very high
Environmental Models Data types required: Total Catch and Effort, Catch-at-Length, Natural and Fishing Mortality, environmental variable (rainfall or river runoff or other).	
- In conjunction with recruitment studies and life history data, eliminates some of the stochasticity in cohort strength and parameter estimates	- Requires long time-series
- Historical data often available from environmental monitoring agencies	- Poor predictive power when used singly
	- Analytically difficult methodology
Habitat production models Data types required: Geographically-referenced catch and effort by month, remotely-sensed environmental parameters or "ground" surveys, maps, habitat preference, etc.	
- Ecologically sound principles	- Requires detailed information on habitat (expensive)
- Good for many years unless ecosystem changes	- Need production estimates per habitat unit data
- Additive (progress and knowledge accumulates such as in GIS)	- Difficult integration of seasonal variation
- Can incorporate food chain and ecosystem parameters	- Often multi-sectorial

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 require. A summary of this information in relation to various classes of Stock Assessment Models has been tabulated by Dr. Nelson Ehrhardt (see Table 4).

Table 4: Data requirements for assessments (modified from Dr. N. Ehrhardt, Pers. Comm).

DATA	TECHNIQUES POSSIBLE
Biological	
Total catch CPUE	Surplus production
+ Survey estimates	"Tuned" surplus production
Size information by time and area	Qualitative impacts of closed areas/seasons
Growth, mortality, maturity	Yield-Per-Recruit; spawner-biomass per-recruit
Commercial size category landings + size frequency by category	Length cohort analysis, VPA, T/B Models
All above	Integrated analysis (Ehrhardt)
Habitat/environment: recruitment relationship	Assess impacts coastal development, climate variability

Table 4: Data requirements for assessments (modified from Dr. N. Ehrhardt, Pers. Comm).

DATA	TECHNIQUES POSSIBLE
Economic (Financial)	
Current Value	Extrapolation
Size-based Assessment Fish prices Costs of harvesting Processing costs Foreign exchange costs Opportunity costs Taxes and subsidies	BEAM Analyses
Social/Employment	
Current employment	Extrapolation
Industry Input Demographic Trends	Social forecasts

LIFE-HISTORY DATA (BIOLOGICAL DATA COLLECTION)

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.

A method of determining the age of shrimp and groundfishes 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). The RAU will not be developing age determination methods from hard parts.

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

The detailed data collection programme is outlined in. Methods of biological measurement are in Talbot *et al.* (This volume).

Sampling Lengths or Weights of Individuals Animals

It is particularly difficult to evaluate the bias generated by pre-sorting of landings by the fishermen or intermediate resellers. However, information on size distribution is so important for the proper estimation of parameters used in production models that special attention is required. The assumption in the following discussion is that the shrimp will have been sorted by size categories on board the ship. Species are generally lumped together within these size groupings.

The following procedure, suggested by Hoenig *et al.* (1978) can be adopted effectively in most situations, based on a stratified random sampling technique.

1) A sample of shrimp must be measured from at least one of each of the buckets holding the size-graded shrimp in each size categories.
2) The number of buckets of each size categories must be recorded.
3) An overall length or weight distribution can then be reconstructed by using the formula,

$$\bar{\bar{L}} = \frac{\sum_{j=1}^{J}[(\sum_{i=1}^{I} L_{ij})f_j]}{\sum I_j f_j} \tag{1}$$

where L_{ij} is the length of the i^{th} specimen in the j^{th} bucket, and f_i is the frequency of buckets of a particular size-class. The variances are also computable and should be unbiased if proper representation of the buckets is ensured, as they are in this case proportional to the weighting factor. However, the variance in such a case is not the simple mean of the individual variances, since these are smaller than the true population variance for all the buckets (because of size classification), that the intra-bucket variance is likely size-specific, and the quantities of each of the size-groupings in unbalanced. That is:

$$VAR(L) = \frac{\sum_{j=1}^{J}\left[\sum_{i=1}^{I}\left(L_{ij} - \bar{\bar{L}}\right)^2\right]f_j}{\left(\sum I_j f_j\right) - 1} \tag{2}$$

There are some unverifiable assumptions inherent in this technique, For example, it is impossible to reconstruct the fraction of specimens not appearing in the sample because they were rejected (too small), and therefore the size is probably biased towards high values while the variance is probably underestimated.

This procedure is compatible with the method prescribed by Dr. Nelson Ehrhardt in this report. The determination of sample sizes is given in detail in Talbot (1995).

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 ensure that the 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 CFRAMP catch and effort sup-project is well under way, we do not need to specify implementation details in this document.

FISHERIES-INDEPENDENT RESEARCH

Surveys can be used to collect data on several species groups (i.e. shrimp, groundfish, turtles). Individual surveys 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.

ENVIRONMENT/HABITAT PARAMETERS OF SHRIMP/GROUNDFISH PRODUCTION

Environmental 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.

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, the trade-off between nursery protection and industrial development put environmental 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 approaches would be optimal.

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.). The planned observer programme to be developped by the RAU would fall under this category as well.

DECISION PROCESS FOR STOCK ASSESSMENT ACTIVITIES

Since it is no longer correct to assume 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 managemen. These new objectives are likely to be varied, complex and often incompatible. The best a biologist or fisheries scientist 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 provision of new management guidelines. A ranking of priorities in terms of research, such as is done is the USA, might be a desirable second step. In this example, we retained the scores for the Management vs. Research objectives matrix 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 5.

Table 5: 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							
RESEARCH OBJECTIVES	Opt. size*	Max. Economic function*	Minimize biological risk*	Habitat Manag.*	TOTAL SCORE	MANAG. NEEDS RANK	STATE OF KNOW. RANK **	COMB. RANK
Growth	1	3	2	3	9	6.5	M/5	7
Natural mortality	1	3	2	3	9	6.5	L/1.5	4

Table 5: 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).

RESEARCH OBJECTIVES	MANAGEMENT OBJECTIVES				TOTAL SCORE	MANAG. NEEDS RANK	STATE OF KNOW. RANK **	COMB. RANK
	Opt. size*	Max. Economic function*	Minimize biological risk*	Habitat Manag.*				
Fishing mortality	1	1	1	2	5	1	L/3	1
S/R function	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). ** Level of current knowledge (from Table 1 and 2). 1=Essential, 2=Primary supporting information, 3= Secondary supporting information. 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.

COMMON ACTIVITIES

The proposed stock assessment activities are summarized from the above discussion.

1) We will supplement the existing implementations of catch and effort data collection systems in all countries with biological data. The basic catch/effort data will provide the required information for country and regional statistics as well as to provide data for holistic models (surplus production models). The catch and effort data collection will be developed in accordance with, and integrated into, 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 targeted and captures, and non-targeted 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 the biological data collection documents (Talbot *et al.* This volume). 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 functional species groups,

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, 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 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 for 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 series.

   Training of 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 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 and gear combination. 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 using a predictive model of the Thompson and Bell type.

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 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 manage the information.

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. Guiana). Canada has implemented regulations on the use of by-catch reduction devices in the northern shrimp fishery since 1993 with a by-catch level of only 5-10 % (Savard and Simard, 1994). 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.

8) Bio- and socio-economic research: If collaboration can be established with experts within CFRAMP, either through the Community Participation Sub-project or some other means, 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 officers in the region, who must advise their ministers on the effect of closures on communities.

COUNTRY-SPECIFIC: GUYANA

The Guyana 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.

A comprehensive system for the collection of catch and effort, biological data, economic and social data is lacking for shrimp, by-catch and groundfish, and needs to be developed in Guyana. Length-frequency sampling on a monthly basis for shrimp needs to be implemented. Specifically, the artisanal fleet are not sampled, and therefore their contribution to the fishing industry, mortality and population dynamics of the shrimp and groundfish is unknown. In order to use predictive models, these data will be required.

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.

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.

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

COUNTRY-SPECIFIC: TRINIDAD & TOBAGO

Length-frequency sampling on a monthly basis for shrimp is already implemented in Trinidad. However, a comprehensive system for the collection of catch and effort, biological data, economic and social data is lacking for shrimp, by-catch and groundfish, and needs to be developed. Specifically, Type IV (industrial) vessels are not sampled, and therefore their contribution to the fishing industry, mortality and population dynamics of the shrimp and by-catch unknown. In order to use predictive models, this data will be required.

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Fisheries Information System for the Small-Scale Fisheries in Suriname

Y. Echteld-Babb[1], R. Lieveld [1], P. Charlier[1]

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SUMMARY DESCRIPTION OF THE FISHERIES INFORMATION SYSTEM

BACKGROUND

Data on fisheries have been obtained in Suriname since the 1960's, basically through two systems. There was an annual register of the fishermen, which included information collected through the licensing system. Data on amounts of fish delivered were collected by enumerators, basically at market places.

Both sources of data showed severe weaknesses, a few of which can be mentioned:

- There was no verification of the information supplied by the fishermen, which was often incomplete, and inaccurate;
- Data were processed by hand, in such a way that results become available ONLY after several months;
- Whatever landings were recorded were considered as total landings; no provision was made for the landing places and/or periods without enumerators;
- The type of landing unit (boat, gear) was not recorded;
- No data on effort were recorded.

In order to improve this situation, the UNDP/FAO project "Establishment of a Fisheries Information and Resource Assessment System" (SUR/87/001) was started in October 1990 and completed at the end of 1992. During a workshop organised as the conclusion of the project, the validity of the new system was evaluated and an analysis of the results of the year 1991 was discussed Charlier, 1993).

MAIN PRINCIPLES

The purpose of the new Fisheries Information System (F.I.S.) is to remedy the identified shortcomings and provide the information needed for management. In particular it should produce, for each fishing system, monthly estimates of effort, landing per unit of effort (lpue[2]), landings, that are sufficiently reliable and accurate for stock assessment purposes. In the long-term, time-series of several years will be needed. It is important to check the quality and utility of the results right from the start.

As the shrimp landings by the industrial fishery are already processed in a separate data base, this part of the fishing activities is not included in this F.I.S. Fish by-catch by shrimp trawlers, and the landings of fish trawlers, are part of the F.I.S.

The principles of the system implemented can be summarized as follows.

1. There is a stratification of the landing places. See Table 1 for the list of landing places and strata.
2. Effort, expressed either in number of landings or in number of days at sea (depending on the type of fishing unit), is recorded at all landing places. At important landing places it is recorded by

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[1] Fisheries Department, Paramaribo, Suriname.

complete census (all effort recorded all days). At other places a sampling procedure is implemented, and effort (all effort) is recorded during a given number of days per month.

3. At places where effort is taken every day, lpue [2] is recorded either for all or for part of the landing vessels (see Table 1). At the other places, lpue is recorded for all vessels on the same days effort is recorded.
4. Effort is computed by month by landing place. An effort raising factor (ERF) is used in the case of places that are not covered every day.
5. Average lpue per month is computed both by landing site and by stratum.
6. The system produces two estimates of the landings by month by landing site, one by multiplying effort for the landing site by the average lpue for the landing site, and the other by multiplying effort for the landing site by the average lpue for the stratum.
7. Data on vessels landing at processing plants are reported by those plants.
8. All the above is done separately for each combination of gear and boat.
9. There are primary landings (fish landed for the first time), and secondary landings (fish has been already landed once, and then transported, either by road or by boat, to another landing place). Secondary landings are not included in the total landings. They are recorded by the system in order to keep track of the circulation of the products.

LANDING SITES

Table 1 shows the landing sites and strata included in the F.I.S., and the data collection strategy applied to each of them. The landing sites where the effort of all boats landing is recorded (either in days or trips) every day are noted "C" in column "strategy". Landing is recorded either for all vessels enumerated (places noted "C+"), or only for a sample of the vessels (places noted "C"). At sites noted "S", effort and corresponding catch are recorded during a number of days every month. Places where effort and landing data are supplied by processing plants are noted "A".

MAIN COMMERCIAL SPECIES

Although entries were provided for most species in the former data collection system, it is not possible to record accurate information separately on a large number of species. A selection of the main commercial species and groups of species has therefore been worked out, in such a way that all the data fall into one of the categories. Table 2 gives the list of these species/categories, and how they can be grouped into families and larger categories.

TYPES OF FISHING UNITS, CLASSIFICATION INTO FLEETS

The characteristics of the different types of fishing vessels and gears operated in Suriname are discussed in the national report to this workshop.

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[2] The notion "landing per unit of effort" (lpue) is used instead of "catch per unit of effort", as the system deals only with landings, not attempting to estimate discards or real catch.

Table 1: List of landing sites and strata included in the F.I.S.

LANDING SITE	TYPE	STRATEGY (1)	STRATUM	DISTRICT
001. Pomona	P	S	01. Pomona	COMMEWIJNE
002. Rust en Werk	P	S	02. Commewijne right bank	
003. Rust en Lust	P	S		
004. Nieuw Amsterdam	P	S	03. Commewijne left bank	
005. Marienburg	P	S		
006. Meerzorg	P	S		
007. Ellen	P	S		
008. Voorburg (Commewijne River)	P	S		
009. Voorburg (Suriname River)	P	S		
010. Alkmaar	P	S		
011. Zoelen	P	S		
012. Leliendal	P	S		
013. Matapica	P	S	04. Matapica	
014. Margrita	P	S	05. Commewijne lagoon	
015. Kronenburg	P	S		
016. Central Market Par'bo	P/S	C+	06. Central Market Paramaribo	PARAMARIBO
017. Platte Brug	P	C+	07. Paramaribo North	
018. Boomskreek	P	C		
019. Sluis 2	P	C		
020. Blauwgrond	P	C		
021. De Molen	P	C	08. Paramaribo South	
022. CEVIHAS	P	A		
023. Boxel	P	A		
024. DEBRACO pier	P	C		
052. AMKO landing	P			
025. Boskamp	P	S	09. Boskamp	SARAMACCA
026. Huwelijkszorg	P	S	10. Saramacca River	
027. Stoepeveer	P	S		
028. Calcutta	P	S		
029. La Providence	P	S		
030. Pralala	P	S		
031. Tijgerkreek	P	S		
032. Groningen	P	S		
033. Totness	P	S	11. Coronie canals	CORONIE
034. John	P	S		
035. Burnside 2	P	S		
036. Burnside 1	P	S		
037. Afdamming	P	S	12. Afdamming	
038. Central Market Nickerie	P/S	C+	13. Central Market Nickerie	NICKERIE
039. Zeedijk	P	C+	14. Zeedijk Nickerie	
040. Jamaer kanaal	P	C+	15. Jamaer kanaal	
041. SAIL	P	A	16. SAIL	PARAMARIBO (Processors)
042. SUJAFI	P	A	17. SUJAFI	
043. AMKO processing	P	C	18. AMKO processing	
044. Caribbean Seafood	P/S	A	19. Caribbean Seafood	
045. Murfisi	P/S	A	20. Murfisi	
046. R.O.M. Seafood	S	A	21. R.O.M. Seafood	
047. SURFISI	S	A	22. SURFISI	
048. SUNAFISH	S	A	23. SUNAFISH	
049. STIVI	S	A	24. STIVI	
050. SUCHIFI/SUFICO/TRIDENCO	S	A	25. SUCHIFI	

TYPE: P=Primary, S=Secondary. (1) see text.

Table 2: Species and categories recorded by the F.I.S.

CODE	COMMON NAME	SCIENTIFIC NAME	FAMILY		
ARCOF	KOEMAKOEMA	*ARIUS COUMA*	ARIIDAE	MARINE	FISHES
ARGRF	KODOKOE	*A. GRANDICASSIS/QUADRISCUTIS*			
ARPKF	JARABAKA	*ARIUS PARKERI*			
ARPRF	KOEPILA	*ARIUS PROOPS*			
ARPSF	PANI	*ARIUS PASSANY*			
BABAF	BARBAMAN	*BAGRE BAGRE / B. MARINUS*			
CUIDF	OTHER CATFISHES	ARIIDAE			
RAYSF	RAYS	ALL SPECIES	BATOIDEA		
CAHIF	ZEEZALM	*CARANX HIPPOS*	CARANGIDAE		
CESPF	SNOEK	*CENTROPOMUS SPP.*	CENTROPOMIDAE		
ELSAF	DAGOEFISIE	*ELOPS SAURUS*	ELOPIDAE		
LOSUF	PAOEMA	*LOBOTES SURINAMENSIS*	LOBOTIDAE		
LUPUF	RED SNAPPER	*LUTJANUS PURPUREUS*	LUTJANIDAE		
LUSYF	LANE SNAPPER	*LUTJANUS SYNAGRIS*			
RHAUF	VERMILLION SNAPPER	*RHOMBOPLITES AURORUBENS*			
SUIDF	SNAPPER UNIDENTIFIED	LUTJANIDAE			
MEATF	TRAPOEN	*MEGALOPS ATLANTICUS*	MEGALOPIDAE		
MUSPF	AARDER	*MUGIL SPP.*	MUGILIDAE		
RACAF	BATJAWVIS	*RACHYCENTRON CANADUS*	RACHYCENTRIDAE		
CYACF	BANG BANG	*CYNOSCION ACOUPA*	SCIAENIDAE		
CYSNF	BLAKATERE	*CYNOSCION STEIDACHNERI*			
CYVIF	KANDRATIKI	*CYNOSCION VIRESCENS*			
MAANF	DAGOETIFI	*MACRODON ANCYLODON*			
MIFUF	KROKUS	*MICROPOGON FURNIERI*			
NEBRF	BOTROFISIE	*NEBRIS MICROPS*			
SCJUF	WIT WITTIE	SCIAENIDAE JUVENILES			
WUIDF	OTHER CROAKERS	SCIAENIDAE UNIDENTIFIED			
SCSPF	MAKREEL	*SCOMBEROMORUS SPP.*	SCOMBRIDAE		
PRITF	GRAUMURG	*PROMICROPS ITAJARA*	SERRANIDAE		
SHARF	SHARKS	ALL SPECIES	SHARKOIDS		
MUIDF	MARINE FINFISH UNIDENTIFIED				
TRIEF	TRI (MISCELLANEOUS SMALL PELAGICS)				
CACAF	PLATTA HEDE KWI KWI	*CALLIICHTHYS CALLICTHYS*	CALLICHTHYDAE	FRESHWATER	
HOLIF	SOKE KWI KWI	*HOPLOSTERNUM LITTORALE*			
HOTHF	CATRINA KWI KWI	*HOLPOSTERNUM THORACATUM*			
CASPF	KWI KWI	CALLICTHYDAE UNIDENTIFIED			
ERERF	WARAPA	*ERYTHRINUS ERITHRINUS*	CHARACINIDAE		
HOMCF	ANJOEMARA	*HOPLIAS MACROPHTHALMUS*			
HOMLF	PATAKA	*HOPLIAS MALABARICUS*			
AEQUF	KROBIA	*AEQUIDENS SPP.*	CICHLIDAE		
ORMOF	TILAPIA	*OREOCHROMIS MOSSAMBICA*			
PLSUF	KOEBIE	*PLAGIOSCION SURINAMENSIS*	SCIAENIDAE		
FUIDF	FRESHWATER FINFISH UNIDENTIFIED				
PEBRF	HOPPER SHRIMP	*PENAEUS BRASILIENSIS*	PENAEIDAE	MARINE	SHRIMP
PENOF	PINK SHRIMP	*PENAEUS NOTIALIS*			
PESMF	WHITE SHRIMP	*PENAEUS SCHMITTI*			
PESUF	BROWN SHRIMP	*PENAEUS SUBTILIS*			
XYKRF	SEABOB	*XYPHOPENAEUS KROYERI*	PENAEIDAE	BRACKISH-WATER	
NASCF	WITI BERE	*NAEMOTOPALAEMON SCHMITTI*	PALAEMONIDAE		
GUIDF	SHRIMP UNIDENTIFIED				
CRABF	CRABS UNIDENTIFIED			CRABS	
MUIDS	SMOKED SCALEFISH UNIDENTIFIED		FISH PRODUCTS		
MUIDR	DRY-SMOKED SCALEFISH UNIDENTIFIED				
CUIDS	SMOKED CATFISH UNIDENTIFIED				
MUIDZ	SALTED FISH				
CUIDR	DRY-SMOKED CATFISH UNIDENTIFIED				
FISSR	SHARK FINS				
TRIED	TRI DRIED				
FISHD	FISH HEADS				
BLADS	FISH BLADDERS				
FSSPF	FISH SPAWN (KUIT)				
GUIDD	SHRIMPS DRIED				

RESULTS - ANNUAL ESTIMATES

Table 3 presents the estimated production for each fleet, and the total estimated landings, for 1991 and 1993. It appears clearly that most of the production is coming from the fisheries operating in coastal and estuarine waters (about 40% each), while the fisheries considered industrial (trawling) contribute around 20%. There were no data in 1991 on the snapper fishery, because there were no fishing licenses that year.

Table 3: Estimated production by fleet (tons) in 1991 and 1993.

FLEET	1991		1993	
	landing	%	landing	%
Deep sea fisheries	1,058	14	1,919	20
Finfish trawler	761	10	579	6
Shrimp trawler	297	4	857	9
Snapper liner			483	5
Coastal fisheries	3,292	43	3,858	40
Decked Guyana gillnet	1,585	21	1,793	18
Open Guyana gillnet	1,021	13	1,156	12
Open Guyana njawarie	665	9	649	7
Open Guyana longline	21		260	3
Estuarine fisheries	3,169	42	2,951	40
Medium and small Chinese seine	1,031	14	1,009	10
Large Chinese seine	747	10	732	7
Canoe gillnet	700	9	821	8
Canoe longline	117	2	152	2
Lagoon gillnet	574	7	237	2
Inland fisheries	86	1	1,132	11
River seine	67		11	
Other	19		1,121	11
Total	7,605		9,860	

Table 4 provides an overview of the estimated annual landings of each species and category recorded by the system. The largest part of the landings corresponds to a few species belonging to the two dominant families, the Sciaenidae (42-46%) and the Ariidae (29-35%).

The most important individual species are the bang bang (*Cynoscion acoupa*), kandra tiki (*Cynoscion virescens*), dagoe tifi (*Macrodon ancylodon*), all of the Sciaenidae, followed by several catfish species, such as jarabaka (*Arius parkeri*), koepila (*Arius proops*) and kodokoe (*A. grandicassis* and *A. quadriscutis*).

DISCUSSION - PROBLEMS

RELIABILITY

A review carried out in 1992 concluded that the sampling procedures had been applied satisfactorily, and that the estimates of annual average lpue by fleet were reliable. The accuracy of annual and monthly estimates can still be improved by:

- carrying out statistical analyses in order to optimize the sampling schemes (number of days of observation per landing place);
- enforcing the strict observance of the sampling schedules by the enumerators;
- improving supervision of the enumerators in the field and training them;
- carrying out analyses of variance on the monthly lpue estimates;

- analyzing the cycles (lunar, etc.) affecting particular fisheries and taking them into account when establishing the sampling schemes.

Table 4: Estimated landings per species in 1991 and 1993 (tons).

FAMILY/SPECIES	1991	1993
Sciaenidae	3,234	4,529
Bang bang	1,195	1,621
Blakatere	88	55
Kandratiki	891	1,426
Dagoetifi	431	1,050
Krokus	38	112
Botervis	467	252
Witwittie	112	5
Anderen	12	7
Ariidae	2,238	2,891
Jarabaka	385	455
Koemakoema	144	364
Kodokoe	439	401
Koepila	685	876
Barbaman	108	250
Pani	145	194
Others	332	350
Lutjanidae		615
Redsnapper		385
Vermillion snapper		183
Other snappers		47
Other marine Fish	1,288	1,216
Haai	102	173
Spari	18	43
Makreel	3	185
Grauwmurg	17	15
Trie	349	298
Snoek	216	39
Aarder	34	64
Koebi	99	27
Trapoen	75	126
Paoema	43	28
Others	332	217
Freshwater fishes	469	190
Kwie kwie	5	6
Patakka	34	7
Warapa	39	6
Krobia	20	9
Tilapia	216	156
Others	155	4
Crustaceas	639	420
Sea bob	394	274
White belly	204	133
Mixed shrimps	40	8
Crabs	1	4

The main problem was, and still is, the coverage, as it seems that a significant part of landings by the fleets with an important operating range (coastal fishing) are probably missed by the F.I.S. Based on the list of licensed boats, an investigation should be carried out in order to identify unsurveyed landing places and quantify the unrecorded landings. The activities of unlicensed fishing boats need to be investigated as well.

UPDATING THE SYSTEM

The fisheries sector is still developing in Suriname. New enterprises are created and may use landing sites not previously included in the system. There are also landing places which become less active. On the other hand, the manpower available to the Fisheries Department to perform enumeration tasks, data input, etc., also appears to be changeable. It is therefore necessary to periodically revise and update the system, particularly the list of landing places and the methodology applied to each of them.

CURRENT PROBLEMS

The technical problems currently faced by the F.I.S. have been identified during the workshop of December 1992: vessels landing at unrecorded places, faults by enumerators (absence from the site, improper/incomplete recording), incomplete reporting by industries ("A" sites), split landings (boat delivering at several places, resulting in effort recorded several times), enumerators disregarding the sampling schedule, thereby introducing bias in some estimates (Charlier 1993).

The most important problem since the establishment of the system has been the lack of qualified manpower to operate it properly. The system used to be run by the minimum staff, which meant that its operation suffered slowdowns as soon as one of the persons was temporarily unavailable. This problem has become most acute recently, when the coordinator of the data processing resigned the position before a suitable substitute could be identified and properly trained.

CONCLUSIONS

The Fisheries Information System (FIS) developed for Suriname by the FAO/UNDP Project SUR/87/001, is an essential tool for the development and management of the fisheries of Suriname. Its current level of functioning should be seen as one of the principal ongoing activities of the Fisheries Department. If possible it should be developed in order to include all segments of the fisheries in Suriname.

The reliability of the results produced by the F.I.S. varies very much from one fishery to the other. In general, F.I.S. catch and effort estimates cannot be used for stock assessment purposes. The results should be corrected to account for coverage errors. However, the lpue estimates given by the F.I.S. for each of the main fleets represent an interesting index to be used in stock assessment and management.

Shortcomings of the system have been identified and should be corrected as soon as possible. Several improvements have been suggested, particularly the verification and updating of the list of landing places, especially for the coastal fishery, and the careful supervision of the activities of the field enumerators. It is very important to keep the F.I.S. flexible and able to adapt quickly to a changing situation of the fisheries sector. Assessments of the system should be carried out regularly, in order to eventually amend the methodologies applied (sampling schemes).

Recent experience has shown that the system is very much dependent on the performance and availability of a few key staff. It is necessary to maintain continuing training (on the job) scheme, in order to have several persons with the ability to take over the key tasks/positions.

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Las Pesquerias de Camaron de la Plataforma Cubana

J. Paez Costa[1], L. Font Chavez[1], M. Sosa Blanco[1], M. Morenza Fernandez[1]

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INTRODUCCIÓN

Auspiciado por la FAO y Cuba se desarrolló del 18 al 29 de septiembre de 1995 el Taller sobre la aplicación de Modelos Bioeconómicos a la pesqueria de camarones, langosta y peces tropicales. En particular el empleo del Modelo Bioeconómico Analitico BEAM4 (Sparre y Willmann, 1992) a las pesquerias de camarón en Cuba.

Motivado por el interés de la FAO y Cuba de ampliar el intercambio de conocimientos en la región se consideró oportuno aprovechar la realización del IV Taller de la COPACO y el Grupo de Trabajo Adjunto de camarones y peces demersales de la plataforma Brasil-Guyana y el Taller sobre el Subproyecto de Camarones y Peces Demersales de CFRAMP para trasladar a esta reunión una visión general de las pesquerias de camarón en Cuba y las primeras aplicaciones del BEAM4 a la misma. La amplia experiencia de los cientificos sobre el manejo de los recursos de la plataforma Brasil-Guyana, resulta a su vez de mucho interés a los especialistas en Cuba. Para la realización de este objetivo se desarrolló una acción dentro del marco de los Programa de Cooperación Técnica entre paises en Desarrollo de la FAO.

La aplicación del BEAM4 a las pesquerias cubanas en la región de Manzanillo, se basa en el ejercicio desarrollado durante el Taller de Modelos Bioeconómicos en Cuba. La lista de participantes al mencionado Taller se presentan en el Anexo 1.

BREVE DESCRIPCION DE ALGUNOS ASPECTOS DE LA BIOLOGIA DE LOS CAMARONES CUBANOS

BIOLOGÍA Y CICLO DE VIDA

Especies y regiones principales

En Cuba existen dos especies que sustentan las pesquerias comerciales de camarón; ellas son *Penaeus notialis* (Pérez-Farfante, 1967) y *Penaeus schmitti* (Burkenroad, 1936), aunque han sido identificadas otras siete especies de los géneros *Penaeus, Trachypenaeus, Xiphopenaeus y Sicyonia* en diferentes zonas costeras, bahias y ensenadas. Además se han identificado los géneros *Aristeus, Pleoticus, Parapenaeus, Plesionika* y *Penaeopsis* encontrados en arrastres en aguas profundas (150-350 m).

La especie principal y de más amplia distribución espacial es *P. notialis* (camarón acaramelado o rosado) que representa alrededor del 96 % de las capturas. *P. schmitti* (camarón blanco) más asociado a la presencia de agua dulce, se encuentra principalmente en ambos extremos de la región suroriental, en los sistemas lagunares y cauces fluviales de los rios más importantes, tales como los del Cauto y Zaza, aunque sólo el primero sostiene actualmente una pesqueria comercial de este crustáceo. Esta especie también aparece en las capturas de la Ensenada de la Broa y la Bahia de Cienfuegos.

En el último decenio las pesquerias de camarón representaron el 5 % de las capturas totales de la plataforma cubana y el 20 % de las exportaciones del sector.

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[1] Centro de Investigaciones Pesqueras, Ministerio de la Industria Pesquera, Cuba.

Esta pesqueria se desarrolla básicamente en la región suroriental de la plataforma cubana en las que se destacan dos Golfos, los de Ana Maria y Guacanayabo (Fig. 1).

El arribo de particulas organógenas y minerales en suspensión, acarreadas por los rios, provoca la acumulación de fangos. En las depresiones centrales de estos Golfos se encuentran fangos arcillosos y emergiendo bancos rocosos con algunos corales y sedimento areno-fangosos (Revilla y Rodriguez en prensa a y b). La caracteristica general de ambos Golfos es el predominio de fangos de origen terrestre, representativos de lo que Baisre (1985) clasificó como complejo ecológico litoral-estuarino, el cual ocupa el 63 % del área total (Revilla y Páez, 1990).

En su conjunto la región suroriental abarca unos 18 702 km^2 de los cuales cerca de la tercera parte son fondos de pesca del camarón. Los numerosos cayos que matizan su relieve le dan protección general y sirven de refugio y zona de alimentación a post-larvales y juveniles de camarones, complemento de las zonas principales de cria que se encuentran a través de la linea costera de los dos golfos ya mencionados.

El Golfo de Ana Maria (9398 km^2) al Oeste constituye una cuenca bien definida. Sus fondos están cubiertos principalmente por sedimento arcillosos, areno aluviales y aluvio marinos (Pavlidis y Avello, 1975; Baisre y Páez, 1981). En su borde externo el Archipiélago de los Jardines (Jardinillos) de la Reina limita el intercambio con el Mar Caribe adyacente. Su profundidad media es de 15 m aunque pueden encontrarse valores cercanos a los 30 m.

El Golfo de Guacanayabo (9304 km^2) al Este, separado del anterior por los Cayos Pingüe, se encuentra en la depresión del rio Cauto (Pavlidis y Avello, 1975) y está dividido en dos regiones por el Gran Banco de Buena Esperanza. Presenta un mayor intercambio con el Mar Caribe que el de Ana Maria, ya que en su borde externo los pocos arrecifes coralinos y bancos que posee no afloran a la superficie. Su talud es de pendiente más suave y su profundidad media ligeramente menor que en Ana Maria. La profundidad máxima alcanza los 30 m.

Una descripción detallada de los tipos de fondos de ambos Golfos, asi como la relación de éstos con la distribución de las especies comerciales que los habitan han sido expuesta por Revilla y Rodriguez (en prensa a y b y Revilla y Páez 1990), respectivamente.

Las caracteristicas ecológicas generales de esta región fueron presentadas por Baisre (1985 e inédito) mientras que Emilsson y Tápanes (1971) y Lluis (1977) resumieron aspectos sobre el régimen hidrológico de la región.

Desove, áreas de cría y reclutamiento

Similar a otros congéneres, el desove se produce durante todos los meses, aunque presenta dos periodos de máxima actividad, uno principal (primavera) y otro secundario (otoño). La talla de primera reproducción varia de acuerdo a la región (Guitart *et al.*, 1982 y Guitart inédito) y oscila entre 8.5 cm y 10.0 cm para *P. notialis* y 8.7 cm y 10.4 cm en *P. schmitti*.

Las zonas de cria de post-larvas y juveniles se encuentran en áreas bajas costeras y se caracterizan por presentar fondos fangosos o fango arenosos. *P. notialis* se encuentra asociado a *Halodule wrightii* (Puga *et al.*, 1982; Guitart *et al.*, inédito a; Alfonso y González, inédito y Páez, en prensa a) aunque también con *Syringodium filiforme* Guitart, *et al.*, inédito b), mientras que *P. schmitti* se distribuye principalmente en el interior de las lagunas costeras o en la linea de costa con fondos blandos sin vegetación, frecuentemente asociados a los brotes de mangle (González, *et al.*, inédito; Guitart, *et al*, inédito a,).

De ello se establece que para la pesqueria cubana, el biotopo conformado por *Halodule wrightii* juega un rol de trascendental importancia para las poblaciones camaroneras. Páez, *et al.* (en prensa) ha evidenciado su función como zona de refugio y alimentación, por lo que su deterioro o reducción puede influir notablemente en la disminución de la biomasa poblacional.

En la Figs 2 y 3 se presentan las principales áreas de desove y cria, así como las rutas de migración más importantes. Estudios recientes, empleando técnicas de identidad genética como la electroforesis de proteinas (Espinosa y Páez, en proceso) y más reciente la del DNA mitocondrial, se desarrollan para delimitar lo más posible las unidades poblacionales y las relaciones interzonales.

Aunque existe reclutamiento durante todos los meses, en un esquema general se observan dos periodos fundamentales en el año, el más importante comenzando regularmente desde finales del verano hasta finales del otoño, y un segundo normalmente más pequeño, se presenta hacia principio del año siguiente. Los meses de mayor intensidad varian de acuerdo con las condiciones de cada año, incluso, aunque poco frecuente, el segundo periodo de reclutamiento puede resultar de mayor magnitud que el primero. Las causas que motivan esto último aún no están bien determinadas, pero seguramente las poco marcadas diferencias entre las épocas del año en los paises de clima como el de Cuba (tropical con verano relativamente húmedo) conjuntamente con otros factores ambientales favorables como alimentación, corrientes para la deriva larvaria, acondicionamiento de las zonas de cria, etc., influyen en el éxito de estos grupos de reclutas.

Alimentación

Un conjunto de estudios sobre los hábitos alimentarios desde post-larvas hasta adultos en el medio natural de *P. notialis* y *P. schmitti* han sido ejecutados (Anderes, 1982; 1983 a y b ; 1986 e inédito). De ellos puede resumirse que son epibentófagos omnivoros oportunistas, con una dieta basada en zooalimentadores (principalmente copépodos harpacticoides), microalgas y detritus. Las tallas más pequeñas estudiadas (6-9 mm de largo total) consumen las primeras fases de estos copépodos y a partir de los 19 mm van incrementando el porciento de adultos, así como la variedad de los crustáceos. *P. notialis* reduce las microalgas de un 22 % a un 5 %, y resulta más carnivoro que *P. schmitti*.

Los estudios sobre demanda alimentaria y velocidad de digestión en *P. notialis* en el Golfo de Ana Maria indicaron que en las zonas de cria, más del 70 % de los juveniles se encontraban comiendo las 24 horas del dia, aunque la mayor frecuencia de estómagos llenos era a las 11:00 h y a las 23:00 h . En la zona de adultos la actividad alimentaria era nocturna con un máximo a las 22:00 h.

RELACIÓN CON LOS FACTORES AMBIENTALES

El desarrollo de las diferentes fases del ciclo de vida de las especies depende de diversos factores ambientales (Odum, 1966) y del efecto antropogénico sobre el medio.

La lluvia, el acarreo de nutrientes, la temperatura, la salinidad, la alimentación, la vegetación, las corrientes y la pesca son algunos de los factores que influyen sobre el desarrollo del ciclo de vida de estas especies, que han motivado y motivan a numerosos investigadores a relacionarlos con las variaciones de la densidad y la conducta general de estos crustáceos en alguna de las fases de su ciclo de vida. Muchas veces con la intención final de explicar los sucesos de la pesquerias e incluso pronosticarlos.

Garcia y Le Restre (1986) y Sparre *et al.*, (1989) han señalado las dificultades en el establecimiento de estas relaciones y en general cuando se modelan no pueden extrapolarse fuera de la región y periodo objeto de estudio. Garcia y Le Restre (1986) hacen un análisis detallado de estos aspectos para los camarones peneidos.

Los estudios en Cuba tampoco han podido sustraerse de tales intentos y en general han presentado similares limitaciones. No obstante, el factor de carácter global más importante en el caso de Cuba resulta la disminución de las descargas fluviales producto del represamiento de los ríos y la sequía.

Por una parte la tendencia al incremento de los años secos en las cuencas que drenan hacia las áreas camaroneras (Fig. 4) y el incremento del agua embalsada (Fig. 5) se consideran las causas fundamentales de la disminución de las capturas comerciales de la plataforma cubana (Fig. 6).

Se estima en unos 3000 a 4000 millones de m^3 la disminución del agua dulce que llega a la plataforma con la consecuente disminución de nutrientes, afectando los sistemas lagunares y costeros. Revilla, *et al.*, (1990) demostró empleando sensores remotos la pérdida de unos 98 Km^2 de espejo de agua de las lagunas costeras en el sistema asociado al rio Cauto, probando el incremento de la salinidad, de la evaporación, la disminución de la profundidad, la elevación de la temperatura, la pérdida de manglares y otros efectos cuyos factores limitantes se potencian unos con otros. Efectos similares han ocurrido en todos los sistemas lagunares camaroneros de Cuba.

FAUNA ACOMPAÑANTE

La fauna de acompañamiento de la pesqueria camaronera, constituye una importante fuente de alimentación tanto humana como animal.

Composición de la fauna

Mesloub (inédito) partiendo del análisis de la fauna presente en los cruceros de prospección realizados entre 1982 y 1987 , reporta la presencia de 87 especies, 66 géneros y 46 familias en la zona suroriental, donde predominan los peces con el 57 % y 77 %, según los estudios realizados por Puga *et al.*, (1982 b) y Claro (inédito) respectivamente, en los cuales no se observó diferencia en dicha composición entre los dos golfos que conforman esa región (Ana Maria y Guacanayabo).

En el presente, 22 especies pertenecientes a 16 familias de peces, crustáceos y moluscos son seleccionadas para el consumo humano, con predominio de los primeros, que alcanzan valores cercanos al 78 % del total dedicado a este fin. Las especies de mayor incidencia son: clarín ***(Lephophidium graëllsi)***, biajaiba (***Lutjanus synagris***), verrugato (***Micropogonias furnieri***) y a partir de 1988 el serrano (***Diplectrum formosum***), así como el grupo de los elasmobranquios (tiburones, chuchos, rayas y levisas). Por otra parte las jaibas ***(Callinectes*** y ***Portunus***), las esquilas (***Squilla*** spp.) y la langosta (***Panulirus argus***) entre los crustáceos, aportan cerca de un 20 % del total, y finalmente los moluscos, representados por el calamar (***Loligo pealei***) y los bivalvos ***(Amusium laurenti*** y ***Laevicardium laevigatum***) conforman el 2 % restante.

Desembarques

Los desembarques para el período 1984-89 se mantuvieron con ritmo ascendente hasta alcanzar las 25 500 toneladas, con un valor promedio de 24 300 toneladas, destinándose para consumo animal el 88 % y el resto para consumo humano, lo que representa unas 2 600 toneladas. La veda de tres meses aplicada a la pesquería de camarón a partir de 1990 produjo una caída en la captura de la fauna acompañante, ya que trajo por consecuencia la reducción de cerca del 36 % del esfuerzo aplicado, a lo cual debe agregarse que el período en que se aplica la misma se corresponde con los meses en que se producen incrementos en la densidad de algunas especies, posiblemente debido a sus períodos reproductivos y de reclutamiento.

El análisis de series cronológicas mostró estacionalidad en dichos meses. Como consecuencia de lo anterior durante los años 1990-92 sólo se alcanzaron como promedio unas 17 100 toneladas por año, no obstante a pesar de ello se logra mantener la cifra de desembarques con destino al consumo humano producto del mejor aprovechamiento de las especies que componen la fauna.

Fluctuaciones del rendimiento

Dado que la pesca de la fauna no siempre fue totalmente aprovechada, Puga *et al.*, (en prensa e inédito) habian señalado que la cpue no resultaba un buen indicador de la abundancia. Mesloub (inédito) consideró que la magnitud de los desembarques dependen de factores de indole técnica y socioeconómica.

No obstante lo anterior, el análisis de este coeficiente indica que mientras en 1984 se obtenian 742,6 kg/dp, en 1992 se alcanzan los 1067 (con un máximo de 1202 kg/dia pesca en 1989) para la fauna de acompañamiento en su conjunto, debido en lo fundamental al incremento en el aprovechamiento de casi toda la fauna capturada en la operación extractiva, excepto en la Empresa Pesquera Industrial de Cienfuegos donde existe la tendencia a devolver al mar uno de los cuatro lances que se realizan diariamente por cada embarcación.

En cuanto al consumo humano la incorporación de nuevas especies a este destino, tales como el serrano (*D. formosum*), y el patao o la mojarra (Gerreidae) con importantes aportes del orden de las 118,4 y 583,6 toneladas anuales como promedio respectivamente, trajo por consecuencia que de valores de 109 kg/dp hasta 1988 se alcancen los 166,3 kg/dp en los últimos años.

Aprovechamiento de la fauna de acompañamiento

A finales de la década del 70 se comienza el aprovechamiento de la fauna de acompañamiento con fines de alimentación animal, mediante la producción de hidrolizados y harinas de pescado, situación ésta que se mantiene hasta 1981, comenzándose a partir de entonces la selección de algunas especies con fines de alimentación humana, las cuales se fueron incrementando desde el 7,8 % del total en 1983 (Puga *et al.*, inédito) hasta un 15,2 % en 1993 .

Estas especies son consumidas por la población frescas, congeladas o procesadas en forma de ahumados, picadillos en bloques o conformados y diversos enlatados.

PRINCIPALES VÌAS DE MEJORAMIENTO EMPRENDIDAS SOBRE LOS RECURSOS CAMARONEROS

Existen diversas acciones destinadas a alcanzar el aprovechamiento biológico y económico del recurso. Las principales acciones emprendidas en Cuba se sintetizan en:

Ordenamiento de las pesquerias,

Repoblación de áreas camaroneras,

Mejoramiento de áreas de cria.

Cada uno de estos aspectos son tratados en sintesis en el presente trabajo.

ORGANIZACION DEL SISTEMA PESQUERO

GENERALIDADES

Existen tres Empresas extractivas que operan en la región, para las cuales existen sus respectivas zonas de pesca.

En la Fig. 1 se ilustra las principales áreas camaroneras de Cuba y el sistema de ubicación por cuadrículas de 5 mn^2, desde la cual se establece el sistema básico de organización de la operación de las flotas y la información estadistica.

En la Fig. 6 se presenta la evolución de la captura, el esfuerzo y la captura por unidad de esfuerzo de los últimos 25 años. En ello se asocian la sobre-explotación del recurso (Baisre y Zamora, 1983; Pérez *et al.*, 1984) y de la disminución paulatina de la capacidad de carga del ecosistema, motivado por la afectación acumulativa de las zonas costeras, áreas de cria de camarones y otras especies.

Diversas medidas de regulación pesquera se han aplicado. Entre las principales están las siguientes:

- Prohibición de pesca en la franja costera hasta 1 o 2 millas.
- Prohibición de la pesca en las cuadriculas con un 20 % o 25% de ***trilla***[2] según la zona.
- Regulación del nivel de esfuerzo anual.
- Tamaño y caracteristicas de los chinchorros.
- Regiones de pesca por Empresa.

COLECTA DE DATOS

Se dispone de tres fuentes básicas de información de la pesca industrial:

- Estadisticas comerciales de captura (kg), esfuerzo (dias pesca) y captura por unidad de esfuerzo (kg/dp) por barco y cuadricula de la pesca diaria.
- Estructura de la población a través de los grupos de talla del procesamiento industrial por Empresas y Establecimientos.
- Muestreos mensuales en barcos de prospección de la captura (kg), esfuerzo (horas) y de la cpue (kg/h), composición por talla (clases de 0.5 cm), sexo y estadio de madurez gonadal.

Sin embargo, en las zonas lagunares y costeras se desarrolla una pesca artesanal la cual se ha ido incrementando, pero dado su carácter no legal hasta el pasado año, no se dispone de estadistica alguna.

ADMINISTRACIÓN PESQUERA

Basándose en las estadisticas referidas anteriormente, diferentes evaluaciones y análisis biológico-pesqueros ha realizado el Centro de Investigaciones Pesqueras. Las recomendaciones al Ministerio de la Industria Pesquera y a las Empresas extractivas sobre la administración de la pesca se efectúan sistemáticamente.

A partir de septiembre de 1995 se comenzó la aplicación del BEAM4, complementando los análisis bioeconómicos de esta pesqueria.

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[2] trilla: se refiere a los camarones que por su tamaño pequeño, estado de muda o daños mecánicos tiene poco valor comercial y conforman un grupo independiente.

APLICACION DEL BEAM4 EN UNA PESQUERIA DE CAMARON AL ESTE DEL GOLFO DE GUACANAYABO (MANZANILLO)

METODOLOGÍA BIOECONÓMICA

Una descripción detallada se encuentra en los Manuales elaborados por Sparre y Willmann (1992), asi como en el Reporte de FAO al Taller de bioeconomia de pesquerias demersales del Norte de la India (1993) (guia del presente análisis) y en Willmann y Garcia (1986).

Este Programa posibilita evaluar y predecir los resultados bioeconómicos de la aplicación (simulación) de diferentes variantes de ordenamiento pesquero (vedas, esfuerzo, selectividad, etc).

Permite integrar los resultados de pesquerias secuenciales, asi como considerar varias especies, varias flotas y plantas procesadoras y considera la migración de los individuos y la estacionalidad, tanto del reclutamiento como de la mortalidad por pesca y natural. Basado en los conceptos de Análisis de Cohortes trabaja por grupo de edades o categorias comerciales.

Está compuesto por dos submodelos; el biológico/tecnológico y el económico, aunque el primero puede correr independientemente del segundo, no asi el económico ya que para algunos datos toma en cuenta los resultados del primer submodelo.

El Modelo biológico/tecnológico contiene la dinámica del recurso, tales como su rendimiento en número y en peso y la mortalidad debida a causas naturales y a la pesca. También permite describir el movimiento de los camarones entre zonas.

Contiene además algunos elementos de naturaleza económica, como el valor de la captura para la fase extractiva, la distribución industrial y los mercados finales.

El modelo económico introduce un detallado análisis de las partidas de gastos de la actividad extractiva y del procesamiento en las plantas, costos fijos y variables y otros elementos económicos.

BEAM4 puede predecir las utilidades del sector privado, renta del recurso, el valor agregado, el ingreso neto en divisas y otros.

El carácter predictivo del BEAM4 está desarrollado sobre la base del Modelo descrito por Thompson y Bell (1934).

Consta de tres pasos generales; el primero referido a la introducción de datos básicos, tanto biológicos como económicos, el segundo relativo a la sintonización del modelo, de tal forma que la modelación reproduzca lo mejor posible las capturas del año de análisis y el tercer paso, consistente en la simulación de diferentes alternativas dentro de los diferentes escenarios que pueden presentarse o ser considerados por los investigadores y por los que tienen que tomar las decisiones productivas.

Variaciones en la extensión y estacionalidad de la veda, incremento o disminución del esfuerzo pesquero, cambios sobre la talla de primera captura, implicaciones sobre las relaciones entre pesquerias secuenciales, etc., son algunas de la interrogantes sobre las que BEAM4 puede contribuir a responder.

BEAM4 ofrece tablas y gráficos de salida que ilustran las predicciones ante diferentes tácticas y estrategias de pesca que ayudan a las recomendaciones de los cientificos y a la toma de decisiones por los productores. En el caso de este análisis todos los valores están expresados en pesos cubanos.

La formación de un ***equipo de biólogos y economistas*** es muy necesario para el aprovechamiento más eficiente de BEAM4.

ENTRADA DE DATOS (PESQUERÍAS DE MANZANILLO)

Parámetros Biológico/Tecnológicos

Especies o grupos sujeto a estudio

Existen dos especies en la región, *P. notialis* y *P. schmitti*. Esta última de hábitos diurnos y dependiente fuertemente de los sistemas fluviales, se encuentra distribuida en un área relativamente pequeña. Debido precisamente a su fuerte dependencia con los sistemas fluviales ha disminuido en 10 veces su biomasa y está sometida a regulaciones que limitan su captura comercial de día, aunque se efectúa una pesca para la captura de progenitores hacia los bancos reproductores de la camaronicultura, lo que disminuye la efectividad de las regulaciones anteriores.

La pesca es dirigida a *P. notialis* (90 % de las capturas) de hábitos nocturnos y ampliamente distribuida en la región, debido a todo ello no resulta posible diferenciar el esfuerzo pesquero entre ambas especies, por lo que a los efectos del presente análisis fue considerada una sola población. Evaluaciones ulteriores deberán tomar en cuenta estas circunstancias, así como evaluar el efecto de tratar a los sexos por separado. Un estudio de identidad genética (electroforesis de proteínas y DNA mitocondrial) se desarrolla para precisar las unidades poblacionales potenciales.

Debido al gran número de especies que conforman la fauna de acompañamiento, se crearon grupos teniendo en cuenta especies predominantes. El resto se distribuyó en relación a la mayor semejanza con las primeras.

Grupo A: Casabe (*Chloroscombrus chrysurus*), sardinas (Engraulidae y Clupeidae), otros carangidos (*Caranx* spp., *Oligoplites sp, etc*) y otros peces pequeños (*Sphoeroides* sp., *Achiros* sp., etc.)

Grupo B: Mojarras (Gerridae), corvinas (*Micropogonias* sp. , *Odontoscion* sp.) y otros (Chaetodontidae).

Grupo C: Clarín (*Lepophidium graëllsi*), roncos (*Haemulon* spp. , *Pomadasys* spp.), biajaiba (*Lutjanus synagris*) y otros (Lutjanidae, Priacanthidae, Grammistidae).

Grupo D: Rayas (Dasyatidae), chuchos (Miliobatidae), y tiburones (Orectolobidae, Sphyrnidae, Carcharhinidae).

Grupo E: Jaibas (*Callinectes* spp., Portunidae), esquilas (*Squilla* spp.) y otros crustáceos.

Los principales parámetros biológicos se ofrecen en la Tabla 1.

Tabla 1: Parámetros biológicos empleados por grupo de especies.

ESPECIE GRUPO	TIEMPO DE VIDA (años)	PERÍODO DE TIEMPO (mes)	PARÁMETROS CRECIMIENTO		PARÁMETROS LARGO/PESO		M NATURAL (año)
			L_∞	K (año)	a	b	
Penaeus	1	1	17.5	3.0	0.01050	3.1516	4.8
A	*	3	14.0	0.22	0.01680	2.0050	0.32
B	*	3	27.0	0.28	0.01800	2.9200	0.39
C	*	3	29.0	0.40	0.01200	2.8540	0.48
D	*	3	100.0	0.07	0.000074	2.8056	0.21
E	*	3	14.2	1.20	0.000305	2.8200	2.40

* No se consideró debido a la variación en la edad máxima dentro de cada grupo.

Flota de Pesca

La pesca oficial se desarrolla en barcos arrastreros, sus características esenciales para el área de Manzanillo son descritas en la Tabla 2.

Tabla 2: Característica de la flota camaronera en el área de Manzanillo.

TIPO DE EMBARCACIÓN	ESLORA (metros)	TIPO DE MOTOR	CABALLOS DE FUERZA
Ferrocemento IV	18.25	Volvo Penta	350

Un solo tipo de arte de pesca (chinchorro doble por cada banda) y la característica de un solo tipo de embarcación hace innecesario la estandarización del esfuerzo.

La pesca artesanal de camarón en la región , es una pesca no autorizada, de relativamente poca trascendencia, aunque existe una tendencia a la intensificación en los últimos años. En esta pesca se utilizan diferentes artes aunque no muy diversos, que van desde la atarraya, hasta pequeñas redes quc arrastran por la orilla los propios pescadores.

No se dispone de datos sobre la captura y el esfuerzo de esta pesquería, no obstante se estiman algunos valores y se simula el efecto que traería para la economía en general la intensificación de la misma, con el interés de evaluar su estimulación o no. De hecho este se convierte en el primer intento en Cuba de considerar este tipo de pesca en las evaluaciones de los recurso camaroneros.

La fauna de acompañamiento producto de esta pesca es también de poco volumen, debido al tipo de arte y lugar de captura y está representada por ejemplares de pequeña talla. Las familias más comunes a la que pertenecen son Gerridae, Mullidae, Carangidae, Albulidae, Engraulidae y juveniles dc Lutjanidae.

Sin embargo, resulta necesario obtener datos más exactos, por lo que un sistema de muestreo y recolección de estadísticas pesqueras debe ser desarrollado.

Areas consideradas

Fueron consideradas dos áreas:

- 0 a 5 metros: para la pesca artesanal, aunque esta se realiza en las lagunas y la linea de costa sobrepasando rara vez los dos metros.
- 5 a 25 metros: para la pesca industrial, debido a que estos barcos no pueden arrastrar a profundidades menores de 5 m y la plataforma cubana rara vez sobrepasa los 25 m . Tal como fue expresado en el epígrafe introductorio, la macrolaguna donde se desarrolla la pesca del camarón presenta hacia su borde exterior (Mar Caribe) un cambio en el tipo de fondo, de fangoso y fango arenoso a arenoso, tipico de especies como la langosta y de otros organismos asociadas a los arrecifes de coral. La pesca de camarón se desarrolla fundamentalmente entre los 8 y 20 m.

Plantas Procesadoras

Dado las caracteristicas de la pesca artesanal no se tuvo en cuenta su destino hacia alguna planta de proceso. Para la pesca industrial de camarón y la fauna de acompañamiento se consideraron dos plantas independientes. El descarte es despreciable y eventual, por lo que fue considerada nulo su existencia.

Capturas

Las capturas de camarón y de la fauna acompañante se presentan en la Tabla 3.

Tabla 3: Capturas por especies o grupo de especies para cada flota en la región de Manzanillo durante 1994.

ESPECIES	ARTESANAL*	INDUSTRIAL	TOTAL
camarón	3.3	523.6	529.9
A	5.8	1562.1	1567.9
B	14.2	1944.6	1858.8
C	10.5	100.0	1105.0
D	0.0	200.2	200.2
E	0.5	122.2	122.7
*estimados			

Tabla 4: Desembarques (toneladas) y esfuerzo (días pesca) de camarones mensuales en Manzanillo durante 1994.

	E	F	M	A	M	J	J	A	S	O	N	D
Industrial												
C	48.7	54.9	56.1	50.6	54.2	59.4	15.8	8.6	-	79.6	52.0	43.7
f	464	466	489	423	433	513	126	72	-	590	527	466
Artesanal												
C	0.2	0.1	0.3	0.4	0.5	0.3	0.3	0.3	0.3	0.2	0.2	0.2
f	0.5	1.0	1.0	2.0	2.0	2.0	0.5	0.5	0.5	0.5	0.5	1.0

Tabla 5: Desembarque de fauna por trimestre.

	I	II	III	IV	TOTAL
A	424.9	567.0	129.7	440.5	1562.1
B	510.3	653.4	166.2	614.7	1944.6
C	56.8	21.7	2.3	19.2	100.0
D	30.0	76.8	14.4	79.0	200.2
E	28.2	5.6	1.3	87.1	122.2

Datos de Exportación de camarones

El destino final de la captura de camarón es su venta en divisas. El precio por categoria comercial se presenta en la Tabla 6.

Tabla 6: Estructura de precio por categoria comercial de camarón.

CATEGORÍAS COMERCIALES	COMPOSICIÓN %	PRECIO RELATIVO %
<13	-	100
13/22	1.3	88
22/28	5.0	71
28/34	6.6	61
34/43	12.9	55
43/52	8.3	47
52/58	8.2	41
58/80	11.5	38
80/100	11.2	32
100/120	35.0	28
>120 *	-	24

Le fue agregada la categoria mayores de 120 para considerar la captura producto de la pesca artesanal.

Tabla 7: Precio de venta máximo de camarón.

TIPO DE PESQUERÍA	PRECIO DE DESEMBARQUE	PRECIO PRODUCTO TERMINADO
Artesanal	4350	4350
Industrial	11000	13630

SINTONIZACIÓN DEL SUBMODELO BIOLÓGICO

A partir de estimados mensuales del reclutamiento y del coeficiente de capturabilidad, obtenidos previamente por diferentes métodos (tales como el APV) se evalúa mediante un proceso iterativo las variaciones que proporcionan un mejor ajuste entre los valores observados y estimados. Diferentes cambios en los parámetros de entrada pueden efectuarse para buscar este objetivo. BEAM4 facilita la evaluación al suministrar automáticamente, después de cada variante, la opción de evaluar gráficamente la sintonización.

No debe ejecutarse el submodelo económico, si no se ha logrado antes un ajuste, al menos aceptable.

DATOS ECONÓMICOS DE ENTRADA

Están compuesto de tres aspectos básicos; los costos extractivos, los de procesamiento industrial y los que ocasionan las propias ventas.

Costos extractivos

La información estadística de la pesqueria industrial se obtuvo a partir de los libros de registros oficiales de la Empresa de Manzanillo durante 1994, no asi la de la pesca artesanal, para lo cual fueron estimados todos los valores sobre la base del conocimiento empirico de la forma y sistema en que se desarrolla esta actividad.

Tres categorías de costos extractivos son considerados en BEAM4:

a) costos dependientes del esfuerzo de pesca.

b) costo dependientes del número de embarcaciones.

c) costos dependientes del valor de las capturas.

Todos los costos empleados en BEAM4 se refieren al promedio anual por los costos fijos y al promedio de los costos de operación por viaje, dias mar o dias pesca de cada flota.

En las Tablas 8 al 13 se presentan una selección de las principales partidas de gastos de la actividad extractiva.

Tabla 8: Sector Extractivo. Costo Variable Por Unidad de Esfuerzo Dependiente del Numero de Unidades de Esfuerzo.

	ARTESANAL		INDUSTRIAL	
	Total	Divisas	Total	Divisas
Comb. y lubr.	0	0	109.8	109.8
Alimento	5	2.5	5.8	5.3
Hielo	0	0	5.4	4.1
Repar. y Mntto.	1	1	48.2	43.3
Licencias Puerto	0	0	0.0	0.0
Salario tripulac	0	0	6.1	1.8

Tabla 9: Sector Extractivo. Costo Fijo Por Embarcación Costo Dependiente Del Numero De Botes.

	ARTESANAL		INDUSTRIAL	
	Total	Divisas	Total	Divisas
Deprec. Casco	0	0	10600	9540
Deprec. Máquina	0	0	2667	2667
Deprec. Arte	25.0	25.0	0	0
Interés del Capt.	0	0	0	0
Seguros	0	0	0	0
Salario Administr.	0	0	793.6	0
Otros	0	0	0	0
Licencia de pesca	0	0	0	0

Tabla 10: Sector extractivo. Empleos por unidad de esfuerzo.

	ARTESANAL	INDUSTRIAL
No. tripulantes/barco	1	4
Personal tierra/día pesca	0	0.58
Tripulación/día año	264.0	130.5
Personal tierra/día año	0	264.0

Tabla 11: Sector extractivo. Inversiones.

	ARTESANAL	INDUSTRIAL
Casco	0	159 000
Máquina	0	40 000
Artes de pesca	100.0	0

Tabla 12: Sector extractivo. Costo de la mano de obra Costo de oportunidad. Depreciación e intereses.

	ARTESANAL	INDUSTRIAL
Costo Mano de obra/persona-año	0	3842.9
Costo depreciación casco	0	10600.0
Costo depreciación máquina	0	2666.7
Costo depreciación arte	25.0	0
Costo intereses del capital	10.0	19900.0

Costos de Procesamiento

La planta de procesamiento industrial pertenecen a la misma Empresa, pero existen diferenciados los gastos extractivos y de procesamiento para el camarón y la fauna acompañante, por lo que las cifras económicas de ésta última también fueron tomadas de los libros de registros oficiales de la empresa de Manzanillo

Es de señalar que BEAM4 emplea los costos de procesamiento por unidad de peso.

El mercado de camarón cubano está dirigido fundamentalmente a la producción de camarón entero, aunque otras categorías son obtenidas.

Del resultado de este procesamiento industrial, cuatro productos son obtenidos; camarón entero, camarón cola, partido y cola nacional, cuyos por cientos relativos representaron en 1994 el 75 %, 17 %, 7 % y 1 % respectivamente.

A los efectos del BEAM4 fue considerado el costo el costo total como la suma de los costos de cada producto.

Para el costo de la materia prima básica (camarón), se tomó el valor fijo por estructura de tallas que tiene definido la actividad extractiva para sus desembarques, aunque en realidad este es un proceso en el que no median pagos reales, sino solo desde el punto de vista contable.

En el caso de los peces, acorde al destino, humano o animal, existen precios diferenciados. En el primer caso depende de la especie (independientemente del tamaño) y en el segundo caso se paga un precio fijo la tonelada.

En 1994 el 21.6 % de la misma fue utilizado para alimento humano por la Empresa de Manzanillo, el resto se emplea para consumo animal como harina o ensilados. El valor de estas últimas es mucho menor y han sido incorporados proporcionalmente en los diferentes valores de cada grupo de la fauna correspondientemente agrupados en la 5 categorías de la A a la E .

El destino de la captura de la pesca artesanal, puede considerarse que se vende como camarón y peces frescos o procesado en minutas, aunque sobre estas operaciones no hay control ni registro alguno. En la industrial todo el camarón se lleva a proceso , pero la fauna (consumo humano) una parte se procesa como picadillo o precocidos y el resto se vende fresco. La otra parte de la fauna se destina para el consumo animal, aunque se vende sin ningún procesamiento, puesto que éste lo realizan las propias empresas que la utilizan.

En la Tabla 13 se ofrecen algunos elementos de los costos por unidad de peso procesada en 1994 en la Empresa de Manzanillo.

Tabla 13: Sector de procesamiento costo por unidad de peso procesada.

		CAMARÓN	FAUNA
Transporte y Seguro	Total	0	0
	Divisas	0	0
Materiales de empaque	Total	298.17	2.12
	Divisas	298.17	0.64
Agua y Energía	Total	35.27	0.55
	Divisas	33.51	0.53
Reparación y Mntto	Total	109.41	1.87
	Divisas	109.41	1.87
Sueldos y Salarios	Total	735.53	10.63
Depreciación	Total	294.8	4.77
	Divisas	265.32	4.77
Intereses del capital	Total	1527.88	52.94
Misceláneas	Total	364.29	10.04
	Divisas	109.29	3.01
Tasas de exportación	Total	0	0

Precios de Venta

Los precios del camarón dependen de la estructura de talla de los desembarques, y varían en el tiempo de acuerdo al mercado de destino.

Para este trabajo se tomaron los precios por categoría comercial promedio de 1994 (FOB).

Los precios por unidad de peso de los peces y otros grupos componentes de la fauna se dirigen la mayor parte hacia el mercado nacional y su precio se establece de acuerdo a la especie. Existen 7 grupos de calidad (independientemente de la talla de los ejemplares).

La fauna de acompañamiento para consumo animal se vende a 70 pesos la tonelada.

SIMULACIÓN

Todas las medidas de desarrollo y de administración pueden usualmente ser expresadas en términos de esfuerzo pesquero.

En general las medidas de estrategia y táctica de la ordenación pesquera pueden expresarse en función del esfuerzo de pesca, (incremento o reducción), pero también el manejo del recurso incluye otras medidas como vedas estacionales, vedas zonales, cambio en el largo de la primera captura, limitaciones o prohibiciones de pesca en virtud de la talla o el estado de madurez, etc.

BEAM4 permite a través de factores elevadores o directamente en los datos de entrada, variar entre otros parámetros los niveles de esfuerzo por flota, es decir, de la mortalidad por pesca (F=qf), que de hecho permite tomar en consideración la existencia de pesquerias secuenciales y el ritmo de las emigraciones entre áreas, asi como la imposición de vedas, también permite cambiar el largo de primera captura, la mortalidad natural, etc.

Atendiendo a las condiciones particulares de la pesqueria en la región de Manzanillo, una serie de interrogantes se presentaron por productores e investigadores. Atendiendo a ello para el presente análisis fueron variados diferentes parámetros de entrada y se simularon diferentes estrategias de manejo del recurso.

Entre ellas:

1. Incremento del esfuerzo en la pesqueria artesanal.
2. Variación del esfuerzo en la pesqueria industrial.
3. Variaciones en la mortalidad natural.
4. Variaciones en la temporada de veda.

A continuación se presentan los principales resultados.

Sub Modelo Biológico

Una vez ajustado lo mejor posible las capturas estimadas a las observadas se está en condiciones de evaluar los resultados Bioeconómicos de BEAM4.

Dado que ilustrar todas las tablas y figuras de todas las variantes empleadas resultaria un documento excesivamente extenso, se presenta una selección de las mismas.

Resultados del sub modelo biológico

Sector extractivo

En general para todas las variantes empleadas se llegan a resultados similares para la flota industrial (Fig. 7). Un incremento sostenido del esfuerzo pesquero no parece provocar, en términos de las poblaciones un descenso considerable de las capturas como sería de esperar para muchas otras pesquerias, aunque el valor producido presenta el máximo incrementando un 40 porciento el nivel de esfuerzo actual, debido a que después de cierto limite los camarones capturados son demasiado pequeños y en consecuencia de un bajo precio en el mercado. Al parecer la elevada tasa de crecimiento y mortalidad natural son la causa fundamental de este comportamiento.

Este comportamiento del recurso ya fue señalado en la India (FAO, 1993), en donde se notaba que esa situación era frecuente observarla en especies de vida corta.

Los estudios mas recientes de las tasas de crecimiento y mortalidad natural (Pérez y Morenza , inédito; Páez, en prensa b; Páez y Sosa, en prensa b y Morenza y Alvarez, en prensa) coinciden en obtener altas tasas de crecimiento y M. La mejor sintonización de este modelo se logró con valores de K_{mes} =0.25 y una M_{mes} media de 0.40.

No obstante, una simulación reduciendo a la mitad los valores K y M, no alteraron los resultados bioeconómicos generales del presente trabajo.

Sector de procesamiento: (Planta)

Se ilustra solamente un ejemplo referido a los camarones. De acuerdo a los resultados encontrados (Tabla 14) aún con el doble del esfuerzo se elevaria el volumen de las exportaciones, pero el mayor valor se alcanza con un incremento del 40%. Ello por si solo pudiera crear la falsa impresión de que la estrategia mejor resulta de incrementar el número de dias pesca para alcanzar mayores niveles de venta, pero se de lo que se trata es de obtener mayores ganancias a largo plazo, deberán analizarse los resultados que se obtengan en el modelo económico.

Tabla 14: Resultado de la simulación (equilibrio) para el sector de procesamiento. Largo Plazo.

FACTOR	CAPTURA	VALOR DESEMBAR.	VALOR TOTAL	CAPTURA EXPORTADO	VALOR EXPORTADO
0.0	0.0	0	0	0.00	0
0.2	220.16	1566901	1941533	220.16	1941533
0.4	353.80	2400288	2974175	353.80	2974175
0.6	438.16	2844533	3524635	438.16	3524635
0.8	493.12	3074699	3809832	493.12	3809832
1.0	529.85	3184152	3945454	529.85	3945454
1.2	554.90	3224584	3995552	554.90	3995552
1.4	572.27	3225467	3996647	572.27	3996647
1.6	584.49	3203994	3970040	584.49	3970040
1.8	593.17	3170359	3928364	593.17	3928364
2.0	599.40	3130672	3879187	599.40	3879187

Sub Modelo Económico

Tal y como se expresa para el modelo biológico varias simulaciones fueron realizadas.

BEAM4 ofrece la oportunidad de un análisis detallado para el sector extractivo, para el industrial y para el resultado combinado de ambos.

Una selección de resultados para el análisis integral se ofrece en la Fig. 8.

Por los resultados que se ofrecen todo indica la conveniencia económica para la Empresa de Manzanillo de reducir el esfuerzo pesquero entre el 80% y 60% del ejecutado en 1994.

Por su parte un incremento de 5 y 10 veces en el esfuerzo de la pesca industrial produce un balance económico desfavorable para el análisis integral de los resultados (Fig 9).

Es de notar que debido a los altos precios del camarón en comparación con otras especies de la fauna. Los resultados económicos en general se ven fuertemente influidos por cualquiera de las variaciones que se produzcan con relación a los resultados del camarón.

Consideraciones generales

Sobre la base de estos resultados y en la diversa información y conocimiento sobre la evolución de la pesca en Manzanillo y conjunto de aspectos biológicos ecológicos y sociales de la región, se produjo entre los dias 5 y 7 de diciembre una visita a la Empresa de Manzanillo y se sostuvo reuniones de trabajo con empresarios y con los pescadores en la propia zona de pesca a bordo de sus embarcaciones, donde se evaluó la necesidad de reducción del esfuerzo pesquero para 1996. Debido a que la reducción a los niveles más apropiados implica la salida de un número importante de barcos, una politica de reducción por etapa parece que será la decisión que tomen los productores, lo que permitirá la reubicación paulatina de esos pescadores en otras pesquerias o actividades pesqueras.

El empleo de BEAM4 resultó un instrumento útil para el análisis de los resultados bioeconómicos de las pesquerías de camarón. Resulta muy importante para su adecuado maneio, que la información sea integrada por biólogos y economistas. No obstante queda claro que BEAM4 no sustituye el conocimiento sobre los aspectos biológicos, ecológicos, económicos y sociales de un pesquero, mas bien necesita del perfeccionamiento cada vez mayor de estos conocimientos por parte de biólogos y economistas.

REPOBLACION

Diferentes experimentos se realizaron con vistas a poder establecer una metodologia dirigida a la siembre de camarones en el mar para incrementar el número de reclutas y compensar la disminución de las capturas que se viene produciendo desde la década del 70 . Esta via ha sido empleada a gran escala en Japón y China (Kuratta, 1981 y Liu, 1990), los resultados referidos por estos autores son exitosos y el número de ejemplares sembrados está en el orden de los miles de millones. En Cuba se comenzó un primer intento en las regiones de los Golfos de Guacanayabo y Ana Maria (18702 km^2) pero la extensión de esta área y los limitados suministros de postlarvas y juveniles para la liberación, hacian presuponer que resultaria muy dificil evaluar la efectividad de la siembra. La continuación de estos ensayos se trasladaron para la Ensenada de la Broa, la que con una extensión de 600 Km^2 de fondos camaroneros, parecia un área mas favorable para tales propósitos. La metodologia y resultados de estos trabajos aparecen en Páez (en prensa a)y Páez *et al.*, (en prensa).

De ello se puede resumir en que la frecuencia y cantidades de camarones liberados no fue suficiente para producir un incremento de la biomasa camaronera. No obstante, sí fue demostrada la presencia de camarones liberados en las poblaciones adultas, ya que estos alteraron el patrón estacional mensual del indice de abundancia obtenido en análisis de series de tiempo y se encontró la frecuencia génica de los progenitores (extraídos de la región suroriental) postlarvas sembradas en la población adulta de la Ensenada de la Broa (Espinosa et al, en prensa) y Páez et al, inédito a).

MEJORAMIENTO DE ZONAS DE CRIA

Partiendo de la hipótesis que la causa fundamental de la disminución de la biomasa de las poblaciones camaroneras en Cuba es el deterioro, en primer lugar de las áreas de cria y que estas dependen en gran medida del desarrollo de las praderas de *H. wrightii*, se desarrollaron varios experimentos destinados a evaluar la posibilidad del empleo de vegetación artificial como complemento y ampliación de estas áreas.

Los resultados alcanzados en estos ensayos indican que existe la posibilidad potencial de mejorar estas áreas (Páez, *et al.*, en prensa) y Páez *et al.*, en proceso). En 1993 se seleccionó un área natural de cria y por muestreos previos se determinó la existencia de juveniles de *P. notialis* en los pastos de *H. wrightii*, y la no presencia de éstos en las zonas desprovistas de vegetación. En esta última se sembró una sección de la vegetación artificial y ya en el primer muestreo a los 15 dias de sembrado se concentraron los camarones. El resultado final, al término del ensayo, indicó que entre ambos "biotopos" no existió diferencia significativa en la densidad de organismos que concentró.

Estudios posteriores indicaron que tanto el perifiton como el epibentos asociado a ambas vegetaciones tenian indices de afinidad muy altos y estos organismos tanto vegetales como animales eran de las mismas especies que las encontradas en el estudio del contenido estomacal (Páez y Anderes, en preparación).

Un programa de desarrollo a escala piloto se proyecta realizar en 1996 con vistas a ampliar estos experimentos.

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LISTA DE PARTICIPANTES — Taller de Bioeconomia. FAO-Cuba, 18- 29 de Sept. 1995

Profesores: Sr. Rolf Willmann (FAO), Dr. Per Sparre (FAO), Dr. Juan C. Seijo (FAO), Estudiantes (Grupo Camarón): Juan Páez (coordinador)(Centro Investigaciones Pesqueras, Cuba), Luís Font (CIP, Cuba), Mireya Sosa (CIP, Cuba), Marta Morenza (CIP, Cuba), Sita Kuruvilla (Trinidad y Tobago), Onelio Guerra (CIP, Cuba), Jorge Risquet (Min. Industria Pesquera, Cuba), Raúl Coyula (Univ. Habana, Cuba).

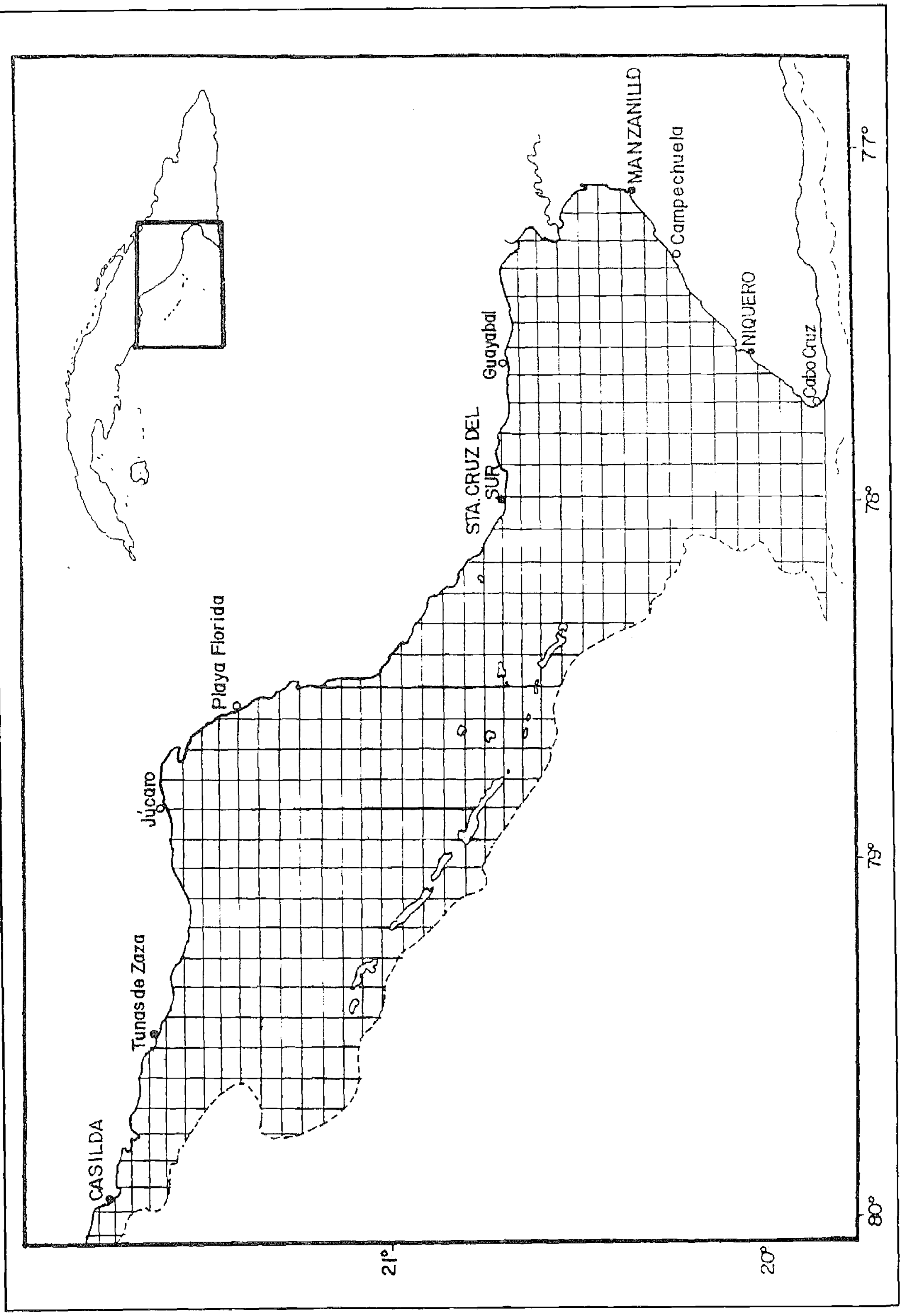


Figure 1: Zona de pesca de camarones en Cuba.

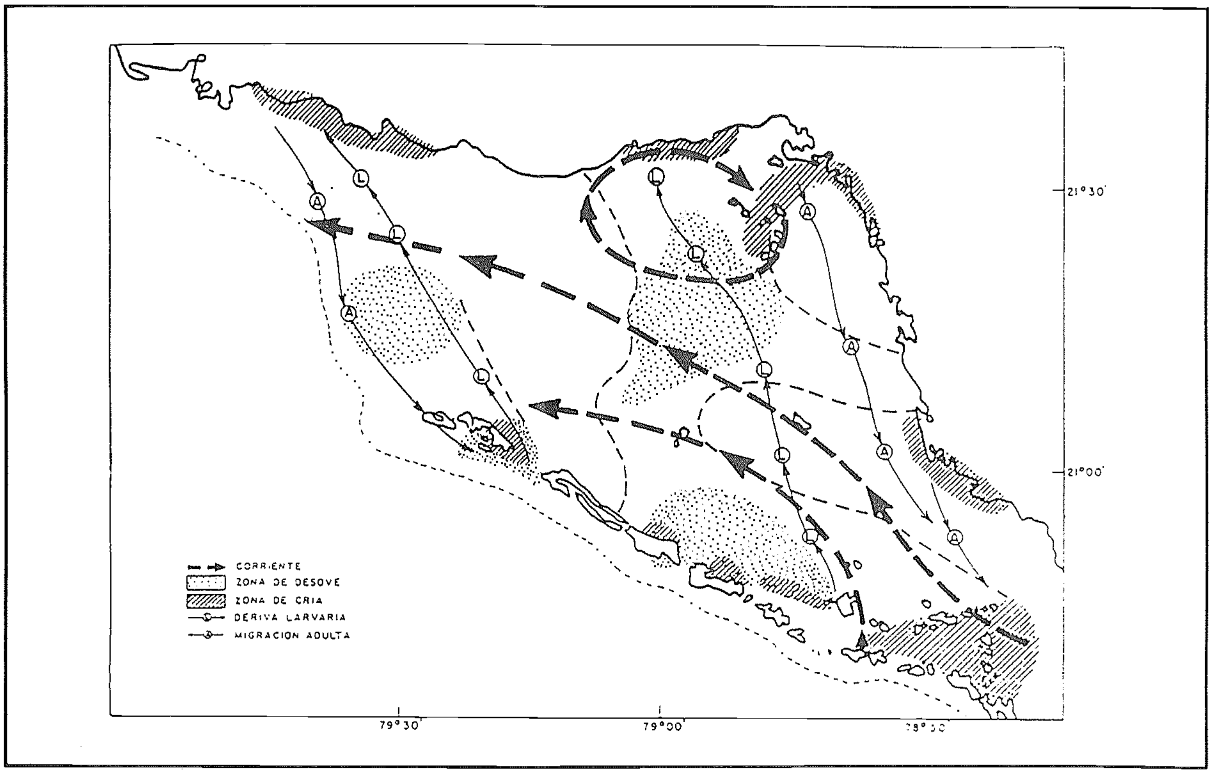


Figure 2: Areas de cría y desove de camarón en el Golfo de Ana María (Según Morenza *et al.*, inédito).

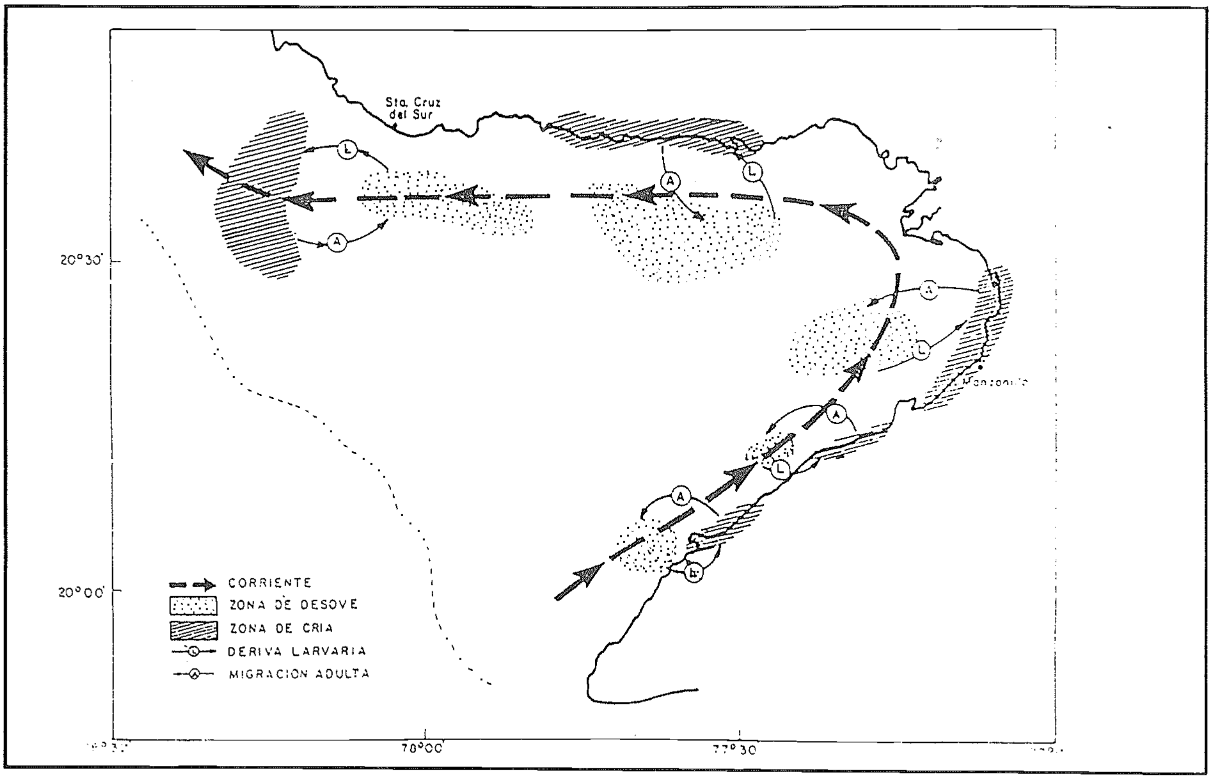


Figure 3: Areas de cría y desove de camarón en el Golfo de Guacanayabo (Según Morenza *et al.*, inédito).

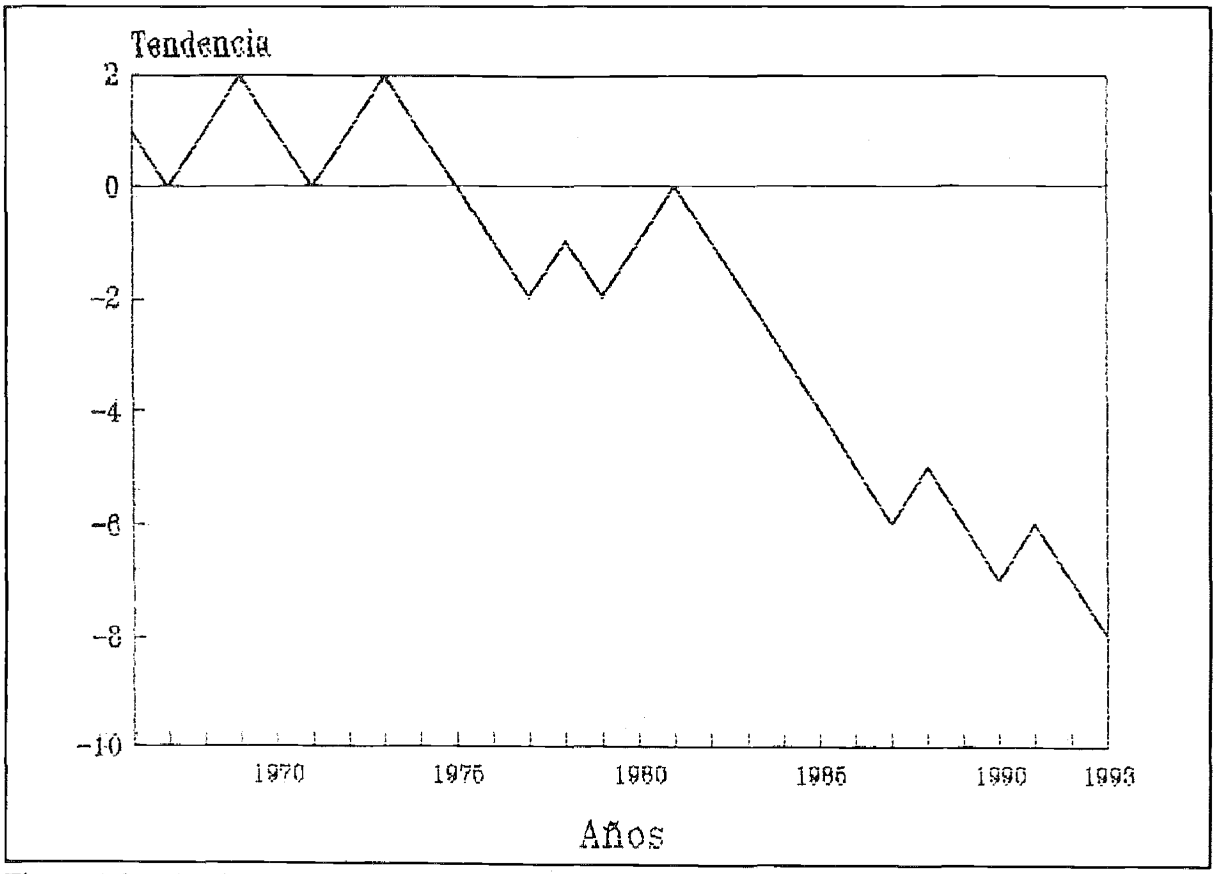


Figure 4: Tendencia a los años secos en las provincias camaroneras.

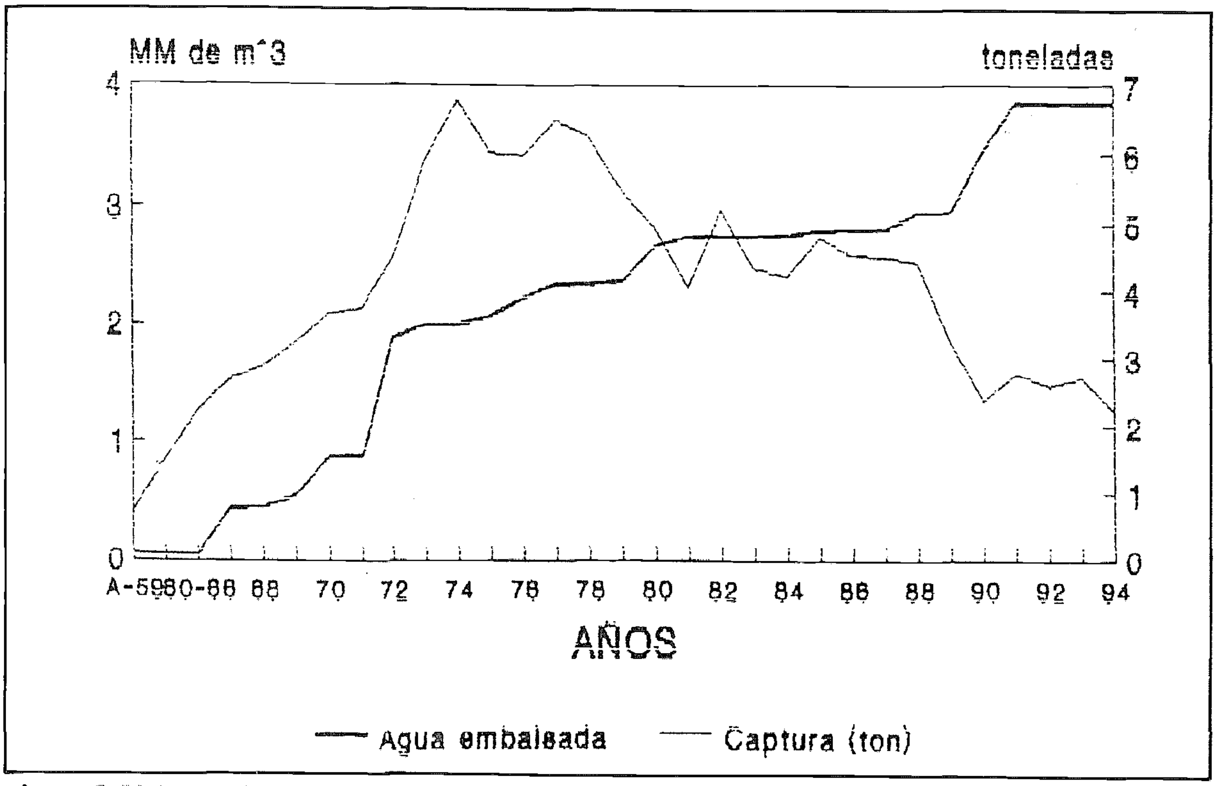


Figure 5: Volumen de agua embalsada y captura de camerón. Región suroriental de Cuba.

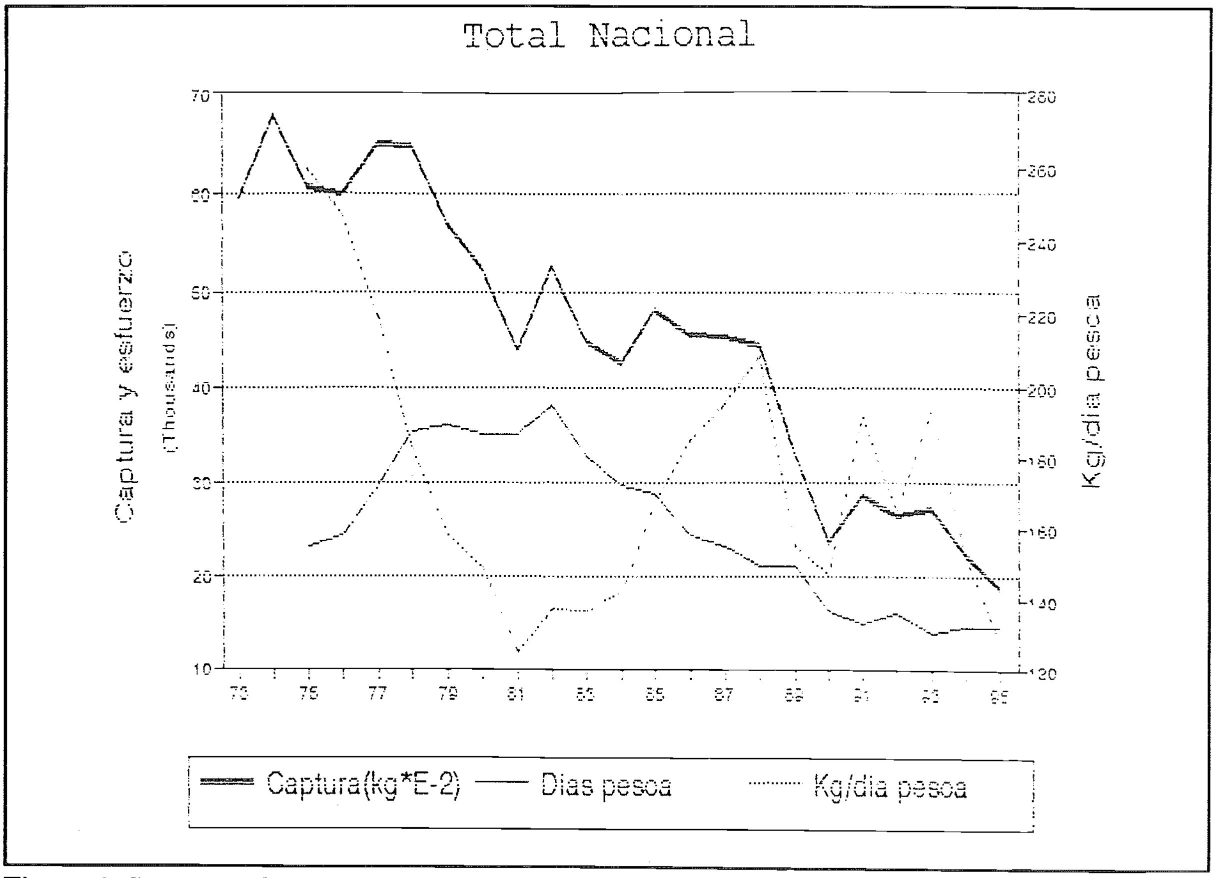


Figure 6: Captura, esfuerzo y CPUE.

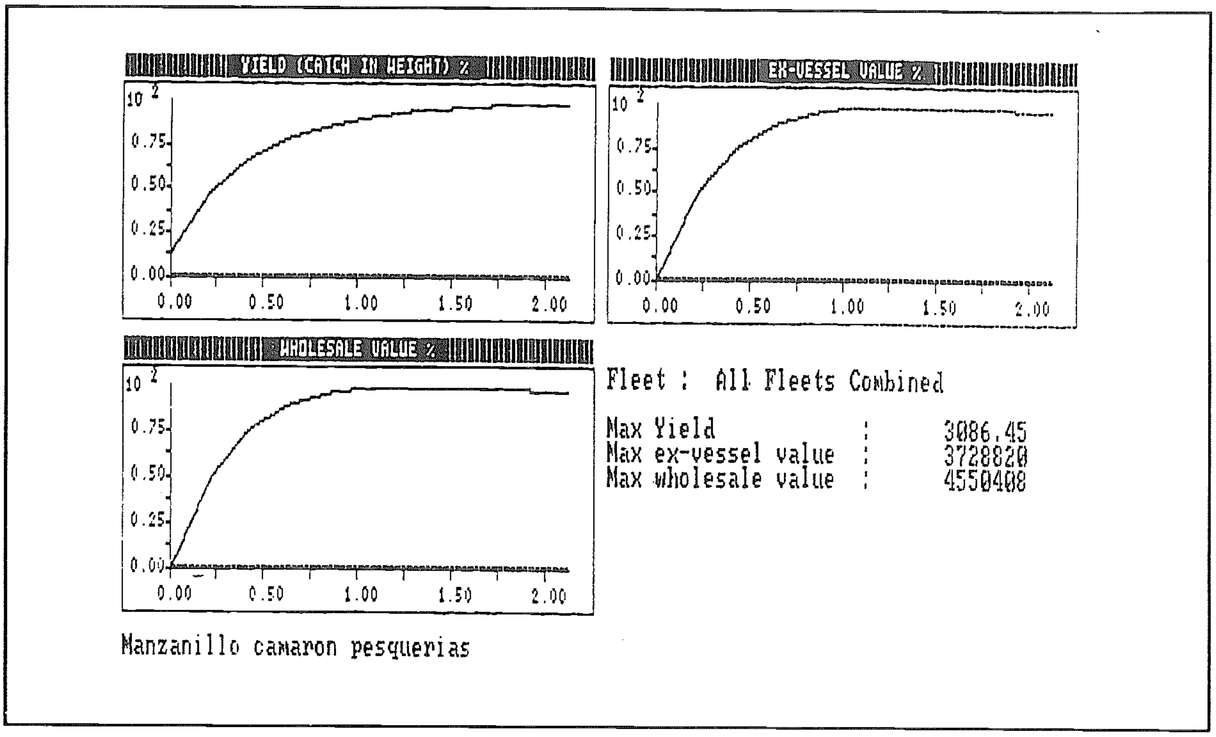
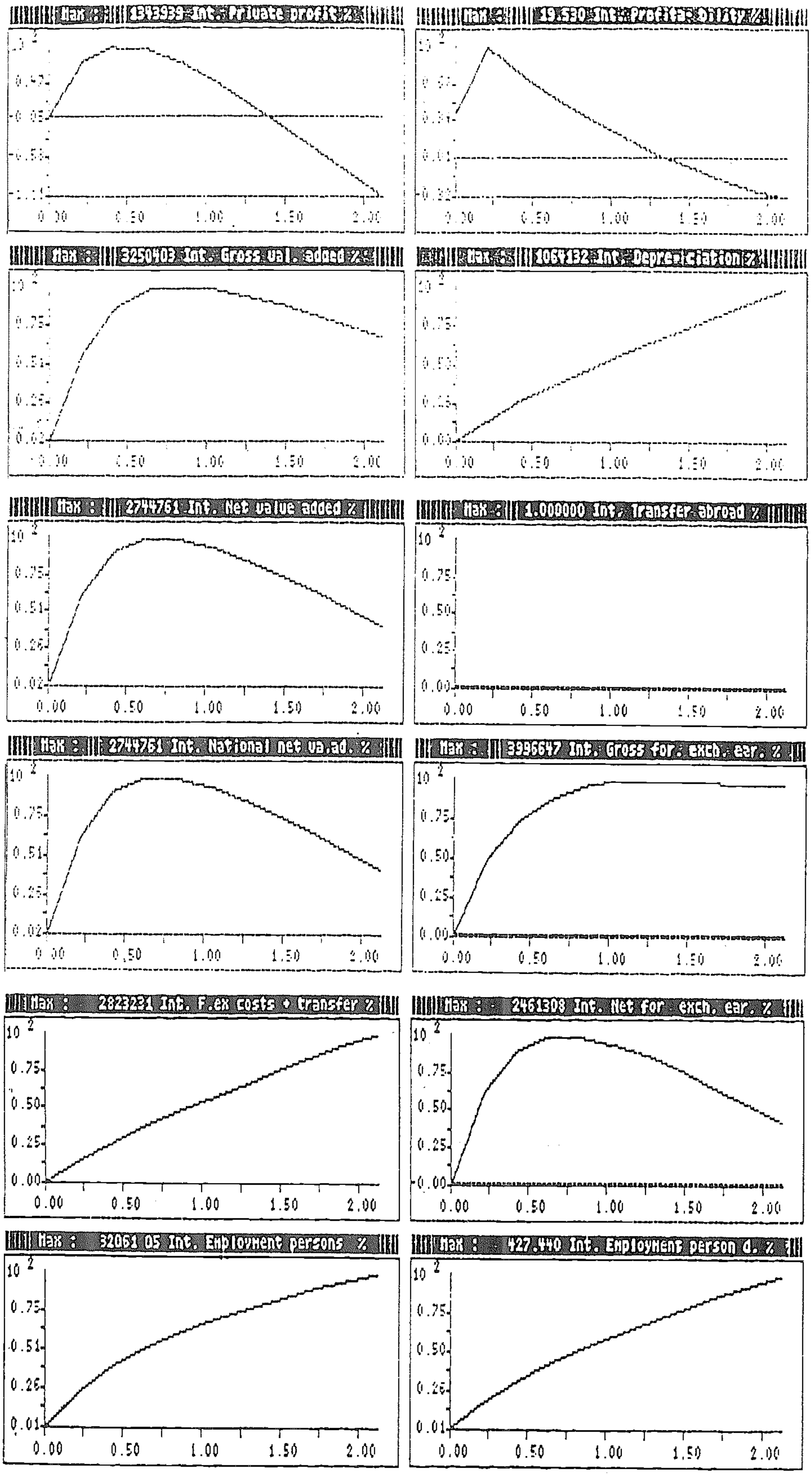


Figure 7: Resultados del Sub-Modelo Biológico.



Manzanillo camaron pesquerias

Figure 8: Resultados del Sub-Modelo Económico.

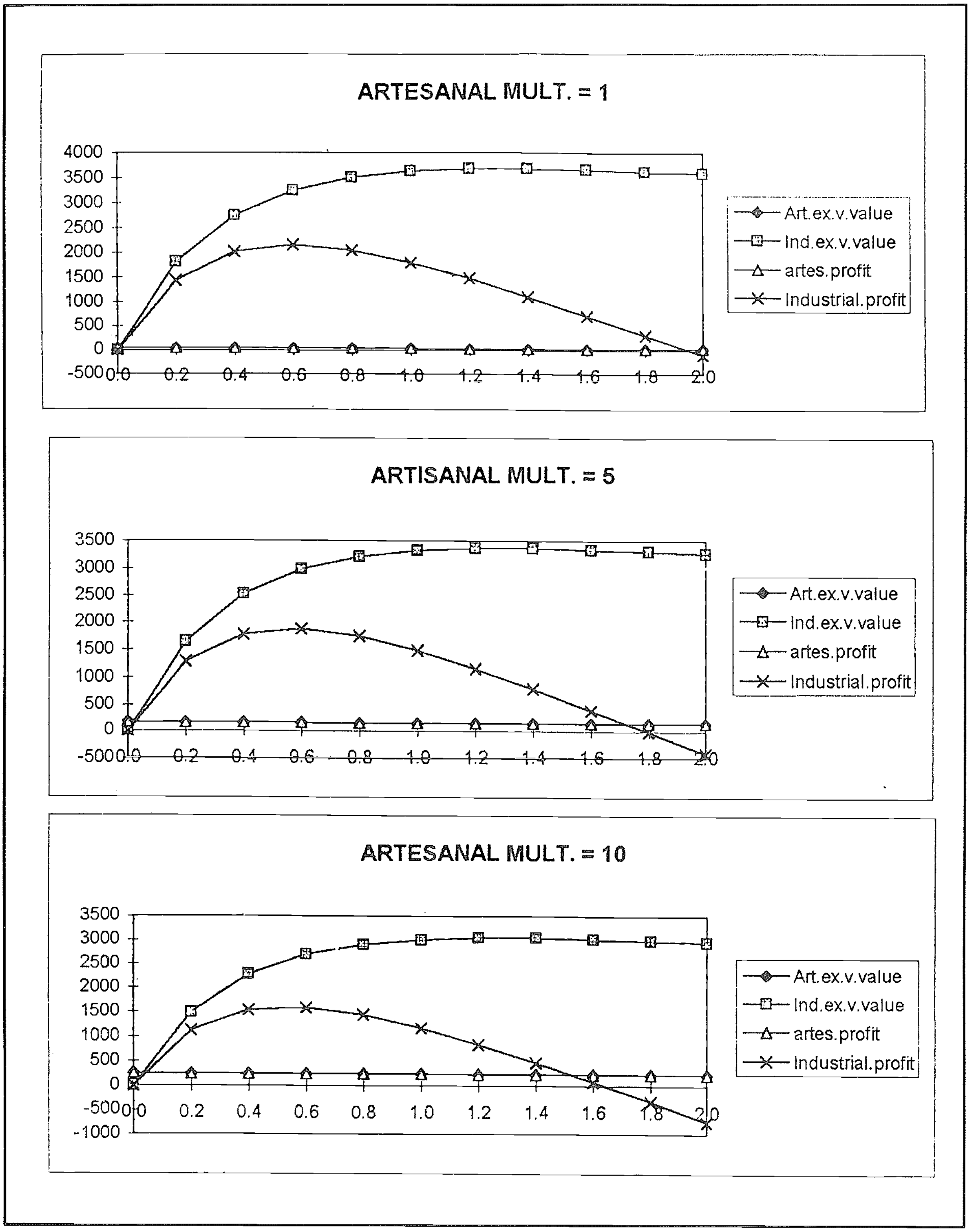


Figure 9: Simulación con el incremento del esfuerzo en la pesquería artesanal de Manzanillo.

Observer Program for Venezuela's Shrimp Fishery

L.A. Marcano[1], J.J. Alió[1]

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INTRODUCTION

ORIGINS AND SIZE OF THE FLEET

Trawling fisheries developed in Venezuela since 1950. At the beginning, the trawling fleet operated in the western zone of the country, mainly in the Gulf of Venezuela, due to the abundance of shrimp associated with the estuarine system of the Lake Maracaibo. The first signs of over exploitation of the resources targeted by this fishery were observed early in the 70's (Novoa et al., 1993), which induced the movement of part of the fleet to the eastern region of Venezuela, using as base ports the fishing harbors of Punta Meta in Anzoátegui State, and Cumaná and Güiria, both in Sucre State. During the recent years the trawling fleet nationwide has grown, doubling its size in the period 1985-90 and reaching 450 vessels (Marcano, 1990). However, in the last two years, an 18% decrease in the number of vessels has been observed in the trawling fleet, reaching 374 vessels distributed as follows: 173 in Punto Fijo (Falcon State) in the eastern region; 5 in Puerto Cabello, central region; 50 in Punta Meta; 95 in Cumaná and 50 in Güiria.

Since the beginning, the trawling fishery has been under study by Official Institutions involved in the fishing sector. Until now, analyses were based on observations of the trends of the catch and fishing effort, using global models for the evaluation of the fishery, because of their lower requirement of information.

Venezuela, like many other fishing countries, lacks a statistical system suited to provide the level and quality of information required to evaluate the turnover capacity of fishing resources. Since 1967, there have been several trials to set up a national statistical system, to register the catch of the different species and fisheries. This effort has contributed to the generation of statistical information, but the data are severely biased, making them unsuitable for the purpose of evaluating the main demersal fish resources.

However, in 1970 the first steps were taken to establish a system to record the catch and effort statistics, mainly in the industrial trawling fleet, with the purpose of improving the official statistics and of evaluating the fishery resources. This program was under the coordination of a mission from FAO/UNDP which remained in the country until 1977. The information was gathered on board, aided by a record of the landings, and by a biological sampling in the harbors and processing plants, as well as by the processing of the logbooks. Although highly positive results were obtained, once the FAO mission ended its work, the system reverted to the old procedure. It relied on the information provided by the trawling enterprises, which was highly biased and uncertain.

In 1981 a new mission from FAO installed a new system for the gathering and processing of fisheries statistics, based upon the analyses of fishing logbooks. This system called SIPES (Sistema de Información Pesquera) did not provide the expected result, which was the substantial improvement of the official fisheries statistics, since it required to maintain the ambiguous procedure for the gathering of the capture and effort data.

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[1] FONAIAP, Venezuela.

At present, there is a complementary system for the collection of the information on catch and fishing effort, based on the procedure originally implemented by the FAO/UNDP program in the early seventies. This system is being put in practice directly by the research personnel of FONAIAP, because of the need for reliable statistical information for the evaluations of the fish resources in the country.

THE OBSERVER PROGRAM

GOALS

This program was developed in 1987 in order to know in detail and with precision the information on catch and fishing effort associated with the activities of the trawling fleet in Venezuela. The main objectives were:

- To obtain a description of the distribution of the fishing effort in space (bathymetric and spatial position) and time;
- To estimate the variation in space and time of the distribution and abundance of the species under exploitation, including a study of the variation in abundance and composition of the non commercial by-catch;
- To develop a biological sampling program on board the fishing units.

The program is planned, executed and supervised by the research personnel of the Laboratory of Demersal Resources of the FONAIAP Center in Cumaná, with the authorization of the National Fisheries and Aquaculture Office (S.A.R.P.A.) of the Ministry of Agriculture. The cooperation and partial financing from the industrial sector has been essential for the success of the program.

The number of trips covered with observers annually have reached between 60 to 70, representing 4 - 5% of an estimated total of 1400 trips performed by the trawling fleet in the northeastern region of Venezuela. The information gathered in the program allows an adjustment of the data provided by the industrial sector of the region to the SARPA Office.

PERSONNEL

The coordinator of the program, Luis A. Marcano, is a fishery biologist with 20 yr. experience in the trawling fishery research. He holds an M. Sc. degree from Universidad de Oriente, Instituto Oceanográfico de Venezuela. Jose J. Alió, a marine biologist with an M.Sc. degree from the University of California, is in charge of the project on fishing gear development and modifications. Four technicians, working part-time for the program, process the information. They are graduates of the Fisheries Technical School of Cumaná, which grants diplomas equivalent to a 6 yr. high school.

Several graduate and undergraduate students of biology from Universidad Central and Universidad de Oriente have proposed as thesis projects different aspects covered by the program, mainly those pertaining to the biology and fishery of several species with commercial interest. The observers are young people recruited from the Fisheries Technical School of Cumaná or from the one in Margarita Island.

All the observers and students in the program receive training from the coordinator and from the technicians, covering the goals of the program, the recognition of the species in the catch, the measurements or estimates to be made on board and the correct filling of the different forms (van Helvoort, 1988). Before going on board, the observer must participate in the processing of several samples of non commercial by-catch in the laboratory, to become familiar with the recognition of the species in the catch and with the procedures in use.

ACTIVITIES ON BOARD

Capture and Fishing Effort

Once assigned to a fishing vessel, the observer goes on board on the day of departure, with the proper identification documents. The observer is introduced to the owner of the vessel and to the crew. The crew members are informed about the purpose of the program and the tasks assigned to the observer; it is stressed that, time permitting, the observer is willing to collaborate with them in other duties that he is requested to (usually the paling out of the non-commercial by-catch).

During the trip, the observer with the aid of the captain, becomes familiar with the navigation and fishing instruments of the vessel, since they will be used during the filling of the forms. Every time the net is lowered and retrieved, the observer should record: the date, time of the day, depth of operation at the moment of lowering the nets, and the position of the vessel. The commercial catch is estimated as biomass per species, combining the product of both nets. The non- commercial by-catch is grossly estimated also as biomass. The unit of biomass is the "box", which holds about 10 kg. The information is recorded on a special form, or fishing logbook (Annex I), similar to the one used by the fleet. Each sheet holds the information of 10 trawls. The estimation of the position of the vessel is aided by a map of the region, divided in squares of 30 x 30 miles, according to FAO recommendations (Annex II).

Biological Sampling

This is one of the most important assignments of the observer. The sampling is made according to a particular purpose, so it can change in different trips. When data are required for population dynamics studies (estimates of growth, mortality or recruitment) of selected species, only a single measurement (total length or any other appropriate parameter), is taken without consideration of the sex of the animals (Annex III). When there is need to record information on the biology of the species, the sampling is made separating the individuals by sex, and estimating size, weight and gonadal maturity (Annex IV). The sample size is a "box" (or less if the species is not abundant) of the chosen species from every other trawl.

In order to complement the data on biological aspects of the species (scales, otoliths, gonads, liver, stomach content), one "box" sample of the chosen species is taken per trip, to be frozen or iced on board, and carried to the laboratory to be examined. The weight of the sub-samples processed from any trawls, and the total weight of the individuals processed for each species, are recorded.

Composition of the Non-commercial By-catch

Every five trawls, a two "box" sample is taken, one from each net, at random, which is processed as follows:

- All fish species in the sample are identified and separated by groups;
- The individuals in every group are counted and weighted;

The invertebrates are neither separated by species nor counted; they are only weighed by group of species, i.e. Crustacea, Mollusca, Echinodermata, etc. (Annex V).

In order to increase the sample size, a ten "box" sample (100 kg) of non-commercial by-catch is collected from those trawls in which no sampling took place on board. This extra sample is frozen or iced, and carried to the laboratory for processing.

The results from the data collected in the eastern region of Venezuela are shown in Marcano (1989) and Cabello *et al.*, (in review).

Turtle Observation and Sampling

With the purpose of estimating the impact of the trawling fleet on marine turtles, the incidental catch of turtles in the nets is recorded by the observer on a special form. The recorded information is: species of turtle, position and depth at which the vessel was operating, date and time of the day, length and width of the carapace, approximate weight, sex, condition of arrival on board, tag number (in case the turtle was tagged), and whether the animal was liberated or not (Annex VI). If the animal was not tagged and is alive, a tag is placed and the animal is liberated. The tagging program is developed in cooperation with Foundation for Nature Development (FUDENA). Furthermore, the observers are trained to revive those turtles which arrive drowned on board. If the reanimation procedure succeeds, the turtle is liberated. The preliminary results of this program are shown in Marcano & Alió (1991).

Observations with Escape Panels in Shrimp Trawl Nets

The project about the use of escape panels in shrimp trawl nets was initiated in 1987, to test mechanisms that allow the escape of shrimp by-catch (mainly fish juveniles), thus reducing the ecological impact caused by the low selective shrimp trawl nets on the marine demersal fauna (Alió et al., 1995). For this evaluation the vessel uses only one net with the escape panel installed, while the other net serves as control. The use of two regular nets for a number of trawls allowed the correction for biases in the fishing efficiency of the different sides of the vessel (Rulifson, et al., 1992).

The information gathered and the biological sampling uses similar type of forms as described before, but the catch of every net is reported separately. Likewise, the samples for the study on net selectivity and population structure of selected fish species are collected in the same proportion from each net. The campaigns were organized every two months.

Observations about the Use of TEDs

This part of the program was organized to evaluate the impact of the TED's use on the commercial operation of the trawling fleet. The observer uses a similar procedure as described before for the evaluation of the escape panels for fish. Results from this part of the program are shown in Marcano & Alió (1995).

The program herein described is also being conducted in the Gulf of Venezuela by the FONAIAP Station in Punto Fijo. It is expected that in the near future it can be expanded for its use as a regular instrument by the Venezuelan Fisheries and Aquaculture Office, with the support of the shrimp trawling industry.

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ANNEX I

Ministerio de Agricultura y Cria

Fondo Nacional de Investigaciones Agropecuarias

Centro de Investigaciones Agropecuarias del Estado Sucre

Proyecto: Evaluacion de recursos demersales de la region nororiental programa de observadores en la pesca de arrastre

CUADERNO DE PESCA

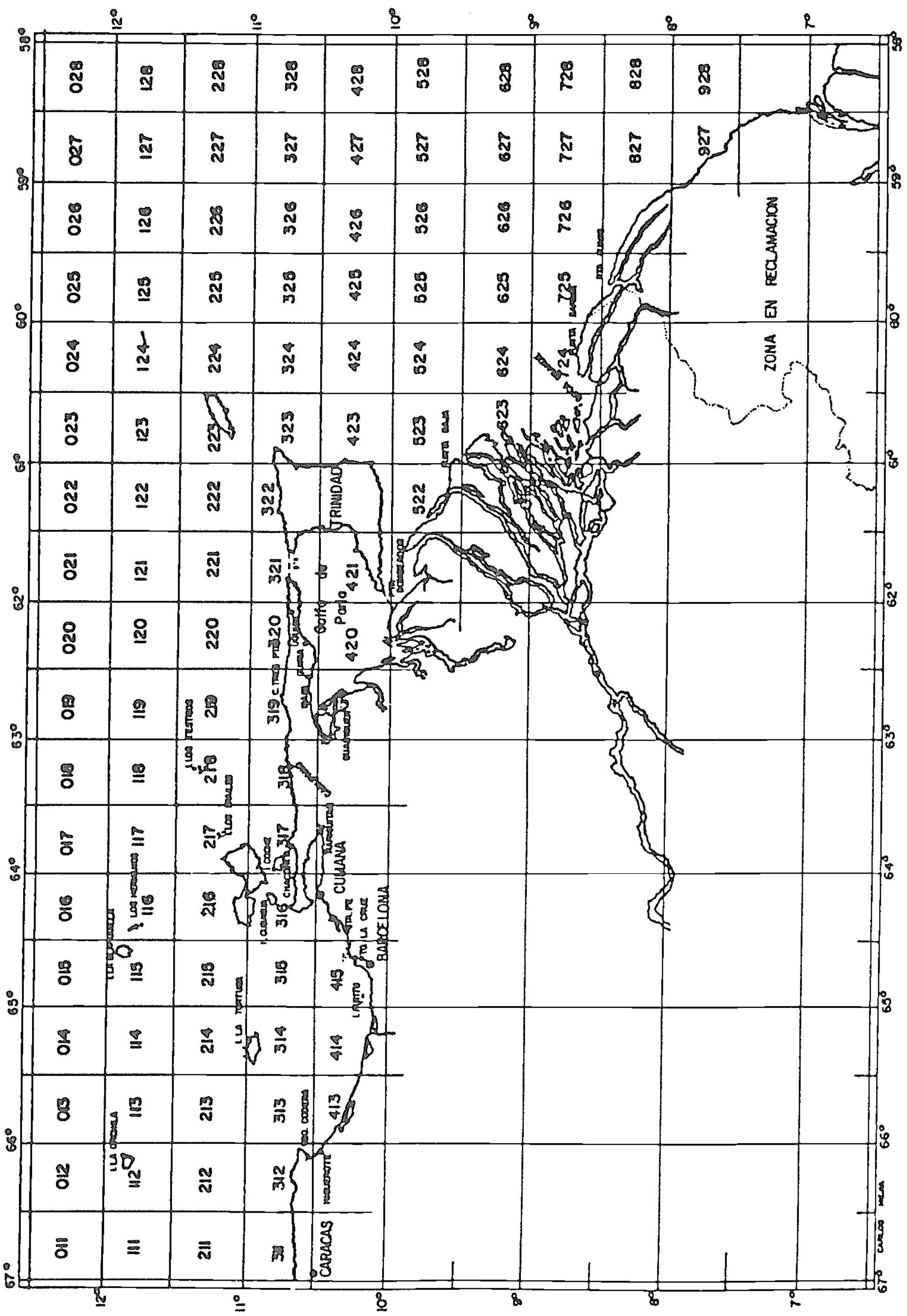
MES:___ AÑO:_________ BARCO: ________________ CAPITAN: ______________________

MATRICULA: __________ ESLORA: __________ H.P: _____ T.R.B: __________ OBSERVADOR: __________

CALADA Nº										
FECHA (DIA)										
HORA TERMINO										
CUADRANTE										
PROFUNDIDAD										
CAMARON MARRON										
CAMARON ROSADO										
CAMARON BLANCO										
CALAMARES										
PULPOS										
CONCHAS										
COROCORO										
RONCADOR										
CAZON										
CATALANA										
CURVINATA										
LAMPAROSA										
CATACO										
GUANAPO										
PERLA										
TAHALI										
CHERECHERE										
CURVINA										
TONQUICHA										
PANCHITO										
LENGUADO										
BROSA										
TORTUGA CARDON										
TORTUGA MANI										
TORTUGA VERDE										
TORUGA CAREY										

ANNEX II

Map of the northeastern region of Venezuela showing the fishing squares where the trawling fleet operates.



ANNEX III

Ministerio de Agricultura y Cria

Fondo Nacional de Investigaciones Agropecuarias

Centro de Investigaciones Agropecuarias del Estado Sucre

Proyecto: Evaluacion de recursos demersales de la region nororiental programa de observadores en la pesca de arrastre

MUESTREO DE FRECUENCIA DE TALLA

BARCO: ________ SALIDA: _______ LLEGADA: __________ OBSERVADOR: ________________

CALADA: __________ CALADA: __________ CALADA: __________

FECHA: ___________ FECHA: ___________ FECHA: ___________

ESPECIE: ___________ ESPECIE: ___________ ESPECIE: ___________

0			0			0		
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
9			9			9		
0			0			0		
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
9			9			9		
0			0			0		
1			1			1		
2			2			2		
3			3			3		
4			4			4		
5			5			5		
6			6			6		
7			7			7		
8			8			8		
9			9			9		
	Kg.	No.		Kg.	No.		Kg.	No.

Peso total por Calada: __________ __________ __________

Captura total en el Viaje : __________ __________ __________

ANNEX IV

Ministerio de Agricultura y Cria

Fondo Nacional de Investigaciones Agropecuarias

Centro de Investigaciones Agropecuarias del Estado Sucre

Proyecto: Evaluacion de recursos demersales de la region nororiental programa de observadores en la pesca de arrastre

MUESTREO BIOLOGICO

BARCO: __________ SALIDA: _______ LLEGADA: ________ OBSERVADOR: ______________

CALADA: __________ CALADA: __________ CALADA: ___________ CALADA: _________

FECHA: __________ FECHA: __________ FECHA: ___________ FECHA: _________

ESPECIE: ______________ ESPECIE: __________ ESPECIE: ___________ ESPECIE: _________

No.	L.Tot	Peso	Sexo	M.S	L.Tot	Peso	Sexo	M.S	L.Tot	Peso	Sexo	M.S	L.Tot	Peso	Sexo	M.S
1																
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ANNEX V

Ministerio de Agricultura y Cria

Fondo Nacional de Investigaciones Agropecuarias

Centro de Investigaciones Agropecuarias del Estado Sucre

Proyecto: Evaluacion de recursos demersales de la region nororiental programa de observadores en la pesca de arrastre

MUESTREO DE FAUNA ACOMPAÑANTE DEL CAMARON

BARCO: ______________________ FECHA DE SALIDA: _______ FECHA DE LLEGADA: ______________________

FECHA DE MUESTREO: _____________ OBSERVADOR: ______________________

CALADA No.										
CUADRANTE										
PROFUNDIDA										
ESPECIES	Kgs.	No. Ej	Kgs.	No. Ej	Kgs.	No. Ej	Kgs.	No. Ej	Kgs.	No. Ej
Crustaceos										
Moluscos										
Equinodermos										
Otros										
TOTAL (Kgs.)										

OBSERVACIONES: ____

____

ANNEX VI

Ministerio de Agricultura y Cria

Fondo Nacional de Investigaciones Agropecuarias

Centro de Investigaciones Agropecuarias del Estado Sucre

Proyecto: Evaluacion de recursos demersales de la region nororiental programa de observadores en la pesca de arrastre

PROGRAMA PESCA CAMARON / TORTUGAS

EMBARCACION: ______________ PUERTO BASE : ______________________ OBSERVADOR: ____________________

FECHA SALIDA: ______________ FECHA LLEGADA: ________________ ZONA DE PESCA : _________________

ESPECIE	FECHA CAPTURA	CALADA No.	CUADRANT No.	PROFU (m)	HORA DE CAPTURA	LARGO CAPAR.	ANCHO CAPAR.	PESO (Kg)	CONDICION	SOLTADA Si No

Observaciones: ____

____

____

____

Preliminary Results on the Studies of Recruitment of Penaeus subtilis in the Shrimp Fishery of French Guiana (1994-1995)[1]

A. Charuau[2]

RECRUITMENT VARIABILITY

The general mechanism of the recruitment of the juveniles to the fishery is known but it is always impossible to quantify its intensity. Recent cruise observations confirm also the migration of the juveniles from the coast to the open sea up to 40 meters depth. Moreover, the gradient of the distribution of recruits seems more obvious during the wet season than during the dry season. These recent observations confirm also a non-monotonous distribution of the recruits on the continental shelf with very strong concentrations in front of the main rivers (Oyapock, Maroni, and Sinnamary). These first results based on a very short sampling period cannot show the seasonal or cyclic mechanisms if they exist. If the results of various cruises are compared, the same events are not observed at the same period of the year. From these cruises, three things can be deduced, that could be important in designing future studies:

- Nothing is known of the catchability of the shrimps, juveniles and adults, i.e. the shrimp trawl seems to be a poor sampling tool;
- The currents are important in the migratory behaviour of shrimps but there is no data on the coastal hydrology;
- The rainfall, with its correlate, salinity, seems to be an important factor in the distribution of the juveniles.

In the past, the 30 m isobath has been considered as the limit of the distribution of the juveniles. The only indices used on the shrimp fishery is the commercial index of the smallest category (category IV). As there is no consistent sorting between various companies, it was in all cases an approximation.

The fishery was divided into four areas, but as fishing is not random, it is very difficult to get consistent sampling of the smallest categories. Another problem, common in all fisheries, it is the progressive decrease of the mean length in each commercial category. These methods were used to give a general description of the recruitment with two maximum periods of abundance in the first part of the year and only one in the second part. That periodicity suggests that there are climatic effects on the level of recruits. Methods that have been used for the assessment of the stock include: global modeling and analytical assessment on age and length, although it seems contradictory to carry out length analysis of the stocks with the assumption of a constant recruitment which was known to be considered as highly variable.

It is likely, but not obvious, that there is an important correlation between the level of the recruitment and the production of the stock. Although no catastrophic variations of the landings are known in last years, there is no evidence that the recruitment was at the same level during the same period.

---

1 This preliminary study is extracted from unpublished works of P. Moguedet and Ch. Bene.

2 IFREMER, French Guiana.

It is obvious that the CPUE of the smallest categories is also in relation with the dynamics of the fleet. If the strategy of the shrimp-trawlers is oriented towards small categories, in the shallow waters, the recruit indices will go up and vice versa. For classical studies, it seems important to get reliable indices of recruitment but the indices from the fishery are very difficult to understand and very often the variability of the recruitment seems to reflect the variability of the habits of the boats.

Another fact is that there is no real problem in the fishery. The CPUE is increasing in recent years except in 1993, and the series are too short to show any trends.

Climatic factors may be important but no relationships can be shown. Preliminary work has been carried out in Monterey to relate climatic effects to intensity of recruitment. Modeling is in progress but no relevant data are ready to verify the modeling.

RELATIONSHIP BETWEEN RECRUITMENT AND PRODUCTION

The observations on the level of recruitment have important consequences in terms of help for the management of the fishery. It seems to be logical to predict the stocks in next months as a consequence of the present recruitment.

The biological argument seems to be logical, but for that fishery, it is also obvious that the estimations of the CPUE of the small shrimps is biased by the strategy of the boats and it is difficult to get reliable prediction of the production. As an illustration of the problem we examined the relationship between the index of abundance of the stock (all commercial categories, except the smallest category IV) and the recruitment index (category IV only), for the whole period (35 years) when data were suitable (Figure 1).

If there was a relationship between the recruitment index and the production of the stock four or five months later, we should observe a relationship between the two series. For example, after a high period of recruitment a high period of abundance would be observed. Short-term variability was eliminated by smoothing the series.

The recruitment index shows two important increases: from 10 to 30, and 30 to 50; neither of which are accompanied by any increase of the value of the index of stock abundance. Similarly, increases and decreases of the general level of the stock are not reflected in the variations of the recruitment index. It seems that the variations of the two series are completely independent.

It seems difficult, at the moment, to use these indices directly, without a correction from the dynamics of the fleet and/or from the catchability of the various age-groups of the stock.

The evaluation of reliable recruitment indices is always difficult. But the purpose of that work is to get good indices of the level of the stock to give advice for the management of the fishery. Many others ways can be used for these assessments but it is very important to get a good relation between the quality and the price of the information. At the moment, the climatic factors can be studied and a relation between these factors and the abundance of the stock can be found.

The real problem is to define the exact purpose of the work: to get very precise value to establish a regulation by TAC, as recommended by the European Union or to get a knowledge of the biodiversity of the ecosystem including finfishes.

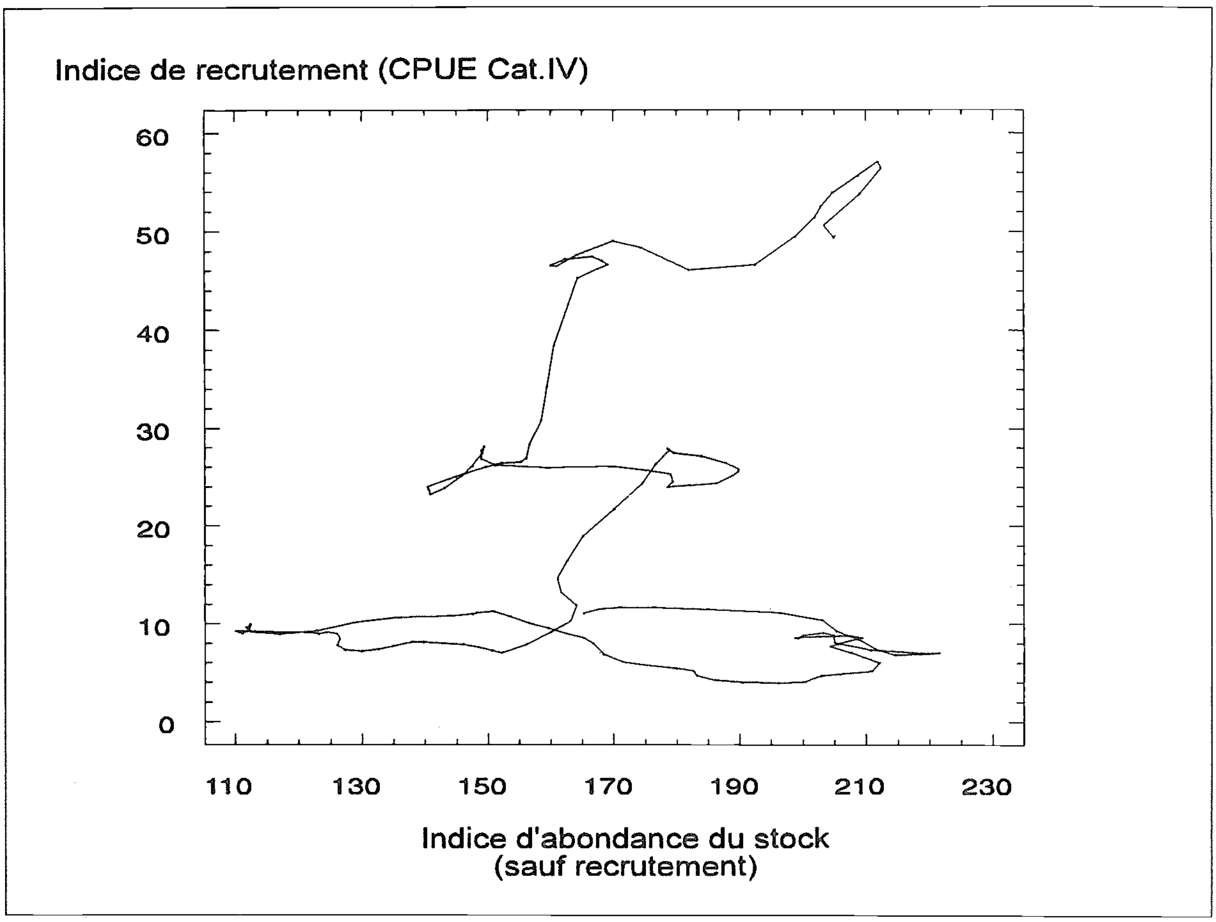


Figure 1: Simultaneous change of the recruit indices on the Y axis (CPUE of the category IV) and of the abundance of the total stock indices (all categories except category IV) on the X axis.

Collection of Biological Data, Identification and Biology of Selected Shrimp and Groundfish Species on the Guianas/Brazil Continental Shelf

A. Talbot[1], M. Benfield[2], L. Morton[3]

INTRODUCTION

This manual deals with biological measurements and species identification of shrimp and groundfish. It is divided into three information levels for ease of use. It incorporates an increasing level of detail as you progress through it. The first level of the manual (section 2) deals primarily with measurement methods. It is all a data collector really needs to know to accomplish his or her sampling work. It is relatively short and encourages the reader to become thoroughly familiar with its content. In the second level, species identification is facilitated through the diagrams and figures found throughout the text and should be referred to when needed. These figures are self-explanatory and are used for species identification. The table of contents can be used to quickly locate the required information on a species. The third level offers an in-depth discussion of the biology of the animals you will be working with. This is the text of sections 3 and 4. It can be used to enhance your personal knowledge and to become, in time, better, more experienced data collectors. It will allow you to discuss from a knowledgeable perspective with the fishermen, who also have much experience in the habits of the species they harvest, but less of the biology of the species.

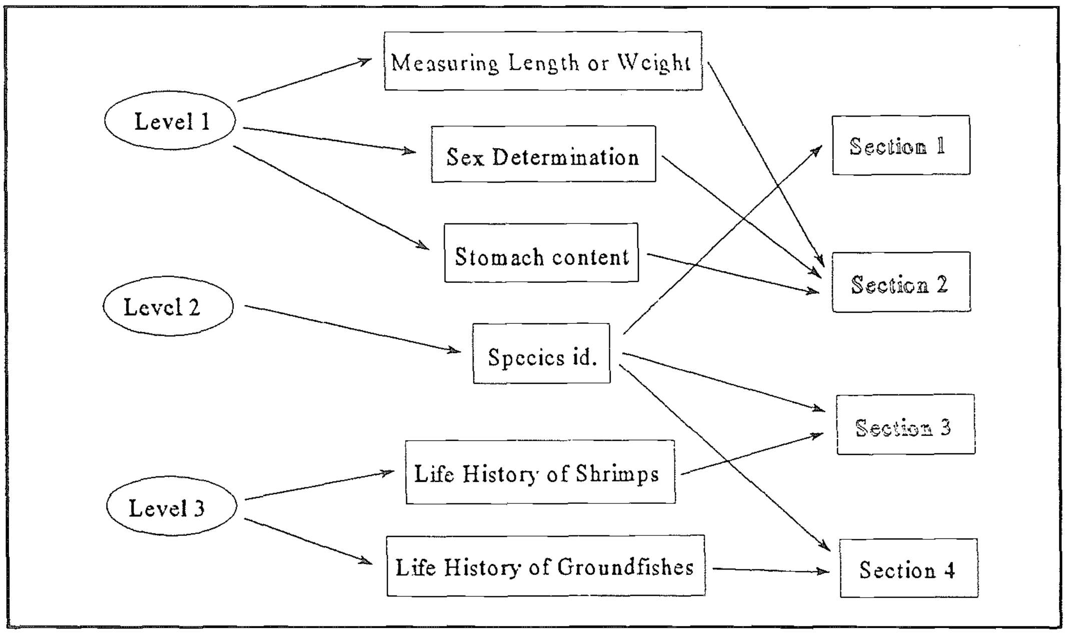


Figure 1: Organisation of this manual. "Levels" indicate the conceptual structure, whereas Sections refer to sections of the manual.

[1] CFRAMP Shrimp & Groundfish Resource Assessment Unit, Trinidad & Tobago.

[2] Woods Hole Oceanographic Institute, MA, U.S.A.

[3] University of the West Indies, St. Augustine, Trinidad & Tobago.

As with all natural systems, we do not have a perfect or complete knowledge of our environment and the species on which the fisheries depend. Nor does this manual pretend to be comprehensive. We would appreciate your inputs and comments on the present document, taken from your personal experience and those of the fishermen you work with, so that future versions of this guide can be improved.

The shrimp and groundfish species of primary and secondary interest to Trinidad and Guyana are as follows:

Penaeidae	Southern white shrimp, *Penaeus schmitti*
	Southern pink shrimp, *Peneus notialis*
	Redspotted shrimp, *Peneus brasiliensis*
	Southern brown shrimp, *Peneus subtilis*
	Seabob, *Xiphopenaeus kroyeri*
Palaemonidae	Whitebelly shrimp, *Nematopalaemon schmitti*
Arridae (catfishes)	Gillbacker (*Arius parkeri* or *Arius proops*)
	Arius grandicassis
	Bagre marinus
	Bagre bagre
Centropomidae	Snooks (*Centropomus undecimalis*)
Scianidae	King weakfish (bangamary, *Macrodon ancylodon*)
	Acoupa weakfish (gray snapper, *Cynoscion acoupa*)
	Jamaica weakfish (bashaw, *Cynoscion jamaicensis*)
	Green weakfish (trout, *Cynoscion virescens*)
	Whitemouth croaker (*Micropogonias furnieri*)

For species of importance in the by-catch from industrial shrimp operations, we have in addition to the above:

Scianidae	Shorthead drum (*Larimus breviceps*)
	Butterfish (*Nebris microps*)

Not all of the above species can be monitored for an eventual full stock assessment. Trinidad and Guyana will have to decide on one or two species of each major functional groups of groundfish (see section 4.0 below) for primary data collection. As for the shrimps, these must be considered as a whole because they are often harvested by the same fisheries in various abundance and proportions throughout the year and in various fishing zones. For the primary species, we will target at least 200 measured specimens per month. For the secondary species, we will target at least 200 specimens per 3 month period. For tertiary species, initially no biological data will be routinely collected unless it becomes important for certain times of the year or fishing gear combinations. For a complete description of the biological data collection programme, please refer to the document entitled "Biological Data Collection for participating countries" produced by the Shrimp and Groundfish RAU. In Trinidad and the Guyanas, the most important commercial species of shrimp are *Peneus subtilis*, *P. brasiliensis*, *P. notialis*, *P. schmitti* and *X. kroyeri*. Dragovich *et al.* (1980), describe *P. subtilis*, *P. brasiliensis*, *P. notialis* as eulittoral and sublittoral, mainly marine animals, and *P. schmitti* and *X. kroyeri* as eulittoral, euryhaline animals, based on their observed depth ranges and frequency of occurrence at different salinities. On the Guiana/Brazil continental shelf *P. subtilis* has been observed at depths from 12.8 to 91 m, *P. brasiliensis* from 30 to 90 m, and *P. notialis* from 27 to 62 m. *P. schmitti* and *X. kroyeri* are found in shallower waters, *P. schmitti* between 4 and 48 m, and *X. kroyeri* between 4 and 44 m (Dragovich, *et al*, 1980; Garcia and Le Reste, 1981), resulting in significant overlap in distribution with soft-bottomed fishes of various groups. The habitat preferences of penaeid shrimp in the Guiana/Brazil continental shelf region have not been as well studied as those of the Gulf of Mexico stocks. However, it is interesting to note that *P. notialis*, *P. schmitti* and *P. subtilis* each have similar habitat distributions to, and show an affinity to one of the penaeid species in the Gulf of Mexico - *P. duorarum*, *P. setiferus* and *P. aztecus* respectively, and were formerly considered subspecies of the later.

BIOLOGICAL MEASUREMENT OF SHRIMP AND GROUNDFISHES

MEASURING LENGTH AND WEIGHT OF SHRIMP

The biological data collected on shrimp will be carapace length and tail length. Figure 2 shows the technical terminology of the shrimp anatomy.

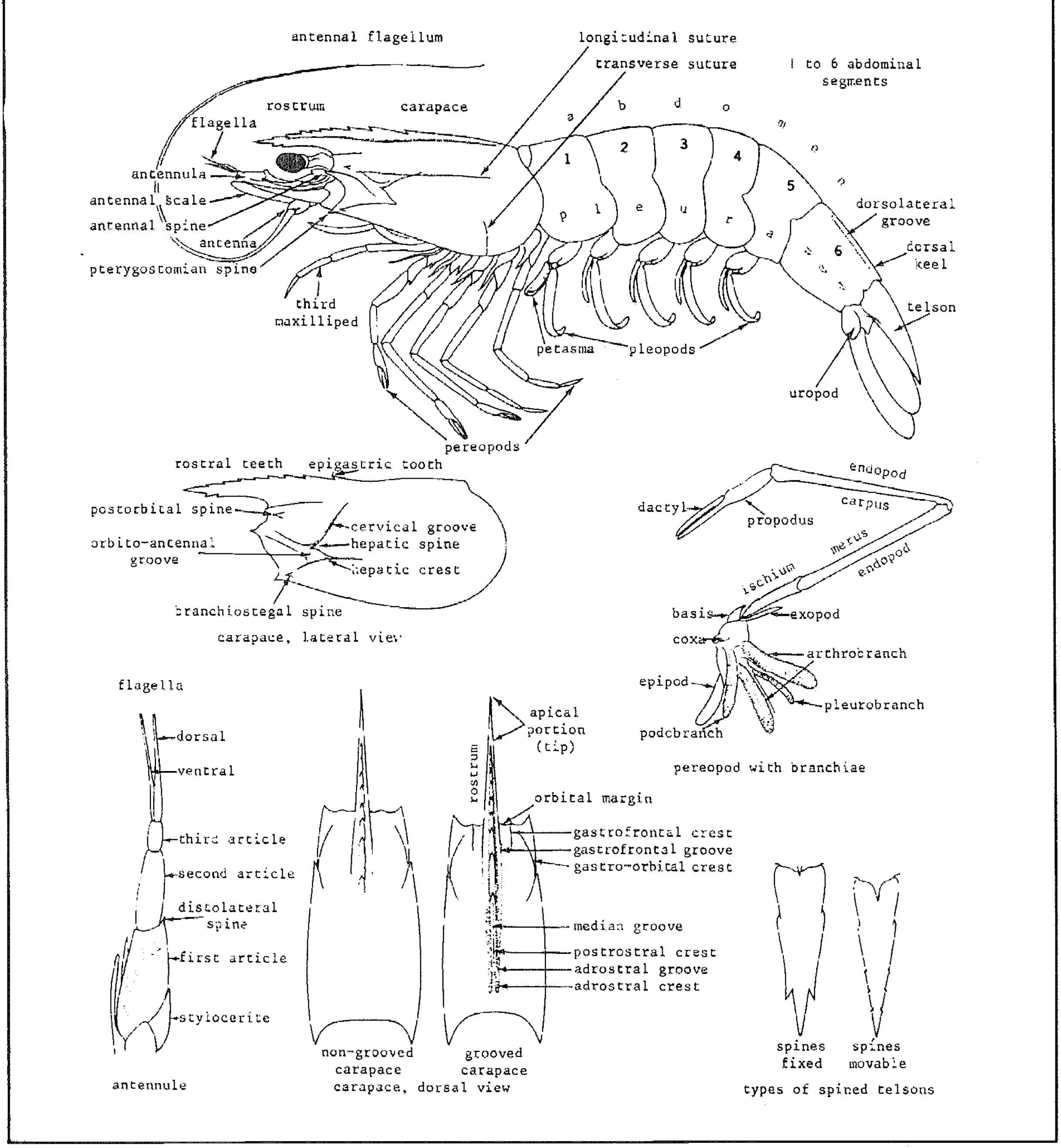


Figure 2: Technical terms of the morphology of shrimp. Figure from Perez-Farfante (1978).

Each species is to be recorded individually. The following procedure will apply:

1. Use fresh specimens unless otherwise impossible. Then, thawed frozen specimens or preserved specimens can be used. The preservation method must then be recorded on the sample sheet.
2. Place the animal on either a measuring board or hold it firmly in your hand.

3a. This technique is to be used when the shrimp are whole.

To measure the carapace length, place the calipers from the orbital margin near the rostrum and measure to the dorsal margin of the carapace (body) (Figure 2, 3).

3b. This method should be used only if the shrimp are landed without the carapace (tails only).

To measure the abdomen (tail), make sure that the abdomen is whole (that there are no somites missing). Place the calipers on the first anterior somite and measure to the end of the last somite but excluding the dorsal keel, which sometimes extends past the edge of the somite. Exclude the telson (last segment, Figure 2, 3).

4. Measure the carapace or tail length using 1 mm intervals.
5. Round to the nearest unit above or below. Systematically rounding off the nearest unit below will introduce a bias in the samples.

In addition to body length, the individual weights of a subset of individuals must be taken. As a guideline to begin data collection, one specimen in 10 should be weighed. This figure can be refined depending on the existence of published length-weight relationships, sample availability and field experience.

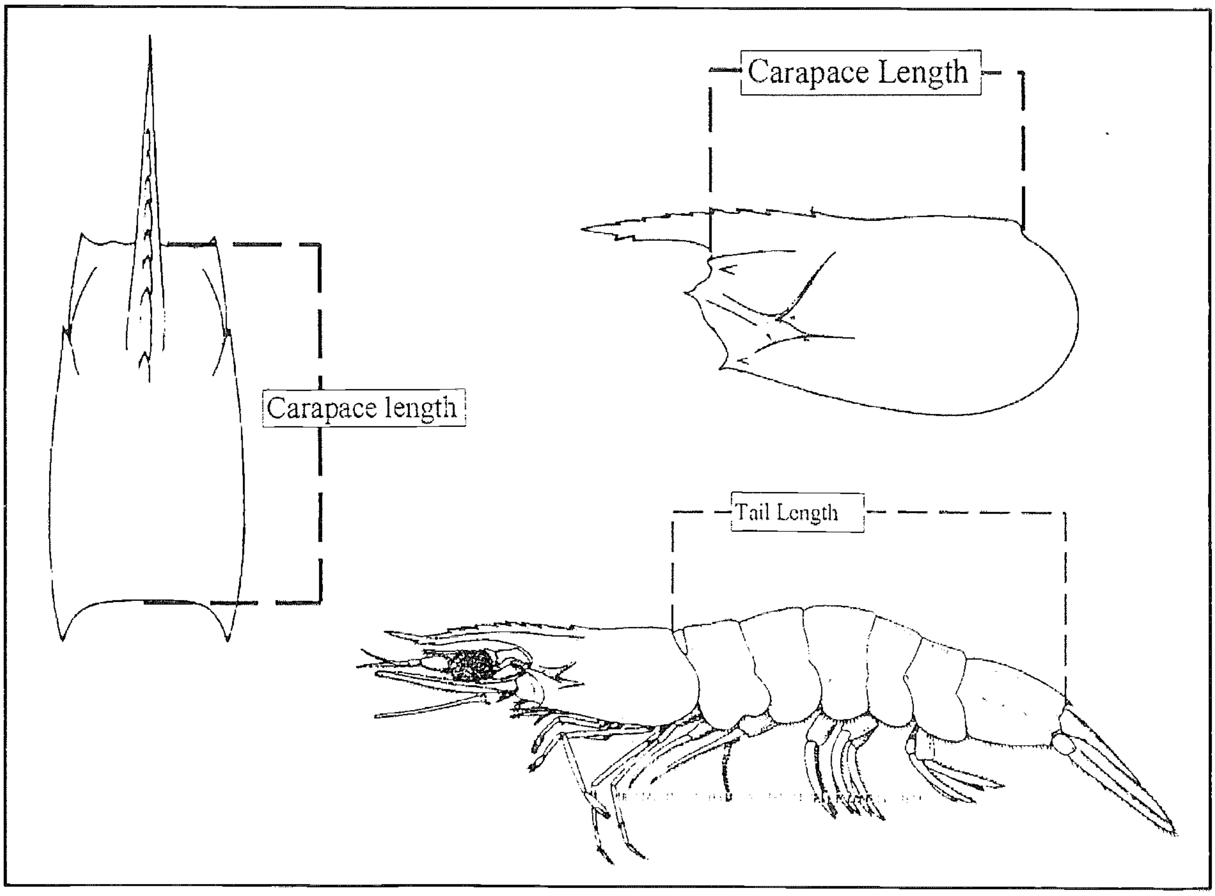


Figure 3: Length measurements for shrimp. Pictured is the white shrimp, *P. schmitti*.

MEASURING LENGTH AND WEIGHT OF FINFISHES

To measure finfishes, we will adopt the method prescribed in Module 3 of the Training in field data collection ("Measurement and recording of catch, effort, fish length and mass," March 1995), prepared by Peter A. Murray on behalf of the Pelagic and Reef Fishes Resource Assessment Unit, except that the length measurement will be rounded to the nearest upper or lower value (not systematically the lower value). Initially, body weight will also be recorded for one specimen in 5. This will be refined based on sample availability, field experience, availability of length-weight relationships in the literature, etc.

DETERMINATION OF SEX AND MATURITY

Shrimp have distinct sexes. It is important to sex the shrimp sampled for length frequencies because the sexes have markedly different growth rates, survival and migration patterns. This can only be achieved if the shrimp are landed whole, or if tail samples are collected before processing. Head parts are usually removed from large or extra-large shrimps. In these, when heads are roughly removed from the body on board the ship, the petasta in males (Figure 2, 3 and individual species identification diagram in Section 3.3) remain with the tail (abdomen). In large shrimps, even if these are accidentally torn off, the scar is recognizable, but these individuals should be set aside and not counted until the data collector has gained significant experience in sexing individuals. The determination of the sex of shrimp is given in the chapter on shrimp life history below (Section 3) and differs slightly from species to species. In Venezuela, sex could be recognized at 7 cm total length for *P. schmitti.* It is probably in that same magnitude for other large shrimp species.

Maturity in females can be recorded by noting the presence of eggs among the pleiopods in the abdomen section. It is much more difficult to determine maturity for males.

Determination of the sexes for the finfishes is difficult except in mature specimens. Sometimes, milt can be extracted from the body cavity of males my squeezing gently from the front of the abdomen towards the anal pore in ripe males. Females may produce eggs the same way, but this is more difficult. Morphological differences are sometimes apparent between sexes and between mature and immature individuals (see Module 4: "How to determine sex and maturity of fish", March 1995, by Dawn Phillip on behalf of the Pelagic and Reef Fishes Resource Assessment Unit). To ensure proper determination of the sexes and maturity status, dissection of fresh or preserved specimens is required, but often the body cavity has been cleaned out before the fish are landed. In such a case, purchase of whole fish from the fishers is required through some arrangement with the owner or captain before he sets out to sea. Otherwise, fishes that are selected for weighing will be dissected, and their sex and maturity status determined.

STOMACH CONTENT ANALYSIS IN FINFISHES

Stomach content analysis will allow scientists to determine the ecological link between the various species of groundfishes and the shrimp population, by a seasonal analysis of prey items in the gut.

For the fish that are weighed and opened for the determination of sex and maturity. The stomach will also be collected and preserved for further analysis. There are several precautions to follow. Not all fish stomachs are identical, and you must ensure that the entire contents of the stomach is collected.

1. Have a ready supply of small (10 ml, 25 ml) bottles. Have on hand a preservative (a liquid of at least 75% alcohol per volume or a solution of 4-5 % formaldehyde).
2. Identify the stomach for the particular species sampled. Note (on your data sheet) if the fish has regurgitated its contents. If this were so, there would be food in its mouth or in the esophagus. If such cases, no further work is necessary.

3. Cut the esophagus above the stomach and the small intestine below the stomach. Place the stomach carefully in the bottle and fill with preservative.
4. Fill out a sample tag with the fish id, boat id, species, length, date, site, and fishing gear. Insert tag in the bottle with the stomach. This is extremely important.

   These will later be analysed in the laboratory.

SHRIMP LIFE HISTORIES

GENERALIZED PENAEID LIFE HISTORY

Penaeid shrimp are relatively short-lived (1-2 years) decapods inhabiting warm-temperate, subtropical and tropical oceans. Although life-histories vary among species, most of the economically important penaeids have a life-cycle (Figure 4) which includes a period of estuarine residence (Garcia & Le Reste, 1981). Estuaries provide juvenile shrimp with abundant food (Zimmerman *et al.*, 1990), places to hide (*refugia*) from predators (Minello & Zimmerman, 1983) and favourable temperatures for rapid growth (St. Amant *et al.*, 1965). After emigrating from estuaries as juveniles or subadults, shrimp move into progressively deeper waters and further from the coast. Those which survive natural predators and fishing pressure complete their sexual maturation, mate and spawn.

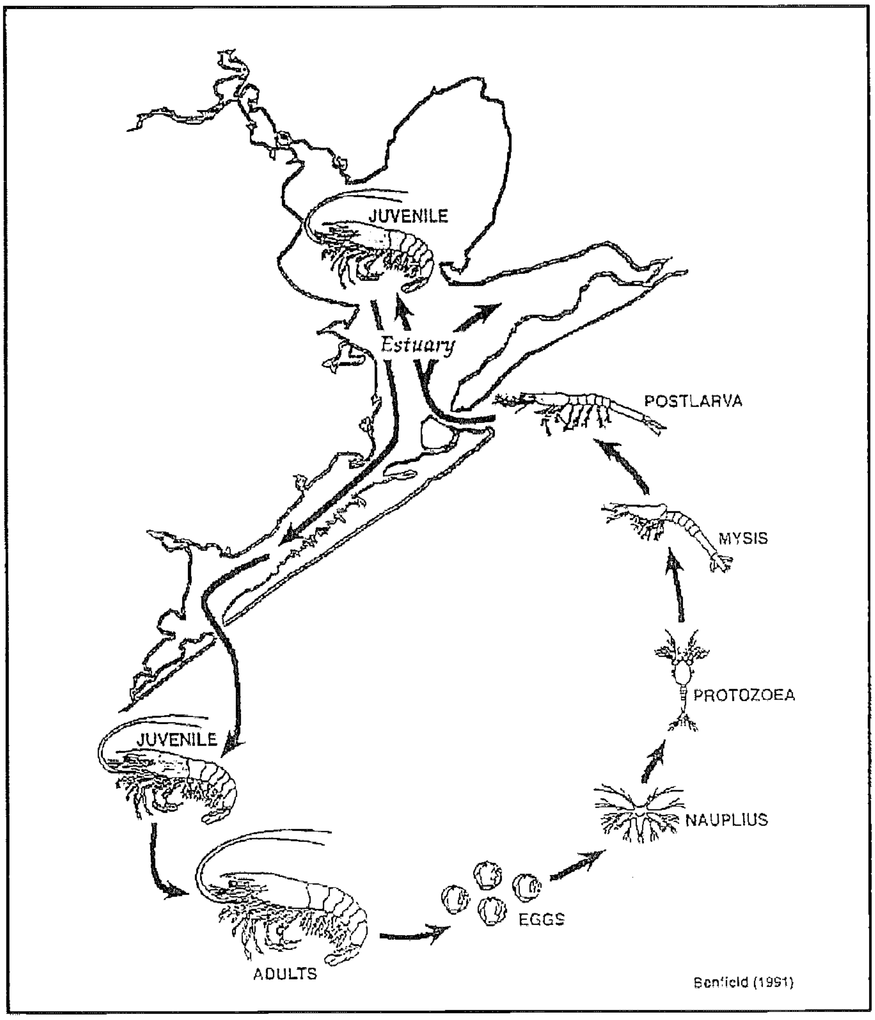


Figure 4: Generalized life history and migration pattern for estuarine-dependence penaeid shrimp. After Banfield (1991).

Adults spawn offshore and release demersal eggs that hatch and pass through a series of larval stages (5 nauplius, 3 protozoeal, 3 mysis) leading to the postlarval stage. During this development period, transport towards the coast normally takes 3-4 weeks (Garcia, 1985). The early larval stages are weak swimmers and their transport is likely a passive consequence of favourable currents (Jones *et al.*, 1970). Vertical migration strategies to exploit favourable currents were reported for penaeid larvae in the Gulf of Carpentaria (Rothlisberg, 1982) and ontogenetic changes in the vertical distributions of Gulf of Mexico penaeids suggest some differences (Temple & Fischer, 1965; Jones *et al.*, 1970); however, attempts to correlate these differences with onshore transport have been inconclusive. The bioenergetic arguments of Miller *et al.* (1983) against purely active transport of diadromous fish larvae appear applicable to these early shrimp larval stages. Postlarvae are stronger swimmers, capable of swimming against weak currents (Hughes, 1969a) and may exert greater control over their lateral and vertical displacement. Shanks (1987) collected significantly higher concentrations of unspecified penaeid postlarvae in slicks over tidally-induced internal waves in the South Atlantic Bight. He suggested that decapod larvae select depth to exploit onshore currents generated by internal waves or by winds.

Postlarvae in coastal waters gain access to estuarine systems via tidal passes and are generally thought to employ selective tidal transport to move into estuaries. This is a consequence of postlarval behaviour(s) that place the animals in the water column during flood tides and on or near the bottom during ebb tides. Postlarvae then ride flood tides into the estuary and resist seaward flushing during ebbs. Increased postlarval abundance in the water column during flood tides has been reported in estuarine systems throughout the world (Copeland & Truitt, 1966; Duronslet *et al.*, 1972; Mair *et al.*, 1982; Staples & Vance, 1985; Forbes & Benfield, 1986; Lochmann, 1990). Vertical migration is attributed to several possible synchronizing factors including salinity (Hughes, 1969a; 1969b), endogenous rhythms (Hughes, 1972) and pressure (Forbes & Benfield, 1986). It should be emphasized that the high variances associated with most planktonic samples often make it difficult to demonstrate statistically significant differences in vertical distributions.

Postlarvae become progressively more benthic after entering estuarine systems and appear to move into shallow water habitats. Parker (1966) concluded that postlarvae used central channels to penetrate into Galveston Bay, Texas, and subsequently fanned out towards peripheral shallow water habitats. Higher postlarval densities in the vicinities of channels were also noted in North Carolina by Williams (1969a). Little is known about the mechanisms employed by postlarvae to locate their nursery habitats. Shortly after ingress into estuaries, postlarvae metamorphose into juveniles, which aside from the lack of functional reproductive systems, are morphologically similar to the adults.

The estuarine habitat preferences of penaeids are species dependent and strong associations have been noted between various species and seagrasses, mangroves, emergent grasses, soft-muds or sandy bottoms. These associations may in part, reflect dietary differences among species. Physical structure confers protection from predators (Minello & Zimmerman, 1983; 1985; 1991). In addition, spatial differences in distributions coupled with temporal differences in estuarine recruitment and diel activity patterns may reduce interspecific competition among congeneric penaeids. The estuarine habitat specificity of penaeids may, in the long term, determine their regional distribution and abundance (Staples *et al.*, 1985). For example, *P. japonicus* postlarvae were abundant in the St. Lucia estuary off Natal, South Africa yet the adults of this species are rare in offshore commercial catches (Forbes & Cyrus, 1991). This shrimp requires sandy bottom estuarine habitat and the estuaries along Natal are predominantly soft mud. The lack of appropriate estuarine habitat means that survival of *P. japonicus* postlarvae (presumed to originate from populations to the north) is low, hence their corresponding absence in commercial catches. Growth rates within estuaries are temperature dependent and frequently approach 1 mm total length (TL) per day (Minello *et al.*, 1989b).

Shrimp remain within estuaries for approximately three months although some species overwinter and emigrate during the following spring. As shrimp grow, they move into progressively deeper water (Baxter *et al.*, 1988) and emigrate offshore as juveniles/subadults. Emigration by many species of *Peneus* is frequently coincident with declines in salinity (Rothlisberg *et al.*, 1985; Staples & Vance, 1986; Jayacody & Costa, 1988) or temperature (Pullen & Trent, 1969; Matylwich & Mundy, 1985) or lunar phase (King, 1971) Once offshore, shrimp undergo further growth and sexual maturation and then spawn.

SPECIES-SPECIFIC HABITAT PREFERENCES

Overall, habitat function may differ for the various species of shrimp depending on the particular strategy of habitat utilization of each species. It is important to understand the specific habitat preferences of the commercially important species in the Guiana/Brazil continental shelf region for effective management.

GENERAL PRINCIPLES OF SPECIES IDENTIFICATION

In this region, 95 % of the shrimp sampled will belong to one of the 7 species described in this chapter. Only rarely will you encounter any of the other species. Therefore, you should concentrate your energies on learning these species well. The other species are not much of a concern to us, as we are not collecting biological data on them. In time, and if any other species are frequently encountered in the catches, then you can identify them with the help of guides such as Cervigon *et al.* (1993) or Fischer (1978).

In shrimp, body colour should never be used for species identification, even though the common names of the different species might be pink, brown, white or red. The individual body colouration varies too much from individual to individual to be a reliable characteristic. In fact, the "brown" shrimp in English is called the "grey" shrimp in French and the "coffee-coloured" shrimp in Spanish. This is even more important in frozen or preserved or even unfresh specimens.

Identification of headless shrimp is particularly difficult. However, all is not lost. There are a few particularities of the tails of shrimp that can help us to identify them reliably.

If the last abdominal segment is observed carefully, the dorsal keel and the dorsolateral groove on it has been found to match the shape and size of the groves and crests on the dorsal surface of the carapace (Figure 5). If the adrostral grove and crest are long and broad on the carapace, the dorsolateral grove and crest will also be long and broad on the last abdominal segment. They will be long and so, the same identifying characteristics can be used on the tails. It will require some practice to get comfortable with this technique.

The following key to the genera of shrimp of the family *Penaeidae* occurring in this area might be useful for experienced data collectors:

1.a. Rostrum toothed on dorsal margin, usually also on ventral margin; Pleurobranch present on last thoracic segment.

- **2.a.** Carapace hairy . . . . *Funchalia*
- **2.b.** Carapace smooth . . . . *Peneus*

1.b. Rostrum toothed on dorsal margin only; No pleurobranch on last thoracic segment

- **3.a.** Telson tridentate, with a fixed spine on each side of tip; Inner border of first article of antennular peduncle bearing a spine (parapenaeid spine)

4.a. Carapace with longitudinal and transverse sutures . . . . *Parapenaeus*

4.b. Carapace without longitudinal or transverse sutures

5.a. Males with symmetrical petasma; A single arthrobranch on last thoracic segment, no trace of a second arthrobranch . . . . *Penaeopsis*

5.b. Males with asymmetrical petasma; 2 arthrobranchs present on last thoracic segment, one of them well developed, the other vestigial . . . . *Metapenaeopsis*

3.b. Telson usually without fixed spines; No spines on inner border of first article of antennular peduncle

6.a. Dactyls of fourth and fifth pairs of pereopods elongate and subdivided . . . . *Xyphopenaeus*

6.b. Dactyls of fourth and fifth paris of pereopods of normal shape and undivided

7.a. Carapace without longitudinal sutures . . . . *Trachypenaeopsis*

7.b. Carapace with longitudinal sutures

8.a. Dorsal flagella of antennules shorter than carapace and not much longer than ventral flagella; Fourth and fifth pairs of pereopods about as heavy as 3 anterior pairs; Exopod of fifth pair of pereopods well developed . . . . *Trachypenaeus*

8.b. Dorsal flagella of antennules longer than carapace and much longer than ventral flagella; Fourth and fifth pairs of pereopods filiform, more slender than 3 anterior pairs; Exopod of fifth pair of pereopods vestigial . . . . *Tanypenaeus*

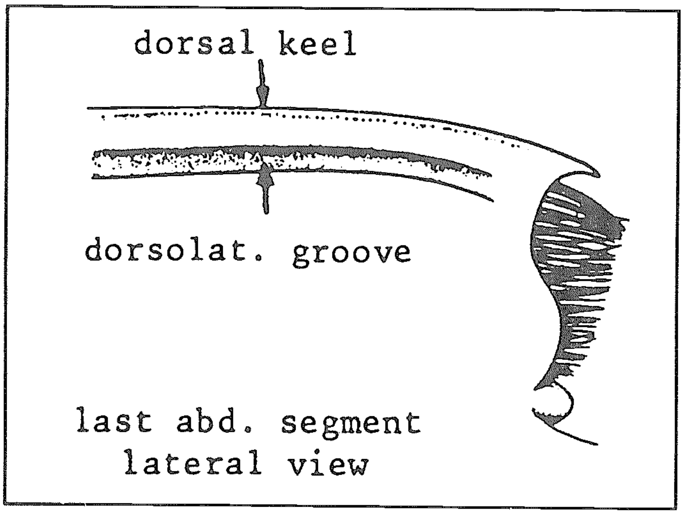


Figure 5: The features of the last abdominal segment of shrimp permits to identify shrimp species when they are landed head-off.

PENAEIDS OF THE BRAZIL-GUIANA SHELF

Five species of penaeid shrimp are exploited by artisanal and commercial fisheries along the Brazil-Guiana shelf: *Peneus brasiliensis*, *P. notialis*, *P. schmitti*, *P. subtilis*, and *Xiphopenaeus kroyeri*. In addition, a caridean shrimp *Nematopalaemon schmitti* is also harvested commercially. Prior to summarizing the life-history data for each of the penaeids in this region, it is useful to distinguish among the two subgenera of the genus *Peneus*. There is a worldwide distinction among white shrimp (subgenus *LitoPenaeus*) and brown shrimp (subgenus *FarfantePenaeus*) (Garcia, 1983; Holthuis, 1983). White shrimp, which include *P. schmitti*, are active during the day and are generally fished during daylight hours while brown shrimp, which include *P. brasiliensis*, *P. notialis*, and *P. subtilis*, are frequently fished at night because they tend to burrow under bright light conditions and emerge to forage at night or in elevated turbidities.

The ecology of the *Peneus* species of the Brazil-Guiana shelf have not been well studied. The data summaries which follow are based on geographically relevant data where available, supplemented by data from other localities.

Peneus brasiliensis

Peneus brasiliensis Lateille, 1817

FAO Common Names: En. - Redspotted shrimp, Pinkspotted shrimp (AFS); Fr. - Crevette royale rose; Es. - Camarón rosado con machas

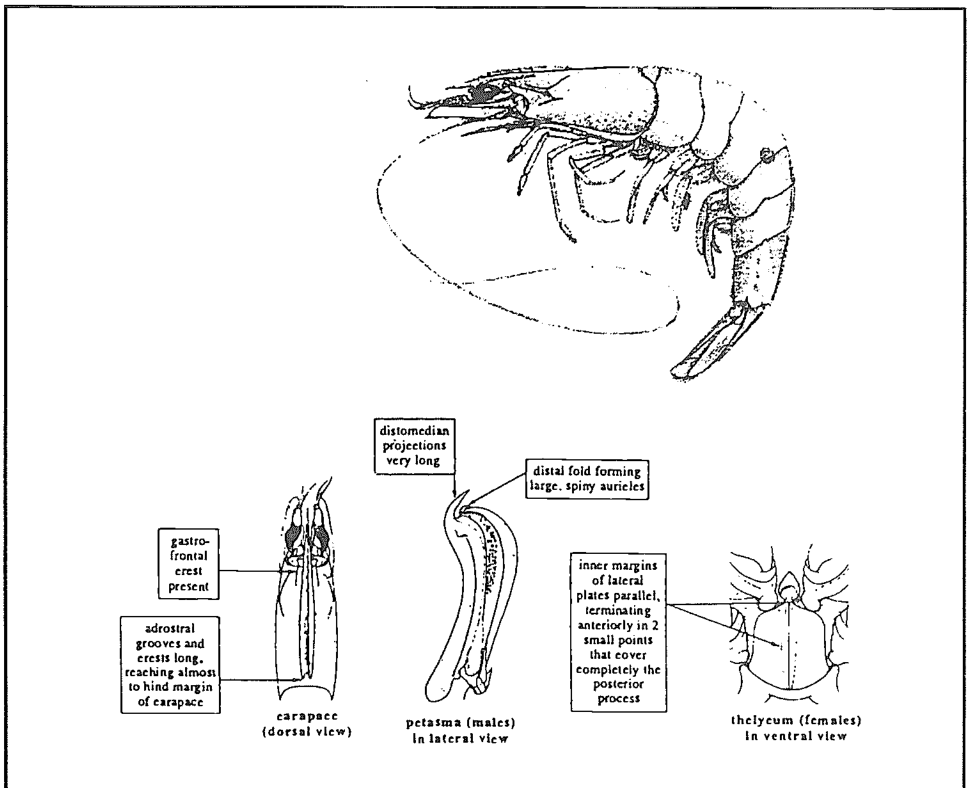


Figure 6: The pink-spotted shrimp, *Peneus brasiliensis*, with morphological details. This species is most abundant off the coast of Guyana and West Suriname, suggesting that nurseries are located mainly in Guyana. Note that there is a predominant pink, brown or red spot at the junction of the 3rd and 4th abdominal somite, found only in this species.

Distribution

Peneus brasiliensis occurs in the Caribbean sea and along the continental coast south to Rio Grande do Sul, Brazil (Cervigón *et al.*, 1993). Pinkspotted shrimp are the second most abundant *Peneus* species along the Brazil-Guiana shelf (Cavalcante & Dragovich, 1984). They are distributed throughout the region (Cummins & Jones, 1973) with concentrations off Suriname and Guyana (Cavalcante & Dragovich, 1984; Villegas & Dragovich, 1984). More recent data suggests concentrations of pinkspotted shrimp from French Guiana to eastern Guyana in deeper waters (WECAFC, 1989). Off Margarita Island, Venezuela, they represented 95-100% of the penaeid catch (Khandker & Lares, 1972). This species is found at depths from 3-365 m with peak abundances in deeper waters between 45-65 m (Cervigón *et al.*, 1993), 27-82 m (Cavalcante & Dragovich, 1984) or 55-72 m (Khandker & Lares, 1972). Japanese vessels off Suriname target pinkspotted shrimp in 40-100 m of water (Kawahara, 1989). Adult shrimp are associated with mud or sandy mud (Cervigón *et al.*, 1993), firm mud (Holthuis, 1983) or hard sandy bottoms often mixed with molluscan shells (Khandker & Lares, 1972). *Peneus brasiliensis* is nocturnal (Holthuis, 1983) and virtually all landings occur from twilight through the night (Khandker & Lares, 1972).

Spawning and Larval Drift

Little is known about the spawning periodicity of the pinkspotted shrimp. Low-level, year-round spawning is suggested by the presence of mature females in all monthly commercial samples off Guyana (Cavalcante & Dragovich, 1984). The presence of mature female *P. brasiliensis* in water >60 m deep off the French Guiana-Suriname border suggests a possible spawning ground (Dintheer & Rose, 1989). Khandker & Lares (1972) suggested that pinkspotted shrimp juveniles enter the commercial fishery during July-December. If shrimp enter estuaries at one month of age and remain for three months, then spawning begins around March. Successful reproduction and development to the juvenile stage has been reported in Alazïo Lake, Brazil (Boddeke *et al.*, 1977). Apparently water can enter this system only via pumps and the authors noted females with ripe ovaries as well as numerous juveniles within the lake after the pumps had been shut off for four months. If this is correct, it is very unusual for this genus.

Assuming that spawning occurs from French Guiana to Suriname border region, larvae would be transported by the Guiana current to estuaries along Suriname and Guyana. Some confirmation of this exists for Suriname because the artisanal fishery there is known to exploit small *P. brasiliensis* and large concentrations of this species are reported in the estuaries of eastern Suriname (Cavalcante & Dragovich, 1984). The presence of pinkspotted shrimp in the artisanal fishery of Guyana could not be confirmed but seems likely. Pinkspotted shrimp are common along the Guyana coast (Cummins & Jones, 1973) suggesting a local nursery ground. Thus, major spawning grounds appear to be along the eastern section of the Brazil-Guiana shelf with larval drift supplying recruits to estuaries along Suriname and Guyana.

Postlarval Recruitment and Estuarine Residence

Boddeke *et al.* (1977) citing Novoa *et al.* (1976) reports that postlarval *P. brasiliensis* are scarce along the coast of Venezuela near Margarita Island from November-March. The presence of large concentrations of juvenile pinkspotted shrimp in estuarine areas of eastern Suriname during April-June (Cavalcante & Dragovich, 1984) suggests early spring recruitment. Stoner (1988) found consistent low-levels of abundance throughout the year in a Puerto Rican lagoon. Juveniles favor sandy, silty (Khandker & Lares, 1972), or soft mud bottoms (Holthuis, 1983).

Emigration from estuaries may take place during the fall and early-winter (Khandker & Lares, 1972). Off Suriname the catch rates of larger shrimp (>100 mm tail length) by Japanese trawlers declined from July-August and September-October while the modal size declined to 80 mm tail length (Kawahara, 1989). That author suggested that the reduction in size indicated recruitment of smaller shrimp which suggests emigration takes place earlier during late-summer. Selective fishing mortality cannot be excluded as a cause for the decline. In Brazil, near Macau, *P. brasiliensis* emigrates from Alazïo Lake from October-May (Boddeke *et al.*, 1977). Emigration may have been stimulated by lunar phase or tidal currents. Cavalcante & Dragovich (1984) speculated that recruitment to the offshore fisheries were primarily from the estuaries of eastern Suriname because this was the only region where *P. brasiliensis* juveniles were abundant. Fishermen report good grounds for small pinkspotted shrimp in the deeper waters of western Suriname during July-September (Kawahara, 1989).

Maturation

Tagged pinkspotted shrimp that were released off Suriname, were all recaptured in Surinamese waters at the same depth as they were released (Cavalcante & Dragovich, 1984) suggesting that this species does not migrate over long distances after emigration from estuaries. This conflicts with a report by Kawahara (1989) that small pinkspotted shrimp captured in Suriname are thought by fishermen to be recruited from Guyana. Juveniles which emigrate from Suriname and Guyanese estuaries would need to migrate offshore initially, and then to the southeast. Kawahara (1986) proposes such a migration, which runs counter to the Guiana current. However, recent work indicates that there may be a counter-current offshore of the coast of Guyana (Martec Inc. 1995). A WECAFC conference concluded that *P. brasiliensis* undertake a migration from Guyana to French Guiana (WECAFC, 1989). Petasmal fusion occurs in shrimp as small as 114 mm TL and this species may survive for three years (Khandker & Lares, 1972).

Fishery

Juveniles are taken in estuaries and shallow coastal waters with seines, cast nets, push nets and dip nets (FAO, 1977), however, the geographic location of these estuaries was not specified. Pinkspotted shrimp are likely important in artisanal catches from Venezuela through Suriname and also in northern Brazil based on their distribution and some tagging studies of juveniles. Commercial trawlers exploit this species which is marketed frozen with some smaller proportion sold as fresh or canned product (Cervigòn *et al.*, 1993).

Species-specific Habitat Preferences

Pink-spotted shrimp are associated with sandy substrate. In samples over the Guiana/Brazil continental shelf this species was found principally over sandy bottom (Dragovich *et al.* 1980). Penn (1984), from personal field observations, also reported that this species is found in sandy substrate and burrows during the day. It is active at night where it is assumed to come out only to feed (and possibly to spawn every so often during recruitment periods).

Pink-spotted shrimp are found throughout the region at depth of 30-90 m (Dragovich *et al.* 1980). This is somewhat deeper than the brown shrimp (Ehrhardt, 1986), although there is considerable overlap.This species is predominant off W. F. Guiana, Suriname and Guyana (Dragovich and Coleman, 1980, Willman and Garcia 1985).

Large areas of concentrations of juveniles of pink-spotted shrimp have been reported off East Suriname in April-June, according the Suriname Fisheries Department. Suriname is the only area in the Guiana/Brazil continental shelf region where large quantities of juveniles are reported caught by fishing companies in Paramaribo. This suggests that recruitment to the offshore fishery is a product of this area mainly. However, it is suspected that the artisanal fishery in Guyana also catches this species in quantities, but the catch records are not available by species.

In Guadeloupe the juvenile migration out of the nurseries reaches its maximum in the wet season, when the temperature and salinity are minimal (Rojas-Beltran, 1982). *P. brasiliensis* was the second most important species captures in Guadeloupe, after *P. subtilis*, and closely followed by *P. notialis*. The dominant nursery habitat types in Guadeloupe were mangroves, drained by canals and natural rivers with scattered small lagoons.

In US port sampling at Georgetown between 1976 and 1978, all four stages of maturity (females) occurred during each month of the year, suggesting year-round spawning (Villegas and Dragovich, 1984).

As for *P. subtilis*, males are more abundant than females in landings at Georgetown, and females reach a larger size than males (Villegas and Dragovich, 1984).

Peneus notialis

Peneus notialis Pérez-Farfante, 1967

FAO Common Names: En. - Southern pink shrimp; Fr. - Crevette rodché du sud; Es. - Camarón rosado sureño

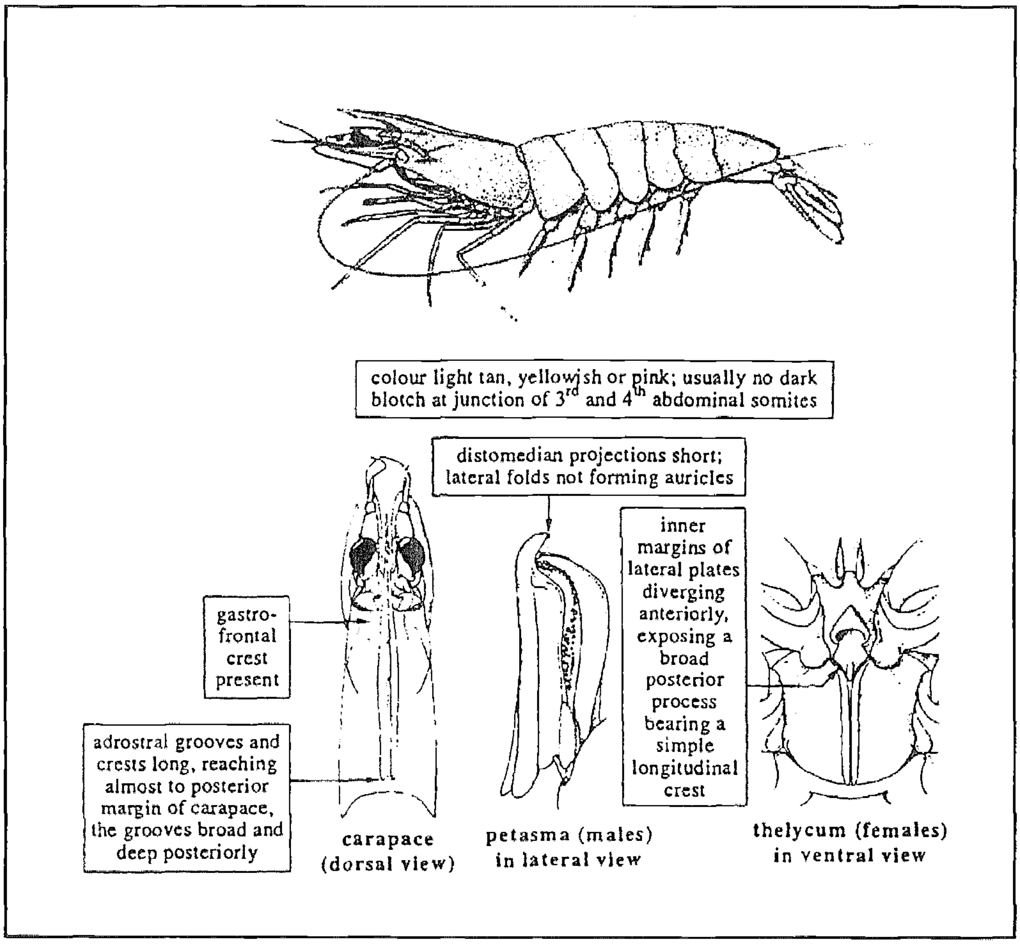


Figure 7: The southern pink shrimp, *Peneus notialis*, with morphological details.

This species may be referred to as *P. duorarum* in some older papers but is now recognized as a valid species.

Distribution

Penaeus notialis occurs in the Greater Antilles from Cuba to the Virgin Islands and along the continental coast form Quintana Roo, Mexico to at least Cabo Frio, Brazil (Cervigón *et al.*, 1993). Over the Brazil-Guiana shelf it is the third most abundant *Penaeus* species with a distribution restricted to waters off Guyana, Suriname, and the western part of French Guiana (Cavalcante & Dragovich, 1984). Surveys by Cummins & Jones (1973) limited the distribution of pink shrimp to waters off Guyana; however, low numbers of large adult female pink shrimp are captured by the Japanese fleet off Suriname along with pinkspotted shrimp (Charlier, 1989). Cervigón *et al.* (1993) indicate that it is also important further to the west in Venezuelan catches. Pink shrimp frequent mud and sandy bottoms as well as sand patches among rocks at depths from 3-100 m (Cervigón *et al.*, 1993). According to Cavalcante & Dragovich (1984) fishable populations occur primarily from 27-82 m. Pink shrimp are primarily nocturnal although some landings occur during the day (Holthuis, 1983).

Spawning and Larval Drift

Pink shrimp populations appear to contain some spawning individuals throughout the year. Ripe female shrimp were noted year-round in commercial catches off Guyana (Cavalcante & Dragovich, 1984) and off Cuba (Guitart *et al.*, 1985) while Stoner (1988) suggested that postlarval abundance patterns supported some year-round spawning off Puerto Rico. Ovarian development peaked in Cuban waters during May-July when 30-40% of female shrimp had mature ovaries (Guitart *et al.*, 1985). Peak spawning off Cuba occurred during January-April and August-December off both Cuba (Morenza *et al.*, 1992), and Puerto Rico (Stoner, 1988). Guitart *et al.* (1985) suggested that spawning was related to temperature, however, their relationship was inconclusive. Spawning appears to take place in 25-30 m off Cuba at night (Guitart *et al.*, 1988). Based on these data, pink shrimp along the Brazil-Guiana shelf probably spawn through late-summer and fall then again during early spring.

If spawning occurs off Suriname where the Japanese fishery captures mature females, then the larvae would be carried by the Guiana current to nursery grounds in Guyana, Venezuela and Trinidad. The presence of pink shrimp has been documented in the artisanal fisheries of the Brazil-Guiana shelf (Holthuis, 1983) but specific regions were not noted. More research is needed to define the spawning grounds, principal nurseries and migratory pathways of all life stages of this species.

Postlarval Recruitment and Estuarine Residence

Recruitment periodicity has not been documented for pink shrimp over the Brazil-Guiana shelf, however, Stoner (1988) noted two periods of ingress into a Puerto Rican lagoon during October, with a second, reduced peak during May-June. This is very similar to the recruitment periodicity of the pink shrimp *P. duorarum* in the Gulf of Mexico where it recruits into estuaries during late-summer and fall.

Estuarine habitat specificity has not been documented for this species however, it may be similar to *P. duorarum* which associates with sea grass (Costello *et al.*, 1986). No information was available on growth rates or migratory timing of emigration for *P. notialis*. Pink shrimp which immigrate during fall, probably overwinter and emigrate during the following spring, while postlarvae which enter during spring, probably emigrate during late-summer.

Maturation

No data were available on the development or dispersion of subadult pink shrimp. Migrations by subadults of the sort proposed for *P. brasiliensis* would be required to return stocks which used estuaries along Guiana and Venezuela, to their hypothesized spawning grounds off Suriname. No tagged pink shrimp were reported recovered by Cavalcante & Dragovich (1984) however, the low numbers tagged (115) made recovery unlikely. Von Bertalanffy growth curves for *P. notialis* in Guacanayabo Bay, Cuba were $L=95.2(1-e^{-0.339t})$ for males, and $L=139.2(1-e^{-0.205t})$ for females (Pérez *et al.*, 1988).

Fishery

Juveniles are taken in estuaries and shallow coastal waters with seines, cast nets, push nets and dip nets (Holthuis, 1983). Subadult and adult pink shrimp are exploited by an industrial trawl fishery and are marketed as fresh, frozen and canned. Although it is one of the most important species in Venezuelan landings, separate fishery statistics are not reported for this species (Cervigón *et al.*, 1993).

Species-specific Habitat Preferences

Pink shrimp are found throughout the region at depths of 27-62 m (Dragovich *et al.* 1980), probably because of ecological constraints. In samples over the Guiana/Brazil continental shelf this species was found principally over sandy bottom (Dragovich *et al.* 1980), but has been reported elsewhere over sediments with high levels of organic matter. It is found in sandy substrate and burrows during the day. This species appears to be nocturnal, coming out only to feed (Penn, 1984 from field observations). Worldwide, the distribution of *P. duorarum* (closely related to *P. notialis*) is limited by temperature, which must rise to a minimum of 24°C and rarely drop below 18°C (minimum bottom temperatures of 15-16°C) (Garcia and Lhomme 1980). This is probably related to metabolic processes limiting reproductive capacity.

In Guadeloupe juveniles migrate out of the nurseries at 3 - 6 months of age at a size of 60 -100 mm TL. This migration begins with the strong rains in September - October, reaches its maximum in the dry season, February - March, and decreases to reach its minimum in July-August (Rojas-Beltran 1982).

US port sampling at Georgetown between 1976 and 1978 found all 4 stages of maturity (females) occurred during each month of the year. This suggests year-round spawning (Villegas and Dragovich, 1984). Females are more abundant than males in landings at Georgetown. Females reach a larger size than males (Villegas and Dragovich, 1984).

Penaeus schmitti

Penaeus schmitti Burkenroad, 1936

FAO Common Names: En. - Southern white shrimp; Fr. - Crevette ligubam du sud; Es. - Camarón blanco sureûo

Distribution

Penaeus schmitti is distributed through the Greater Antilles from Cuba to the Virgin Islands and along the continental shelf from Belize to Laguna, Brazil (Cervigón *et al.*, 1993). Surveys by the R/V Oregon II during 1972 suggested that white shrimp were predominant only off Suriname (Cummins & Jones, 1973). Commercial landings for 1987 from one of the two major processing plants in Suriname contained very small quantities of large female white shrimp (Charlier, 1989), however, this may only reflect a fishery which targets other species in deeper waters. Surveys indicate that commercially important concentrations of white shrimp occur off Trinidad, Venezuela and Guyana (Villegas & Dragovich, 1984) and in the Gulf of Paria (Khandker, 1968). Although this species occurs all along the Brazil-Guiana shelf, it is the least abundant of the four *Penaeus* species (Cavalcante & Dragovich, 1984), and tends to be restricted to shallow (<37 m) waters (Villegas & Dragovich, 1984) and is often associated with mud substrates containing with a high organic content (Villegas & Dragovich, 1984). The northern white shrimp *P. setiferus* appears ecologically similar to *P. schmitti*. Northern white shrimp are abundant in regions of high freshwater discharge and the prevalence of *P. schmitti* along the section of the shelf which is most strongly influenced by riverine input suggests a similar association.

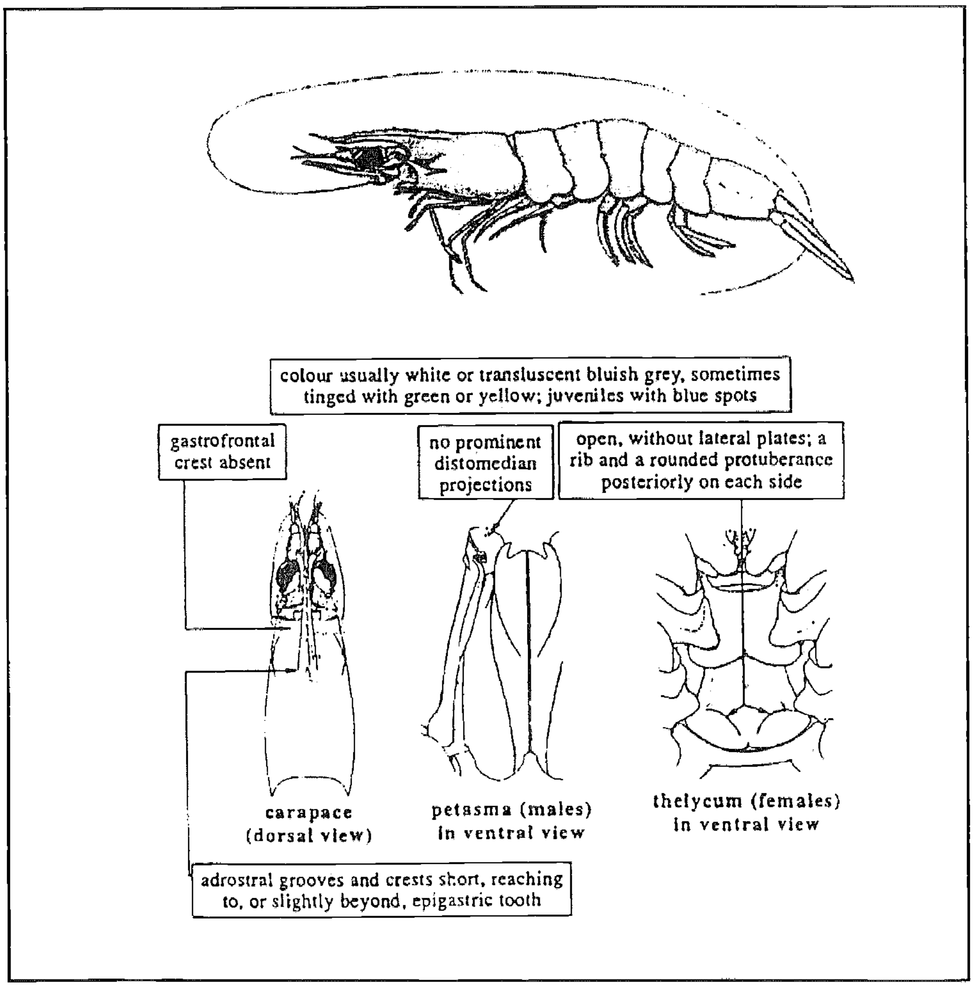


Figure 8: The southern white shrimp, *Penaeus schmitti*, with morphological details. This species is the least common of the 4 major commercial species.

Spawning and Larval Drift

Penaeus schmitti appears to spawn throughout the year with elevated spawning activity during late-spring and early-summer, possibly triggered by warmer water. Port sampling of the commercial catch at Georgetown, Guyana during 1976-78 revealed that ripe females were present during every month of the year (Cavalcante & Dragovich, 1984). While some spawning appears to occur throughout the year, peak spawning activity appears to be coincident with warmer water temperatures off Cuba (Guitart *et al.*, 1985). In Cuban waters, white shrimp spawning intensity increased during April-June (Guitart *et al.*, 1985), March-September (Pérez *et al.*, 1988), February-April and June-August (Morenza *et al.*, 1992). Spawning periodicity over the Brazil-Guiana shelf is not well documented however, Khandker (1968) noted that postlarval white shrimp began to enter Lake Unare, Venezuela during July. Assuming that these small postlarvae (8.5 mm TL) were approximately 3 weeks old, spawning in offshore waters would have occurred during June. White shrimp are reported to be total spawners with nocturnal mating (20h00-23h00) (Guitart *et al.*, 1988). Spawning occurs near shore in shallow (3-10 m) water (Pérez *et al.*, 1988).

There are concentrations of white shrimp in the Gulf of Paria and along the Venezuelan coast to the west. White shrimp are also found off Suriname and Guyana and further to the south off Brazil. Whether these are separate populations is unknown. The white shrimp off Brazil appear to be isolated as this species doesn't reappear along the coast until Suriname. Assuming that white shrimp spawn in shallow water near their nursery grounds, spawning sites from Suriname to the west would produce larvae which would recruit into estuaries along Guyana. Larvae could also be carried into the Gulf of Paria. Clearly, further research is required to locate the spawning sites of this species and determine where larval fluxes are directed.

Postlarval Recruitment and Estuarine Residence

Garcia Pinto *et al.* (1991) found year-round recruitment of *P. schmitti* postlarvae along the southwest coast of the Gulf of Venezuela, with elevated abundance from February-August. As mentioned earlier, postlarvae began to enter Lake Unare during the rainy season in July and were reported entering a Cuban lagoon during the same month (Morenza *et al.*, 1992). Little is known about their habitat requirements. González *et al.* (1984) reported higher juvenile abundances in the peripheral areas of a Cuban lagoon in salinities ranging from 15-47 psu. A closely related species from the Gulf of Mexico, *P. setiferus*, is associated with soft-bottom non-vegetated habitats (Zimmerman & Minello, 1984; Zimmerman *et al.*, 1990).

Estuarine growth rates are generally high and juvenile white shrimp in Lake Unare, Venezuela grew at approximately 1 mm TL per day (Khandker, 1968). The size at emigration is variable and migration is probably influenced by environmental factors. Size ranges of white shrimp juveniles in a Cuban lagoon were 33-65 mm TL (González *et al.*, 1984) while Khandker (1968) reported that juveniles in Lake Unare may be up to 90 mm TL. An interesting observation by Cavalcante & Dragovich (1984) reported that 37 tagged white shrimp (40-110 mm TL) were collected from the Maracana estuary in northern Brazil, released at a nearby offshore site, and recovered back in the estuary within 2 months of release. The size distribution of these recaptured shrimp was not noted, however, these recaptures may indicate that juvenile white shrimp retain a strong affinity for estuarine waters until they reach 90-100 mm TL. While the timing of emigration is not documented, a three month period of residency is common for penaeids (Garcia & Le Reste, 1981). White shrimp which entered during July could be expected to emigrate during October. White shrimp in Lake Unare reached a maximum size of 90mm TL in October (Khandker, 1968) supporting the fall emigration hypothesis.

Maturation

Little is known about the movements and growth rates of subadults in offshore waters. Given the shallow water nature of this species, white shrimp probably remain in shallow inshore waters after emigration from estuaries. Dispersal of tagged white shrimp off the coast of Cuba was only 0.315 km d^{-1} (Pérez *et al.*, 1988) suggesting only localized movement.

Fishery

White shrimp are taken by artisanal fisheries in estuaries (Khandker, 1968), in shallow coastal waters by small boats operating manual trawls. Seines, castnets, pushnets, trapnets and dipnets are also used to exploit juveniles (Holthuis, 1983). Subadults and adults are harvested in somewhat deeper waters by industrial trawlers using otter trawls (Cervigón *et al.*, 1993) and seines of Italian or American design

(Holthuis, 1983). White shrimp are marketed as frozen or fresh with a small portion salted. Most of the catch is exported.

Species-specific Habitat Preferences

In samples over the Guiana/Brazil continental shelf, this species was found over soft bottom consisting principally of clay (Dragovich *et al.* 1980). Associated with mud substrate that is relatively high in organic content. It is found in very turbid waters such as areas of river discharge.

This species is found throughout the region at depth of 4-48 m (Dragovich *et al.*, 1980). This is shallower than most other species. Commercial concentrations are found off Trinidad, Venezuela, Guyana and Para-Maranhao (Brazil). There may be two separate stocks in the region, with Guayana/Venezuela/ Trinidad forming one stock and Brazil the other.

White shrimp may school, generating high levels of turbidity themselves at times of reduced turbidity, e.g.. slack water in the tidal cycle. It is non-burrowing, and its activity is not restricted to night (Penn, 1984).

US port sampling at Georgetown between 1976 and 1978 indicates that all 4 stages of maturity (females) occurred during each month of the year, suggesting year-round spawning (Villegas and Dragovich, 1984).

Penaeus subtilis

Penaeus subtilis Pérez-Farfante, 1967

FAO Common Names: En. - Southern brown shrimp; Fr. - Crevette café; Es. - Camarón café sureño

In 1967, *P. subtilis* was described as a subspecies of *P. aztecus* and is now recognized as a valid species.

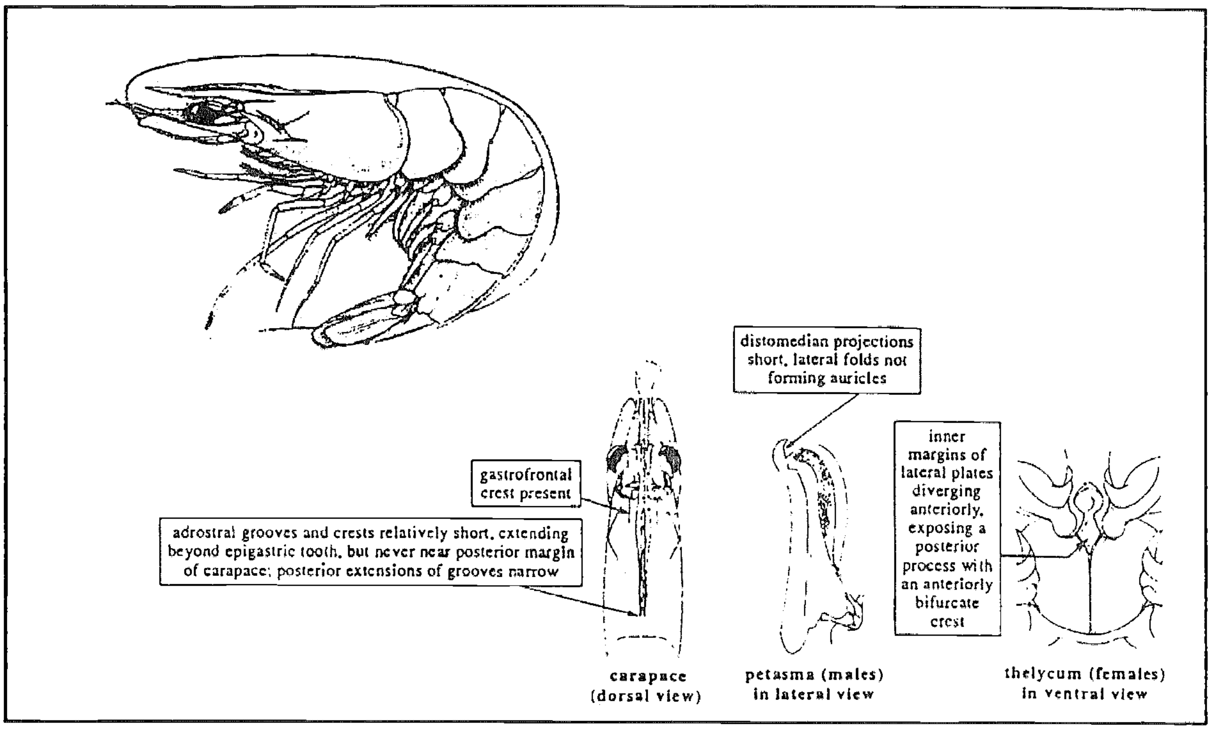


Figure 9: The southern brown shrimp, *Penaeus subtilis*, with morphological details.

Distribution

Penaeus subtilis is the most abundant of the four species of *Penaeus* off the Brazil-Guiana shelf (Cavalcante & Dragovich, 1984) and is distributed in the Caribbean from the southern part of the Greater Antilles and along the continental shelf from Honduras to the state of Rio de Janeiro, Brazil (Cervigón *et al.*, 1993). Brown shrimp occur throughout the Brazil-Guiana shelf (Villegas & Dragovich, 1984) with a region of high abundance which extends from northern Brazil to eastern Guyana (WECAFC, 1989). This species is found in depths to 190m (Cervignùn *et al.*, 1993) with most fishable populations between 27-82 m (Cavalcante & Dragovich, 1984; Villegas & Dragovich, 1984) over muddy (Villegas & Dragovich, 1984; Cervigón *et al.*, 1993) or sandy substrates with shell fragments (Cervigón *et al.*, 1993). Brown shrimp are nocturnal but may also be captured during the day (Holthuis, 1983).

Spawning and Larval Drift

Ripe females occurred in commercial brown shrimp catches off Guyana (Cavalcante & Dragovich, 1984) and French Guiana (Lhomme, 1992) throughout the year. Continuous low-level reproduction by brown shrimp has been suggested with spawning peaks during March, August and November-December (Lhomme, 1992). Fabres (1988) examined the abundance of brown shrimp in the Gulf of Paria and hypothesized that spawning occurs during June or July, however, the presence of small juveniles from March onwards suggests that spawning is initiated earlier. The depths and daily timing of brown shrimp spawning are not documented but it probably occurs within the 27-82 m depth range where they are most frequently captured.

The major areas of spawning are uncertain. Given the importance of the nurseries of northern Brazil, spawning sites likely exist along the coast north of the Amazon and larvae are carried with the Guiana current to estuaries in French Guiana and Suriname. Drifters released in the vicinity of the Amazon River mouth were generally advected along the path of the Guiana current (Limeburner *et al.*, 1995). Additional spawning sites may occur in deeper waters along off the coasts of French Guiana, Suriname and Guyana. Most of the brown shrimp captured off Suriname in 1987 were subadults (Charlier, 1989) which doesn't suggest much spawning off that coast. Given present knowledge of the distribution of juveniles along the shelf, spawning probably occurs from the Amazon to Guyana with westward larval drift.

Postlarval Recruitment and Estuarine Residence

Penaeus subtilis appears to enter estuaries along the Brazil-Guiana shelf during spring and fall. This pattern is similar to that of a closely related brown shrimp *P. aztecus*. Small juveniles were present in Gulf of Paria trawl surveys from March to October with a peak in June and Fabres (1988) suggested that most brown shrimp enter estuaries during spring. Lhomme (1992) noted three pulses of recruitment during April-May, September-October and January in French Guiana. These follow his reported spawning peaks by one month. Stoner (1988) reported recruitment into a Puerto Rican lagoon during May-June at the end of the dry season. Postlarvae enter estuaries at approximately 10 mm TL (Cavalcante & Dragovich, 1984) with peak ingress coincident with flood tides in the Cayenne and Sinnamary estuaries, French Guiana (Lhomme, 1992).

Juvenile brown shrimp were collected from the soft-bottom areas of the Gulf of Paria in the vicinity of seagrasses and mangroves (Fabres, 1988). Stoner (1988) reported that the abundance of juvenile brown shrimp was correlated with low salinities which supports that hypothesis that their primary recruitment coincides with the rainy season. This species is occasionally found in hypersaline systems (Cervigón *et al.*, 1993). Based on Lhomme's (1992) data for French Guiana, size differences between immigrating (10mm

TL) and emigrating (70mm TL) brown shrimp suggest growth rates during the 2-3 months of estuarine residence of 0.7-1.0 mm TL per day.

Emigration occurs at 70 mm TL near Cayenne, French Guiana (Lhomme, 1992), 25 mm carapace length (CL) from the Gulf of Paria (Fabres, 1988), and up to 110 mm near Maracana, Brazil (Cavalcante & Dragovich, 1984). Based on the percentages of small brown shrimp (12.5-19.6 g) in commercial trawler catches, Lhomme (1992) suggested that there were two waves of emigration from French Guiana's estuaries. The emigration of shrimp which entered during April-May and during September-October overlapped, producing a peak during September-November, while the cohort which entered during January, emigrated during April-May. The stimulus for emigration is not known. Fabres (1988) was unable to find a consistent relationship between rainfall and the recruitment of *P. subtilis* to the offshore fishery.

Maturation

Villegas & Dragovich (1984) suggested that the extensive estuarine areas in Para-Maranhïo, Brazil, were an important source of recruitment to the offshore fisheries of Brazil and French Guiana. The importance of nursery grounds along the Brazil coast was emphasized by the WECAFC which reported that the estuaries just north of the Amazon contribute massive recruitment to the fisheries towards the French Guiana border (WECAFC, 1982). Trawling is prohibited out to a depth of 15-20 m along the northern coast of Brazil from the Gurupi River to the French Guiana border. This is done to protect juvenile *P. subtilis* (WECAFC, 1982).

After juveniles leave estuaries, movement is generally in a north-northwesterly direction into deeper water. Tagging studies off French Guiana revealed that shrimp dispersed in a direction roughly paralleling the Guianas Current (Cavalcante & Dragovich). Some shrimp tagged off the Mana estuary near the Brazil-French Guiana border were recovered off Suriname while others moved to the south and were recovered off Brazil. Eastward return of subadults would be necessary to maintain spawning sites in Brazil. Sexual maturity is reached after 5 months of age (Lhomme, 1992) and brown shrimp live for 1-1.5 years (Fabres, 1988) to 2 years (Lhomme, 1992).

Fishery

Brown shrimp support inshore/estuarine artisanal and offshore commercial fisheries. Juveniles are primarily collected with seines, castnets, pushnets and dipnets while commercial boats employ trawls (Holthuis, 1983). An intense fishery operates within the Gulf of Paria employing vessels ranging from small (7.5 m) pirogues to 22.5 m trawlers (Fabres, 1988). This fishery operates both day and night when shrimp are abundant and represents Trinidad & Tobago's most valuable fishery. Brown shrimp are primarily marketed as frozen products for export with some fresh and canned production (Cervigón *et al.*, 1993).

Species-specific Habitat Preferences

Brown shrimp is associated with mud substrate that is relatively high in organic content. In samples over the Guiana/Brazil continental shelf this species was found principally over sandy bottom (Dragovich *et al.* 1980).

Brown shrimp is found throughout the region at depth: 12.8 to 91 m (Dragovich, *et al.* 1980), but are predominant off Brazil and Eastern French Guiana. It is always found in the shallower section of the shelf relative to the deeper distribution of the pink-spotted shrimp, *P. brasiliensis* (Ehrhardt, 1986).

Juveniles are found in lagoons and estuarine areas of the region. Several nursery areas in French Guiana and Brazil have been confirmed. Some have exclusively this species of penaeid.

Juveniles occur frequently off Amapa (Brazil), off eastern French Guiana (esp. in March and April), and off Guyana. Juveniles are also taken throughout the year by the artisanal fishery of Para-Maranhao in Northwest Brazil. This suggests that recruitment occurs from these areas. Para-Maranhao has the most extensive estuarine areas in the region, an important recruitment source for the Brazil offshore fishery and possibly E. French Guiana offshore fishery.

Brown shrimp postlarvae are known to enter coastal lagoons near Cayenne in Feb.-Mar. at total lengths of 10 mm. They migrate to sea two to three months later at lengths of 70 mm.

In Guadeloupe, the juvenile migration out of the nurseries begins with the strong rains in September - October, reaches its maximum in the dry season, February - March, and decreases to its minimum in July-August (Rojas-Beltran, 1982).

Some brown shrimp tagged in the Mana estuary (near the French Guiana/Suriname border) were recovered off Brazil (between 4 and 5 N) and off Suriname (Cavalcante and Dragovich 1984).

US port sampling at Georgetown, Guyana, between 1976 and 1978 reported that all 4 stages of maturity (females) occurred during each month of the year, suggesting year-round spawning.

Females reach a larger size than males (Villegas and Dragovich, 1984), but males are more abundant than females in landings at Georgetown.

Xiphopenaeus kroyeri

Xiphopenaeus kroyeri (Heller, 1862)

FAO Common Names: En. - Atlantic seabob; Fr. - Crevette seabob; Es. - Camarón siete barbas

Distribution

Xiphopenaeus kroyeri is broadly distributed throughout the Caribbean and along the coasts of Central and South America to the state of Santa Caterina, Brazil (Cervigón *et al.*, 1993). Seabobs are common along the coasts of all nations adjacent to the Brazil-Guiana shelf (Holthuis, 1983). The adults of this species are generally found close to shore over muddy and sandy bottoms (Holthuis, 1983; Cervigón *et al.*, 1993) from depths of 1-70 m with maximum abundance above 30 m (Cervigón *et al.*, 1993). Holthuis (1983) reports the highest concentrations above 18 m while surveys off French Guiana found high abundances between 15-40 m (Lins Oliveira & Rose, 1989). The abundance of adults between 15-40 m suggests that reproduction may take place at this depth. Seabobs are diurnally active and are primarily fished during the day (Holthuis, 1983).

Spawning and Larval Drift

Lhomme (1992) suggested, on the basis of postlarval recruitment, that adults spawn during June and again during November-December off the coast of French Guiana. His data suggest spawning during June, September-October and possibly during November-December. Low numbers of postlarvae were present year-round suggesting some continuous spawning. Seasonal patterns of gonadal development suggest that spawning takes place from October-December along the northeastern coast of Brazil (Alves & Rodrigues, 1977). Larvae originating from adults spawning in shallow waters all along the shelf would be transported with the Guiana current to local estuaries. Unfortunately little information is available on the ecology of seabobs and a recent study by Valentini *et al.* (1991) confirms the general lack of information.

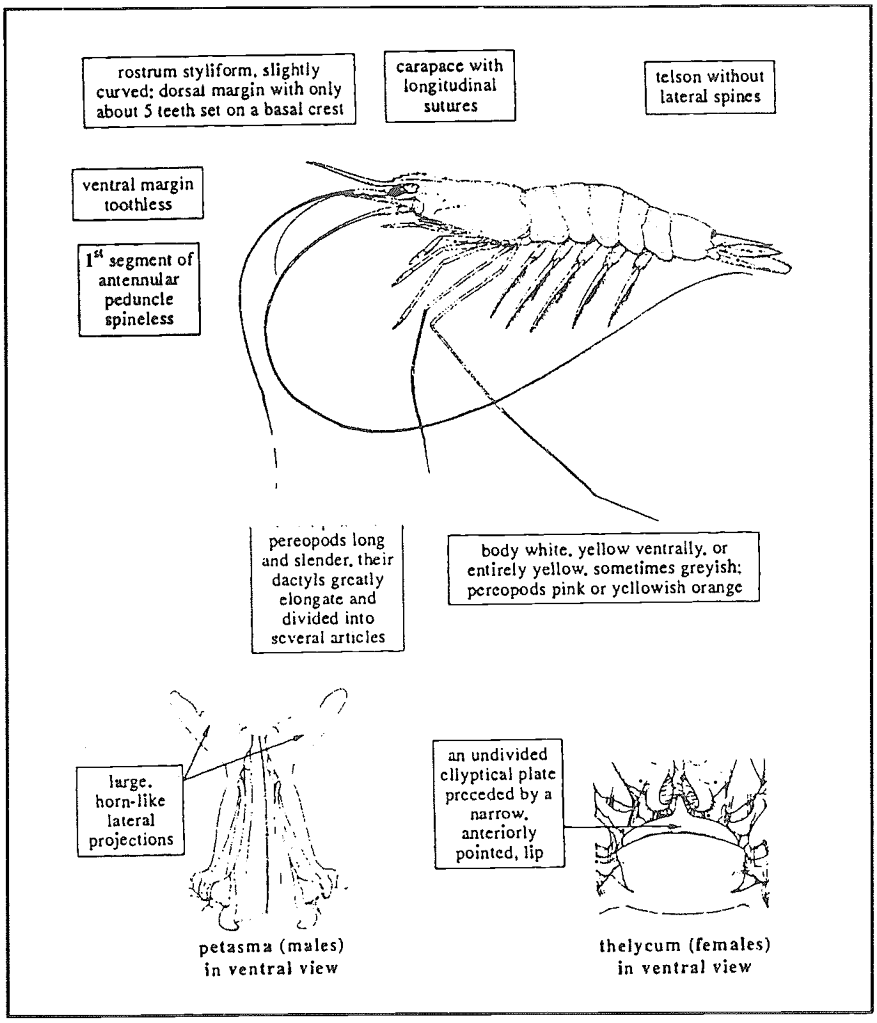


Figure 10: The seabob, *Xiphopenaeus kroyeri*, with morphological details. This species is captured by the artisanal fishery as well as a near shore industrial fishery reported to have a very high proportion of by-catch.

Postlarval Recruitment and Estuarine Residence

Lhomme (1992) noted two recruitment peaks during July-August and October-November in the Cayenne estuary, French Guiana. Examination of his data suggests a third period of recruitment during April. Sampling in the Sinnamary river, French Guiana, revealed a single large peak during November with low numbers of postlarvae in other months (Lhomme, 1992). Seabobs are primarily marine shrimp which are associated with estuarine mouths and deltas, but do not tend to penetrate far into estuaries (Cervigón *et al.*, 1993).

Maturation

The abundance of seabob along the coast of Guyana peaks during March and April (Chakalall & Dragovich, 1980) however, it is unclear whether this reflects recruitment of juveniles to the fishery or changes in catchability related to water flow.

Fishery

Seabob tend to support artisanal fisheries along the coast and in estuaries which employ Chinese seines (fyke nets) (Chakalall & Dragovich, 1980; Dragovich & Villegas, 1982), and industrial trawl fisheries (Holthuis, 1983). Their great abundance makes up for their relatively small size (80 mm TL). In Guyana, Suriname and French Guiana they are the most common species marketed locally (Cervigón *et al.*, 1993). Seabobs are marketed fresh or dried (Holthuis, 1933).

Species-specific habitat preferences

Adult seabob are confined to a narrow coastal strip (Garcia and Le Reste, 1981). They are found throughout the region, at depths of 4-44 m (Dragovich *et al.* 1980). Juveniles do not travel very far into estuaries (Garcia and Le Reste, 1981).

Nematopalaemon schmitti

Nematopalaemon schmitti (Holthuis, 1950)

FAO Common Names: En. - Whitebelly prawn; Fr. - Bouquet covac; Es. - Camarón cuac

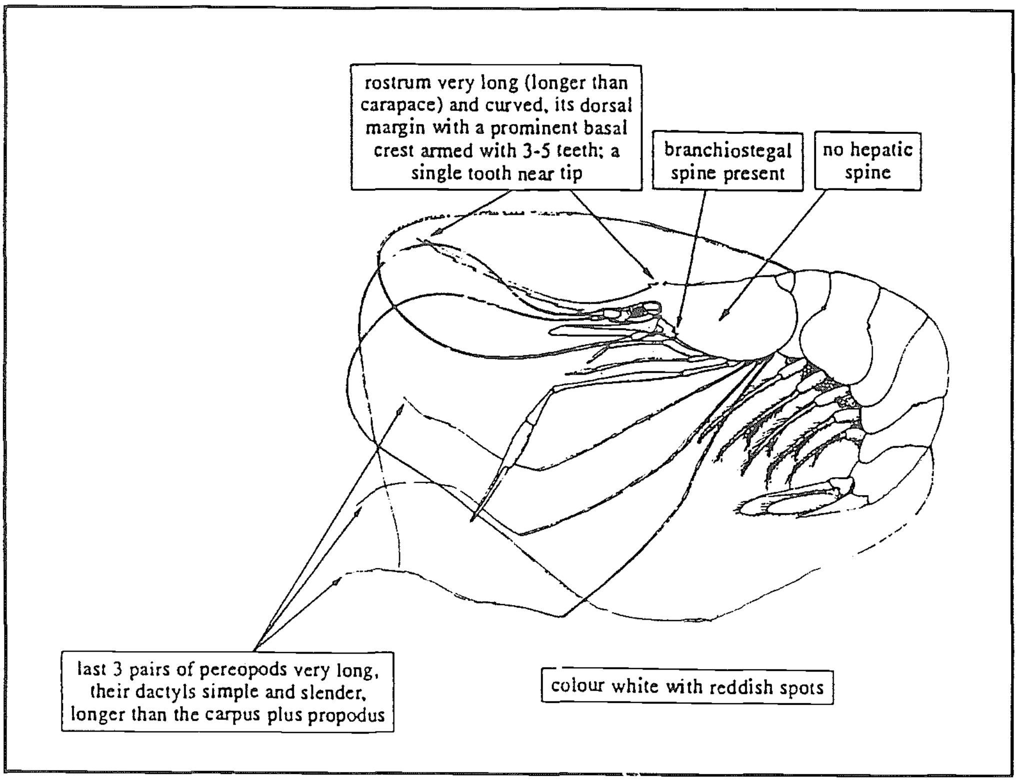


Figure 11: The whitebelly shrimp, *Nematopalaemon schmitti*, with morphological detail. This species is mostly harvested by small-scale fixed net fisheries and sold locally.

Distribution

Nematopalaemon schmitti is a caridean shrimp which is distributed along the Brazil-Guiana shelf from Venezuela to northeastern Brazil (Holthuis, 1983; Cervigón *et al.*, 1993). Whitebelly prawns are found in brackish and marine waters over muddy or sandy bottoms at depths from 5-75m (Cervigón *et al.*, 1993). Holthuis (1983) reports that this is a very shallow water species seldom occurring beyond 7 m depth, however, he was probably referring to their estuarine distribution.

Spawning and Larval Drift

No data were available for this species, however, a related species - the estuarine prawn *N. hastatus*, occurs along the coast of Nigeria where is supports an artisanal fishery which is remarkably similar to that along the Brazil-Guiana shelf. The depth distributions, size ranges, geographical latitude and exploitation pattern by the artisanal fisheries suggest that the life histories of these two species may be similar. The life histories of palaemonid shrimps differ from the penaeids. After mating the females spawn and attach eggs to their pleopods where they are carried for several weeks and then released as newly hatched zoeal larvae. Larval release frequently occurs in freshwater (e.g. *Macrobrachium*) with a reverse migration towards estuarine nurseries., however, *Nematopalaemon* releases larvae in coastal waters.

Nematopalaemon hastatus spawns year round with a major peak between June and October (Enin *et al.*, 1991) which corresponds to the Nigerian rainy season. Adults emigrate from estuaries in response to heavy rainfall at the onset of the rainy season and enter deeper more saline shelf waters to spawn (Enin *et al.*, 1991). This emigration results in a substantial reduction in the artisanal catch, a phenomenon which could be used to determine when *P. schmitti* spawns along the Brazil-Guiana shelf. The abundance of whitebelly prawns along the coast of Guyana peaks during March and April (Chakalall & Dragovich, 1980), however, it is unclear whether this reflects recruitment of juveniles to the fishery or changes in catchability related to water flow. The former is more likely since dynamics of *N. hastatus* off Nigeria suggest that landings increase at the onset of the rainy season due to the aggregation of adults preparing to spawn. Thus, the increase observed off Guyana in March-April which also coincides with the onset of the rainy season, may signify the beginning of the offshore spawning period. The seaward distribution of *N. hastatus* appears to be 25 m depth and about 25 psu salinity, although thermal barriers could not be ruled out.

Female *N. hastatus* reach sexual maturity at 44 mm TL and fecundity increases linearly with size from 333 eggs female^{-1} at 44 mm TL to 2620 eggs female^{-1} at 79 mm TL (Sagua, 1980). The incubation period appears to be 12 days (Sagua, 1980). Larvae of *N. schmitti* are likely transported along shore to the west as they develop into juveniles. Considerable dispersion of larvae and small juveniles may occur since their period in marine waters is longer than that of the penaeids. On the other hand, the juveniles have abilities to swim against coastal currents and could move back towards their source estuaries. Clearly more work is needed in this area.

Postlarval Recruitment and Estuarine Residence

No data were available on the periodicity of larval recruitment to the estuaries although it is possible that this species develops to the juvenile stage at sea. Enin *et al.* (1991) states that at the end of the rainy season in Nigeria, spent adults return to the estuaries along with juvenile recruits from the recent spawn. *Nematopalaemon hastatus* occurs over mud or sandy-mud bottoms and appears to tolerate salinities down to 1 psu (Sagua, 1980).

Maturation

Other than Sagua's prior observation that *N. hastatus* attain sexual maturity at 44 mm TL, little is known about the maturation of this genus. Calanoid copepods are important in the diets of small juvenile *N. hastatus* which then shift to feed on mysids when the prawns exceed >25 mm TL (Enin *et al.*, 1991).

Fishery

Whitebelly prawns support artisanal fisheries along the Guianas along with the caridean shrimp *Exhippolysmata oplophoroides* (Cervigòn *et al.*, 1993). It is interesting that *N. hastatus* in Nigeria is associated with *E. hastatoides* (Enin *et al.*, 1991). The artisanal fisheries in Guyana and Suriname employ Chinese shrimp traps (FAO, 1978) and these gear may be used in by other nations along the shelf. Whitebelly prawns are also taken in industrial trawl fisheries (Cervigòn *et al.*, 1993).

Species-specific habitat preferences

Very little information is available on the white bellied shrimp, other than it probably shares most of the habitat characteristics of the Seabob. They are captured together in the large artisanal fishery of Guyana (Chakalall and Dragovich, 1980). However, separate records are not kept, and their capture is reported as Seabob, white-bellied shrimp or not recorded.

This species is often confused or lumped in with the cock shrimp, *Exhippolysmata oplophoroides*, although the latter is less abundant, but this has never been quantified.

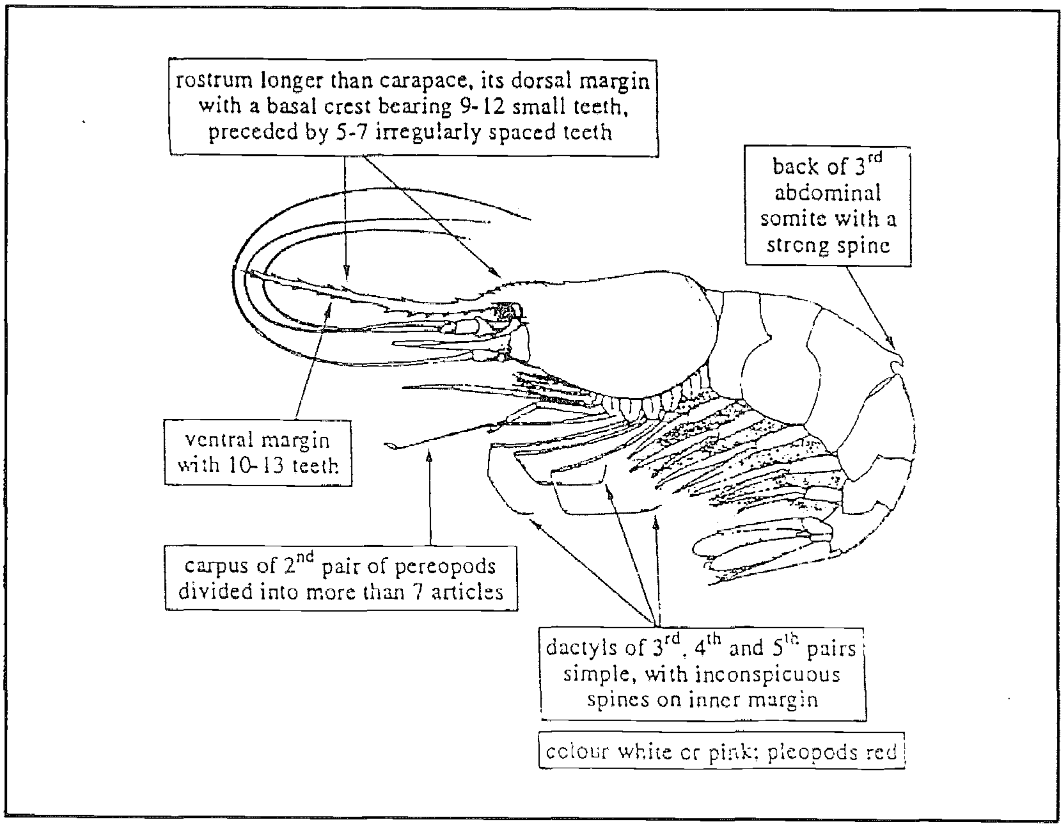


Figure 12: The cock shrimp, *Exhippolysmata oplophoroides*, with morphological details. This species is caught with the whitebelly shrimp but in smaller quantities, and sold unsorted.

GROUNDFISHES

Fishes can be classified into functional groups according to their anatomy and life history characteristics. Within coastal areas, three major groups can be identified: the benthic (demersal), the pelagic and shallow water (Day *et al.* 1989). The demersal [ground-]fishes live on on near the bottom, but can swim and feed in the water column. This is a very diverse group, and can be further classified into 3-4 groups: the omnivorous "mudeaters" (mostly catfishes of the family Ariidae), closely associated to mud bottoms as a consequence of their scavenging and omnivorous feeding habits and as well as their morphology and anatomy; the carnivores, only loosely associated with the soft-bottoms and probably associated with the shrimp fishery as a primary predator of shrimps (the family Scianidae in general, including sea trouts, croakers, etc.); and the opportunistic bottom fishes, generally with down-turned mouths and often barbels (drums, etc.) (Figure 13, 14). Commercially important groundfish in the Guiana/Brazil continental shelf region include members of different families, the sciaenids, the catfishes, the snooks and the drums. Other than the fact that all of these families are exploited by the demersal trawl fishery, they have few similarities and should be treated separately for management purposes.

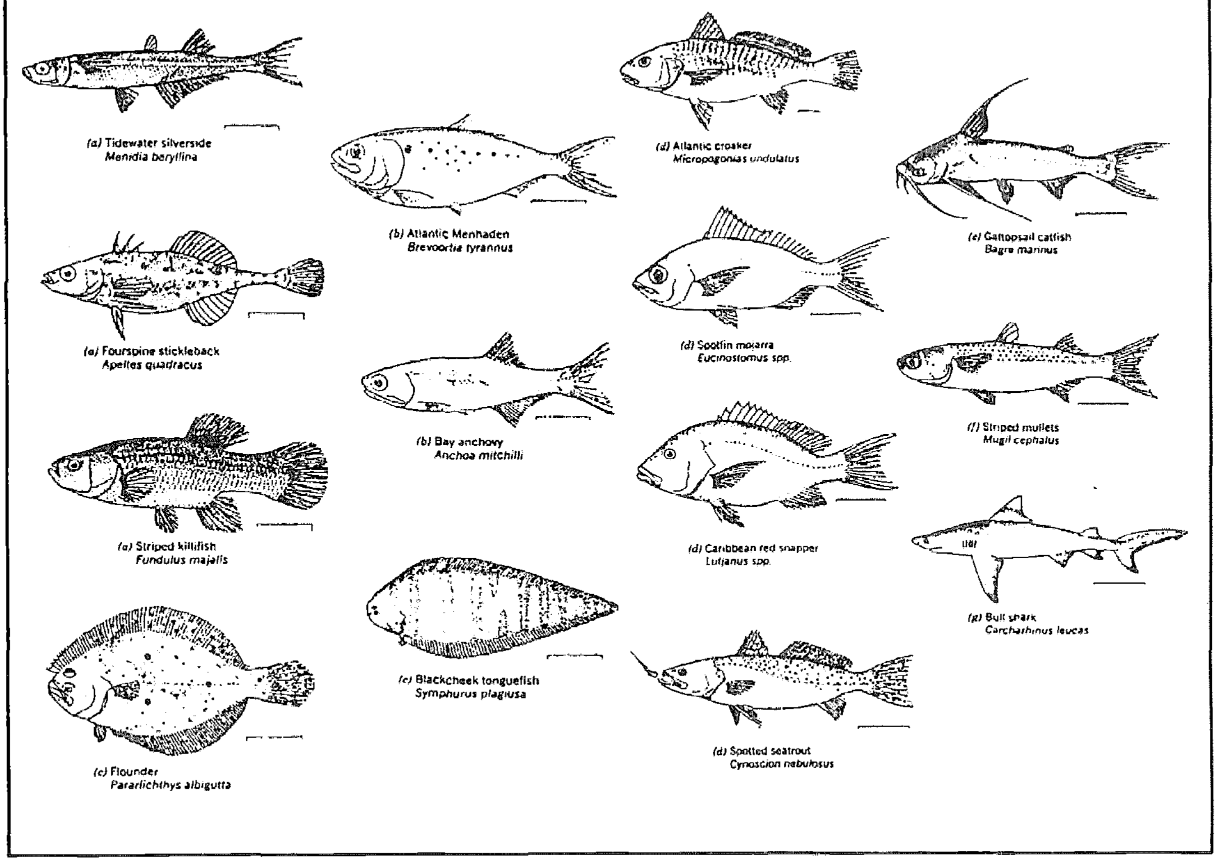


Figure 13: Representative examples of fishes found in estuaries (a) Shallow water fishes, (b) Pelagic fishes, (c) Benthic flatfishes, (d) Benthic demersal midlevel carnivores, (e) Benthic omnivores, (f) Pelagic bottom feeders, and (g) Benthic carnivores. Figure from Day *et al.* (1989).

In a landmark paper by Lowe-McConnell (1966), the groundfish species are described as belonging to 3 groups: 1) Bottom feeders, with inferior mouths, well developed pores of the acustico-lateralis system on the chin and snout, and barbels on the lower jaw. The group includes the croakers, catfishes and other commercially less important species. 2) Pelagic shrimp feeders, with obliquely upturned mouthes, large eyes, and short laterally compressed bodies. This group includes *Larimus breviceps*. 3) Predators feeding on penaeid and mantis shrimp and fish, including all the larger sciaenids, have larger mouths, projecting lower jaws without large pores and enlarged canines in the upper jaw.

GENERAL HABITAT PREFERENCES

Very little information is available on the ecology of these species with the exception of the whitemouth croaker, *M. furnieri*, and to a lesser extent the king weakfish, *M. ancylodon*. A considerable amount of work needs to be done in order to understand the mechanisms through which habitats influence growth survival and reproduction.

In stable environments, year-round spawning in tropical fish is characteristic. However, spawning appears to be affected by changes in salinity and temperature associated with wet and dry seasons with increased activity in the dry season (Manickchand-Heileman and Julien-Flus, 1990).

Habitat use by juvenile fishes is slightly different than for shrimps. It was demonstrated previously that many shrimp species prefer seagrass salt marshes over mangrove swamp. It appears from recent studies that juvenile fishes are more abundant in mangrove than in seagrass salt marshes (Robertson and Duke 1987; Thayer *et al.* 1987). Although this apparent distribution may be interpreted as habitat selection, it is also the result of many factors, including predation and other sources of mortality, that result in observed distributions. In Australian and Florida mangrove swamps, many of the piscivores and carnivorous fishes consume large quantities of penaeid prawns (Yanez-Arancibia 1988; Robertson 1988; Salini *et al.* 1990; Salini *et al.* 1992). The predation rates of fish in mangroves may therefore have a measurable effect on observed shrimp densities.

Catfishes of the family Ariidae are abundant in mangrove swamps (Robertson and Blaber 1992), their omnivorous feeding habits and resistance to sudden changes in water quality well adapted to the conditions of mangroves. It was postulated earlier in the present document that the omnivorous *P. brasiliensis* would also be more abundant in mangroves than other types of nursery habitat. Terminos Lagoon in Mexico is a well studied coastal ecosystem that can be used as an example of habitat use by the family Ariidae. One species (*Arius melanopus*) spawns in very low salinity water and gradually moves to higher salinity water as it grows, but remaining in the lagoon for its entire life cycle (Lara-Dominguez *et al.* 1981; Yañez-Arancibia and Lara-Dominguez 1988). This contrasts with the other 2 species of catfish found in the lagoon (*Arius felis* and *Bagre marinus*), which spend their sub-adult and adult life in coastal marine waters but are estuarine dependent for spawning and juvenile development. The catfishes have few large eggs and are often mouth-brooding. The fry are large and well developed at hatching.

The presence of seagrass beds near mangrove swamps increases fish and invertebrate species diversity and abundance in the Caribbean, Gulf of Mexico and Australian studies (Thayer *et al.* 1987; Robertson and Blaber 1992). However, world-wide comparison of habitat use must be done very carefully. Water quality is demonstrated to have an important effect on species composition and abundance. The occurrence of piscivores in mangroves is greater when water is clear than when it is muddy or turbid. The waters of the Guiana/Brazil continental shelf tend to be more turbid than elsewhere because of the great freshwater and sediment contribution of major rivers in the area, in conjuction with the Guiana current. Proximity to other habitats, including adult and spawning habitats, certainly plays an important role. In general, fish species composition and abundance in a mangrove system will depend primarily on 1) the size and diversity of habitats, together with the flood and tidal regime, 2) its proximity to seagrass marshes and other ecosystems, and 3) the nature of the offshore environment (Robertson and Blaber 1992).

Sciaenids

Gutherez and Thompson (1977) reviewed the biology of sciaenids in the region. Much of the discussion below is extracted from this document.

The sciaenids are demersal continental shelf species found in tropical and semi-tropical regions. Except for a single genus, they spend a significant fraction of their life cycle in estuaries, which therefore are subjected to seasonal and annual physical as well as ecological changes in the characteristics of their environment. Centres of abundance for these species are almost always associated with major estuarine systems and freshwater discharge, which excludes them from most Caribbean islands (Gutherz and Thompson 1977). They are generally associated with muddy bottoms and turbid water (Figure 14).

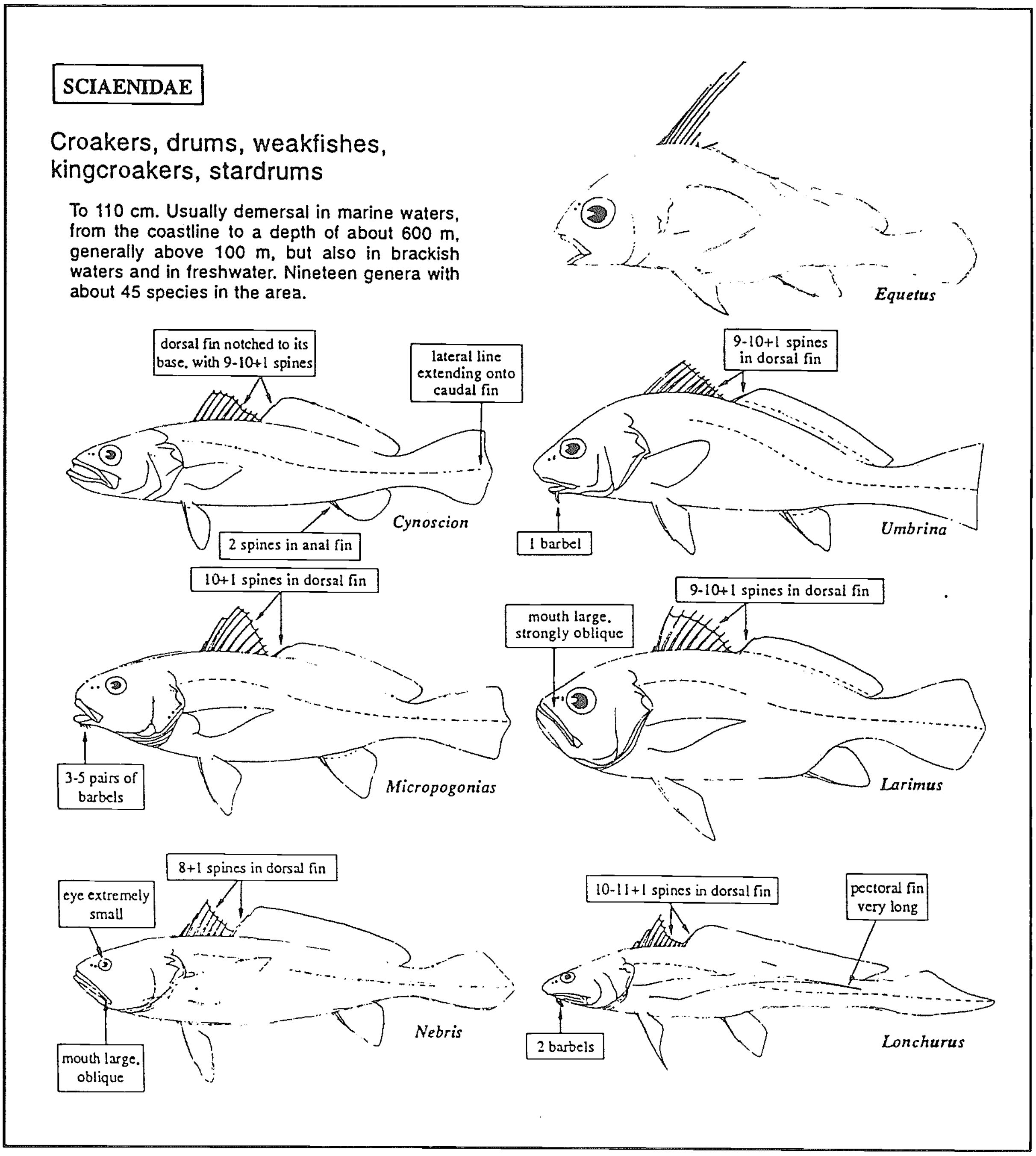


Figure 14: The family Sciaenidae (croakers, drums and weakfishes). This group of fishes is very important to the fishery of the Guiana/Brazil Continental Shelf, comprising upwards of 50% of the catch. Figure from Cervignon *et al.* 1993.

The family Sciaenidae includes the species of primary interest: *Micropodon furnieri, Cynoscion sp.* group, *Nebris microps* and *Macrodon ancylodon*. In the western central Atlantic, Sciaenids are estuarine dependent at some stage of their life cycle and almost all species use the estuary as a nursery. All known Sciaenids have pelagic eggs. Spawning is thought to occurs offshore and eggs and larvae are carried into bays or sounds by wind or tidal currents. Juvenile development occurs in estuarine systems. Subadults gradually migrate offshore. In temperate areas they linger in depths <9 m and move randomly in and out of the bays and sounds during this time. When the water gets cooler they move further offshore to depths between 27-73 m.

From North Carolina to Florida, the major stocks are found in bays and sounds in depths <18 m. In the Gulf of Mexico, the major stocks are found in similar environments but the range extends to depths of 92 m. Large concentrations are found over the soft mud bottom associated with the Mississippi River.

The timing of many aspects of the life cycle of the Sciaenid species appear to be related to temperature changes in the semi-tropical areas. In tropical climates seasonal changes in the life cycle may not be as pronounced. For example, spawning of higher latitude stocks of *M. furnieri* begins in the early spring. However, the spawning season extends in stocks closer to the equator and in the warm waters of Trinidad and Guyana spawning occurs year-round with peaks in the entire life cycle (brakish water and some freshwater species, such as the family Gobiidae), the dispersal and colonization of salt water marshes and mangroves habitats is probably by drift-assisted larval dispersal. It is postulated that the distribution of a species on a geographic scale will be related to the length of the larval stage, such that long larval stages are associated with wide distributions ensuing from the dispersal ability of the species. This hypothesis is testable, either among taxonomic groups or among species, with life history data.

Essentially, there are 3 broad hypothesis to explain the use of mangrove by juvenile fishes: 1) The turbidity of coastal nurseries reduces the predation risks, 2) Mangrove and other coastal ecosystems are important feeding grounds, due to increased productivity, and 3) the increased structural complexity and living space of coastal ecosystems, when compared to the open sea, permits high population densities. There is support for all three hypotheses, and particularly the latter, as increased system complexity (planting bamboo poles on the bottom, etc.) has been used for centuries in lagoons by traditional fishermen all over the world to increase local production.

Sciaenids are characterized by fast growth, short lifespan and extremely high natural mortality rates. Age and growth analysis is complicated by the protracted spawning season on the Guiana/Brazil continental shelf and environmental variability.

No stock estimate for the region exist for the sciaenids. However rough approximations can be expressed. It is generally accepted that the yield of the shrimp fishery is in the order of 20,000 metric tons per year in the Guiana/Brazil continental shelf areas. It is also estimated that the fish/shrimp ratio in the by-catch is approximately 9:1 (reviewed by Talbot and Phillips 1995). Therefore, approximately 180,000 metric tons of finfish are captured and mostly discarded, of which 50-75 % are sciaenids. This amounts to 90,000-135,000 metric tons of sustainable sciaenid biomass per year, of which only a fraction is retained at present. It was estimated by Allsopp (1980) that 20,000 tonnes of by-catch were captured in July and August by the Guyanese industrial fishing fleet.

Catch rates of finfish in kg/hour have been reported for the Guiana/Brazil continental shelf area from exploratory cruises conducted by the CALAMAR (Rathjen *et al.* 1969). Marketable finfish catch rates, where sciaenids represent generally more than 50% of the catch, were as follows: Venezuela, 33 kg/hr; Guyana, 162 kg/hr; Suriname, 229 kg/hr; French Guiana, 84 kg/hr. In 57 days of experimental fishing, the CALAMAR produced 102 metric tons for marketable fish, or 2 metric tons per day. The sciaenid species captured were the weakfishes or sea trouts (*Synoscion virescens, C. jamaicensis, C. similus, C.*

steindachneri, C. acoupa), the croaker (*M. furnieri*), the Suriname butterfish (*Nebris microps*) and the whiting (*Macrodon ancylodon*). Similar results were obtained more recently with the surveys of the R/V Dr. Fridtjof Nansen (Bianchi 1992). However, catch rates were much higher near shore in 15-40 m of water than further offshore. There appears to be an excellent potential for a directed fishery.

SPECIES-SPECIFIC PREFERENCES

Whitemouth croaker (*M. furnieri*)

The biology of this species has been summarized by Isaac (1988). The information below emanates from this study, except where indicated.

The whitemouth croaker is a euryhaline sublittoral species found in the western central and southwestern Atlantic. It is very similar in anatomy and ecology to *M. undulatus*. They in fact are likely to be subspecies of the same species. The eggs are planktonic as with all known scianids. Spawning is reported to take place in estuaries in Uruguay and Argentina, but in "coastal areas" in Guyana. Spawning has been observed in river mouths. In the Rio de la Plata estuary (Uruguay), spawning was observed in 5 m of water over sandy and muddy bottoms in a low salinity region. Spawning takes place throughout the year in Guyana, with a possible peak in April (Lowe-McConnell 1966). In Trinidad spawning by *M. furnieri* appears to peak in February, June and August as indicated by a high percentage of ripe gonads during these months (Manickchand-Heileman and Julien-Flus, 1990).

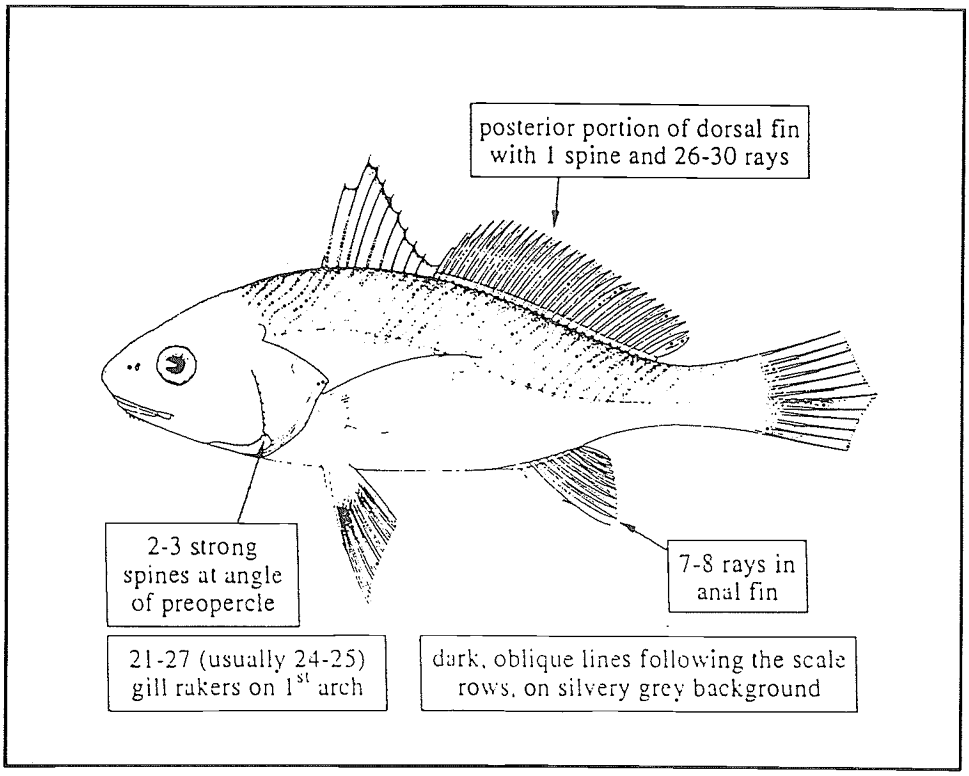


Figure 15: The whitemouth croaker (*Micropogonias furnieri*). Figure from Cervigon *et al.* 1993.

Nursery grounds

Juveniles have been found year round in rivers (up to 200 km upstream in the Rio de la Plata), abundant in river mouths, estuarine lagoons, and other brackish, shallow water regions. In Guyana larvae and juveniles have been found in tidal pools along the open coast and in river mouths. Juveniles have been found in tidal mudflats. Large numbers of fry were caught in a canal leading from the sea to brackish ponds and swamps, with abundance peaking during spring tides. Overall, juveniles appear to have a preference for shallow inshore waters. According to (Gutherez and Thompson, 1977) estuaries function as the nursery grounds for this species. Juveniles were common in quiet marshes, creeks and lagoons in Tampa Bay, Florida (McMichael *et al.* 1989), but also occupied a wide range of other habitats with varying salinity and vegetation.

Adults

Adults live on muddy and sandy bottoms and is associated with estuarine areas. This species has a downturned mouth with a row of barbels and pores, indicating that this species feeds on animals buried in or on soft sediments (mud and sand) on the sea floor. Bottom type appears to be the factor controlling distribution.

In Guyana this species is more abundant inshore in the rainy season. This appears to be linked to the influx of freshwater at this time. From January to March it is more abundant offshore at depths of 30 - 60 m, possibly due to the strong onshore winds that occur during these months. There does not appear to be any seasonal migrations in the stocks off Guyana. However, stocks migrate to warmer waters in the winter in the south.

Spawning was reported to occur from April to December in the Tampa Bay area, Florida, presumably at any time when the water temperature is above a certain threshold.Elsewhere, reports of year round spawning are common.

Diet

This species feeds typically on benthic invertebrates, including shrimp, and is an obligatory demersal species (Isaak 1988). Larvae feed on plankton. Juveniles and adults are benthic feeders and dietary preference changes as size increases. (see chart p.14 in Isaak 1988). They are known to eat crustaceans, including shrimp, but are more likely competitors of shrimp. Shrimp were a major prey group of snook of length greater than 50 mm in the Tampa Bay area, Florida (McMichael *et al.* 1989).

Growth

A study comparing growth between a populations offshore of Rio Grande and in the Lagoa dos Patos show a lower growth rate in the Lagoa dos Patos population. It was suggested that stress caused by living in an estuarine environment reduces growth rates.

Growth was reported at 0.5-1.2 mm (SL)/day in the Tampa Bay area, Florida (McMichael *et al.* 1989). Growth is faster in warmer waters and with increased food abundance, but there appears to be considerable variability among the different populations along the coast of S. America in terms of growth rates, migrations, spawning periods, habitat utilization, and to some extent, feeding. This would make it difficult to apply studies done on this species in other areas to the Guyana and Trinidad populations. Age determination is difficult in this species. The otoliths are large and thick and the scales of older individuals are often too opaque to recognise growth rings. However, there are studies of the growth from scales (Rodrigues 1968; Vassoler 1971; Ehrhardt et al. 1976; Haimovici 1977; Castelo 1986), and these may be useful for Caribbean stocks. The relationship between the daily rates of growth and feeding, expressed in percentage of total weight, is given by the linear equation $y = 0.848 + 0.415\ x$. Maximum survival seems to be about 15-20 years in the shelf region. Vazzoler (1971) reported the length to weigth ratio to be:

$Wt = 0.010312\ Lt^{2.9996}$

Size at first maturity varies between 25 and 40 cm and maximum size is only 48 cm for the Guyana region (Lowe-McConnell 1966). This species is abundant, expecially along the Brazil, Uruguay and Argentinian coasts, with a standing stock biomass of 40-58,000 MT in Brazil alone. Natural mortality (M) is guessed at 0.36 in the Rio de Plata region. The croaker is strongly associated with the presence of *P. brasiliensis* and *Macrodon ancylodon* and negatively associated with *Cynoscion petranus*. Croakers apparently grow to 33 cm in length in 12-16 months in brackish culture in Guyana.

There has been a drammatic decline in the stocks of this species in the last 20 years, as a result of intensive directed fishing in the region, by-catch from the shrimp fishery and in combination with a relatively slow growth rate for a tropical species. It represented 43% of all captures in the 20-60 m depth zone in 1957-59 from the research cruised of the R/V Cape St. Mary (Lowe-McConnell 1966)but never more than 2% in the same zone in 1988 (Bianchi 1992). In trawl samples of waters in northwest Trinidad, *M. furnieri* comprised less than 5% of the total catch (Manickchand-Heileman and Julien-Flus, 1990) by frequency.

Jamaica weakfish (*Cynoscion jamaicensis*)

Adults

In trawl samples carried out in northwest Trinidad, *Cynoscion jamaicensis* was the most dominant species harvested, comprising 28.9% of the total catch by number (Manickchand-Heileman and Julien-Flus, 1990), mostly juveniles. These trawls were carried out at two sites, one in the northeastern Gulf of Paria at depths of 40-42 m, and the other from the first Boca to Maracas Bay at depths of 50 - 70 m (Figure 16).

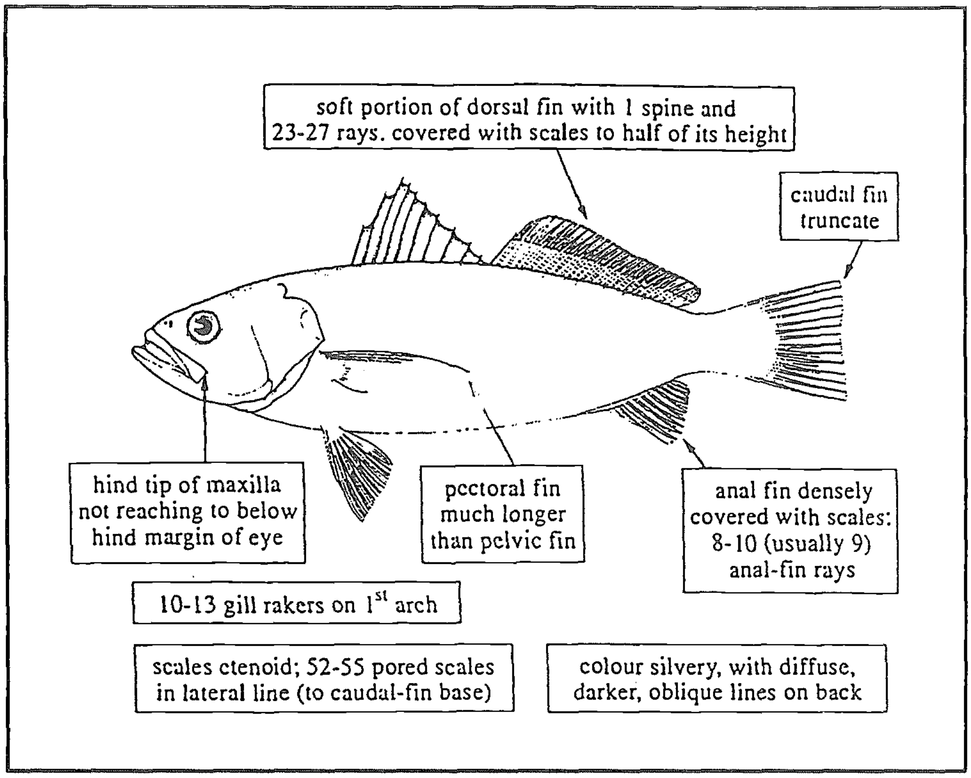


Figure 16: The Jamaica weakfish (*Cynoscion jamaicensis*). Figure from Cervigon *et al.* 1993.

Spawning and Nursery Grounds

In Trinidad the presence of juveniles year round indicates that *Cynoscion jamaicensis* spawns throughout the year (Manickchand-Heileman and Julien-Flus, 1990). According to Guthrez and Thompson (1977) estuaries function as the nursery grounds for this species. Juveniles were found year round in the samples from northwest Trinidad.

King weakfish (*Macrodon ancylodon*)

Spawning Grounds

According to Guthrez and Thompson (1977), December and February are the most intensive spawning months for this stock. This suggests two modes to the level of spawning activity from late spring until summer in this region.

M. ancylodon migrates to the spawning grounds and there appear to be more males than females in the spawning area during the spawning season. Both spawning migrations and feeding migrations are mentioned in this paper but the location and characteristics of the spawning and feeding grounds used are not discussed.

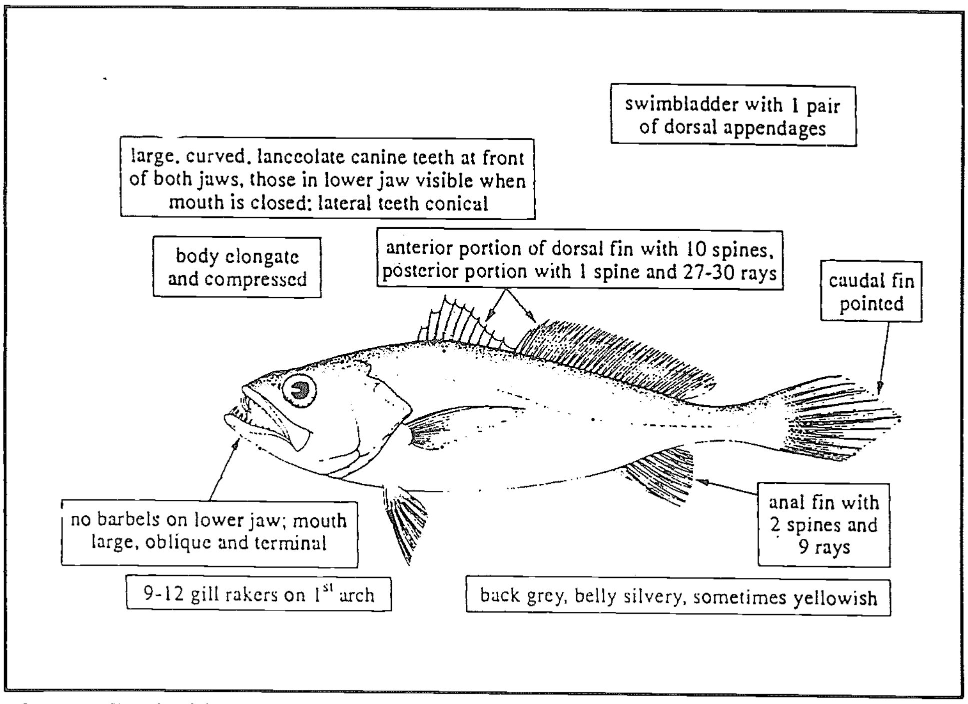


Figure 17: The king weakfish (*Macrodon ancylodon*).

Nursery Areas

According to (Guthrez and Thompson, 1977), estuaries function as the nursery grounds for this species. The seabob (*Xyphopenaeus kroyeri*) is the main prey of this species (Bianchi 1992), and is closely associated with its distribution. *Macrocon ancylodon* was reported as one of the most abundant fishes off Guyana, representing 18% of the catch (Lowe-McConnell 1966). In 1988, it represented 17% of the catch in the near shore stations (20 m), indicating a stable population structure. Analysis of biodiversity indicated that the near shore stations were the most diverse of any, thus resulting in high levels of by-catch in the shrimp trawl fishery (Bianchi 1992). the lowest levels of biodeversity were on the hard bottom deep shelf.

The last two species can easily be confused with other members of the sciaenid family that are present in abundance on the Guiana/Brazil continental shelf, namely the Acoupa weakfish (gray snapper, *Cynoscion acoupa*) and the Green weakfish (trout, *Cynoscion virescens*). Examine figures 18 and 19 below and refer to specialized taxonomical literature for further details.

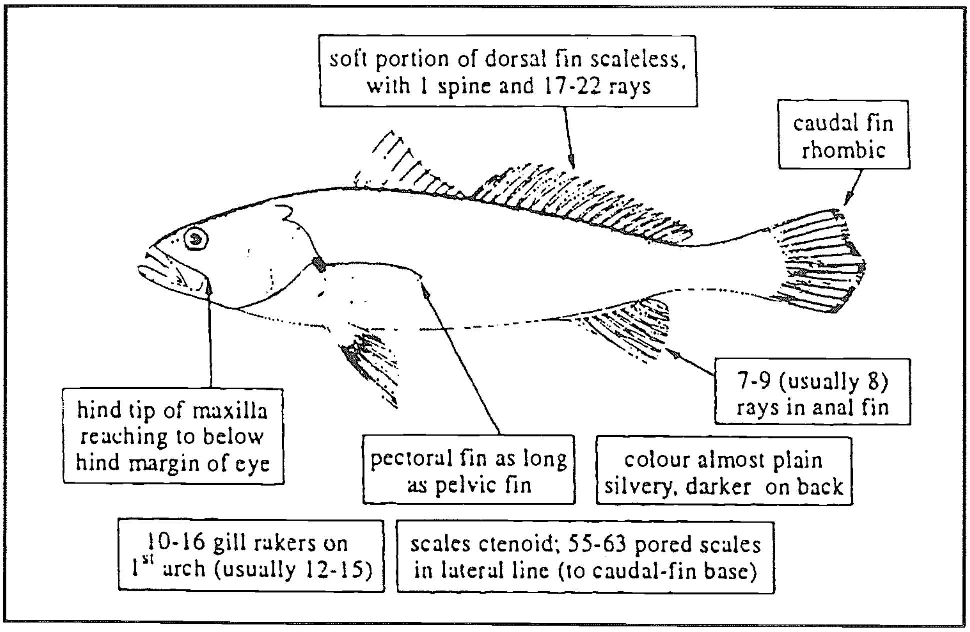


Figure 18: The acoupa weakfish or grey snapper (*Cynoscion acoupa*).

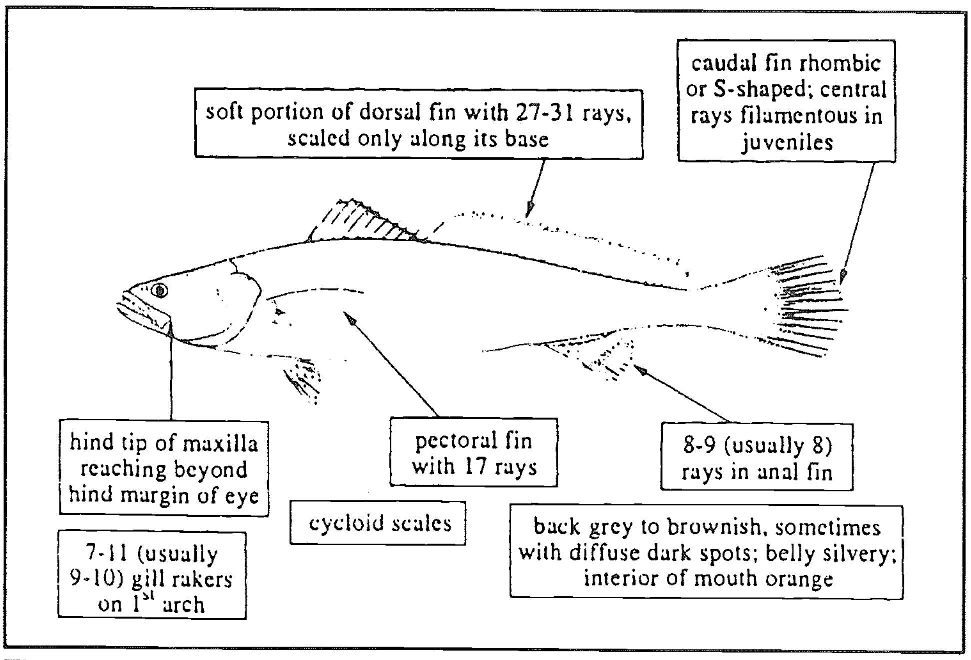


Figure 19: The green weakfish (*Cynoscion virescens*).

<u>Salinity</u>

Distribution does not appear to be limited to any single salinity range. Surface salinities of habitat range between 0 ‰ to 32 ‰.

Common snook (*Centropomus undecimalis*)

Most of the data on the habitat preferences comes from studies of stocks in Tampa Bay, Florida (McMichael *et al.* 1989).

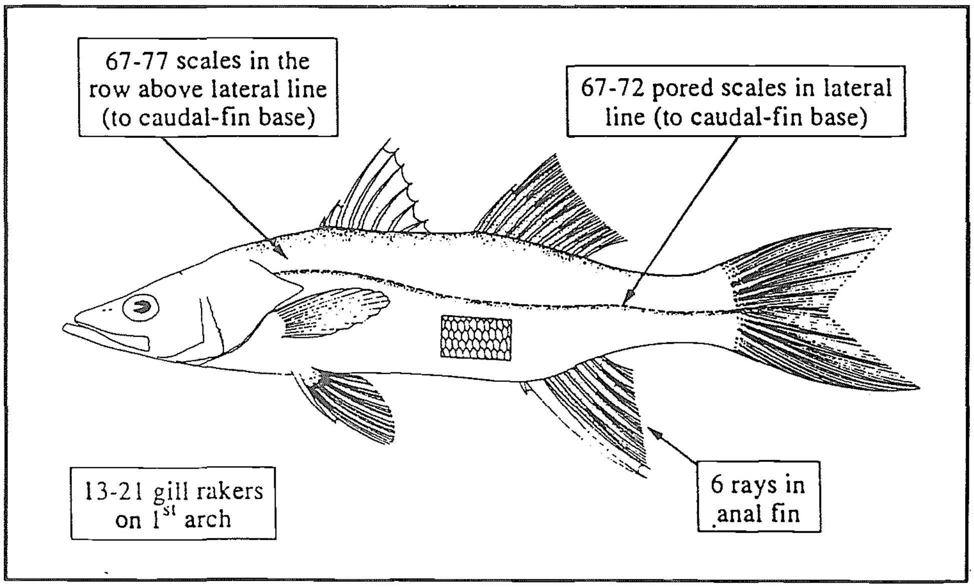


Figure 20: The common snook (*Centropomus undecimalis*). Figure from Cervigon *et al.* 1993.

Adult habitat

Adult habitats include rivers, estuaries and the outer shores of barrier islands. In the Guiana/Brazil continental shelf area, they are a near shore species

Spawning

In Florida spawning occurs between April and December and peaks in the summer months - July to September. Spawning may occur year round in warmer waters.

Nursery Grounds

In Florida, small juveniles are found in quiet marshes, creeks and lagoons. Larger juveniles have an expanded range that also includes the shores of rivers and more open bay. The young have been observed to migrate from shallow riverine habitat to deeper water and salt marshes and eventually to over seagrass beds as they grow.

Temperature

High temperatures (up to 35.6 °C) do not appear to affect habitat utilization by juveniles, however, drops in temperature apparently cause the snook to migrate to warmer waters.

Vegetation

Many different types of vegetation were associated with the nursery areas including floating mats of mixed *Panicum* sp., red and black mangrove prop roots and rhizomes which were submerged at high tides, and stems of *Juncus roemarianus*, *Typha domingensis*, and *Acrostichum* sp. which also became submerged at high tide.

Most nursery areas also have various types of shoreline vegetation including mangroves, palms (*Sabal palmetto*, *Serenoa* species), Brazilian peppers (*Schinus terebinthifolius*), and oaks (*Quercus* species.). The canopy of these trees provides shade. In addition, fallen, submerged branches also provide cover.

Diet

Juveniles have been observed to feed on fishes, shrimps, crabs, and zooplankton. A feeding transition occurs when the juvenile reaches a certain length (45mm in one study, 15 to 25mm in another study). The amount of copepods in the diet decrease and the amount of fish and shrimp increases.

Juveniles 25-120 mm mainly feed on fish, palaemonid shrimp and microcrustaceans. The snook consume the most common small fish species in the habitat. The type of shrimp in the diet apparently depends on the size of the snook and the area in which it feeds. In small juveniles (26-100 mm) palaemonid shrimp are a common part of their diets, whereas in larger juveniles (100-200 mm) the larger penaeid shrimp are more common. Shrimp were a major prey group of snook of length greater than 50 mm in the Tampa Bay area, Florida (McMichael *et al.* 1989).

There are two more species of importance in the family Sciaenidae, mostly associated as by-catch in the industrial shrimp trawl fishery, but sometimes also captured by the artisanal fishery, these are the shorthead drum (*Larimus breviceps*) and the butterfish (*Nebris microps*). They also can be easily confused with other members of the family *Sciaenidae*. Please refer to figures 21 and 22.

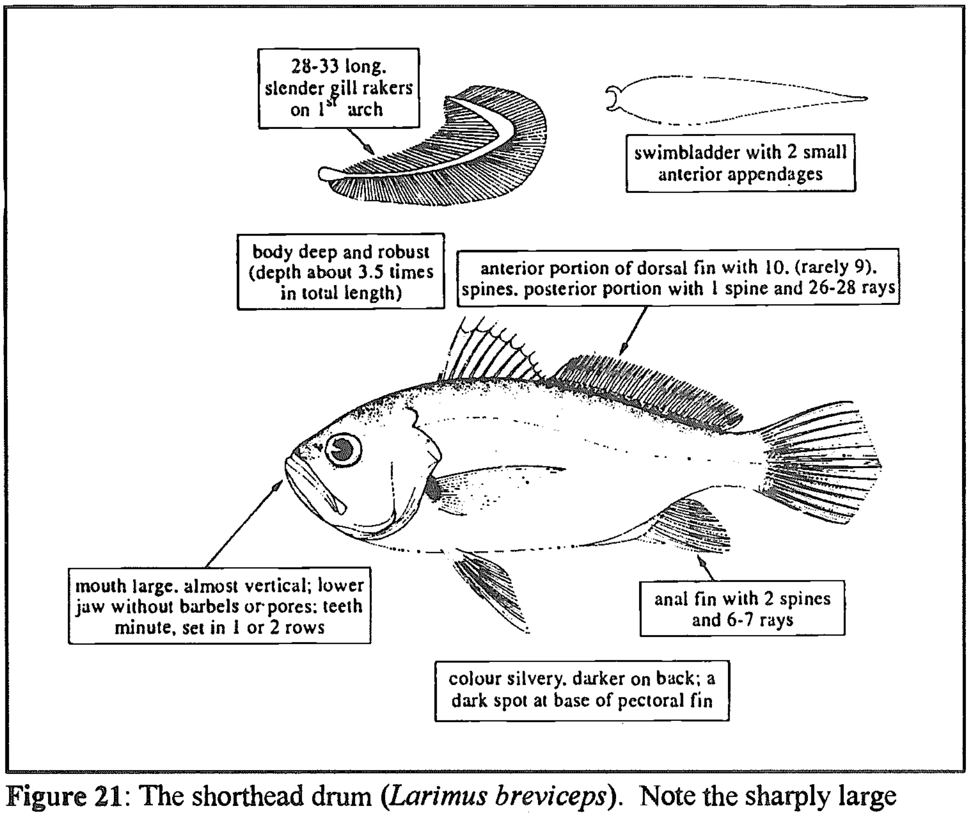


Figure 21: The shorthead drum (*Larimus breviceps*). Note the sharply large upturned mouth, typical of an opportunistic predator.

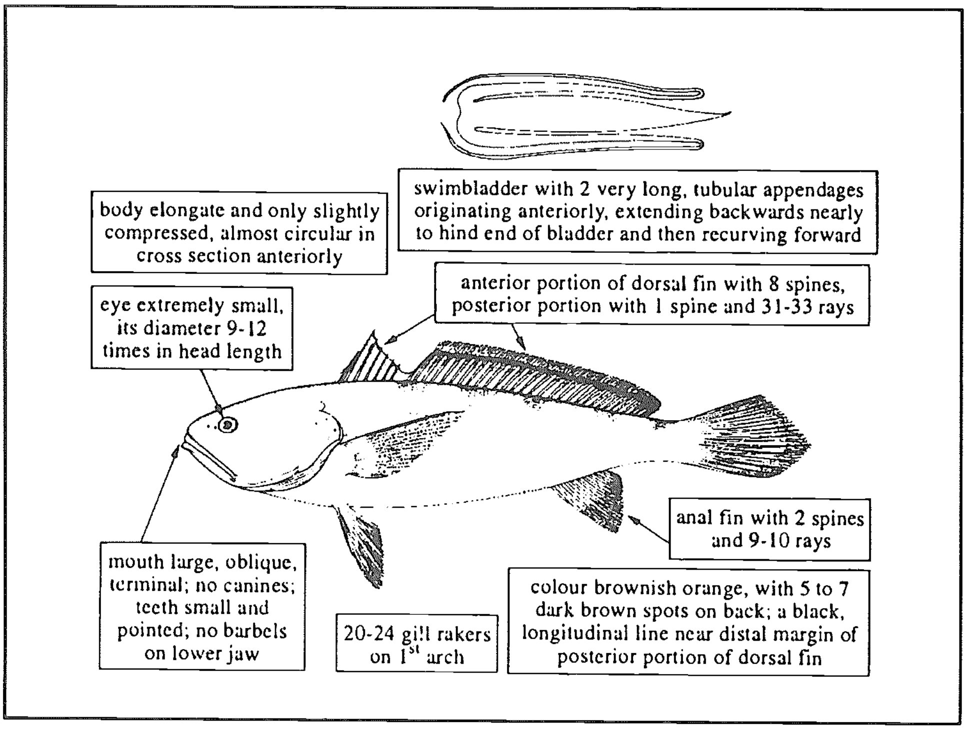


Figure 22: The butterfish (*Nebris microps*). Note also the large u*pturn*ed mouth extending past the very small eye. This species can be easily mistaken for one of the weakfishes, particularly if the head is missing.

ARIIDAE (THE MARINE CATFISHES)

There is very little information on the biology of the catfishes. The information presented below is intended to assist in the identification of the targetted species only. For further information, refer to Cervigón *et al.* (1993).

Arius grandicassis

The fisheries of this species is predominantly artisanal, targetted by the gill net and beach seine fisheries, but may also be caught by the industrial trawl fishery for shrimp. There is very little biological information on this species. It is extremely variable morphologically, and may actually be a group of more than one species.

Arius parkeri (Gillbacker)

The fisheries of this species is predominantly artisanal, targeted by a wide range of gear types, including gill nets, beach seins, hook and line and long-line fisheries, but may also be caught by the industrial trawl fishery for shrimp. There is very little biological information on this species, but it is highly esteemed and very common in the landings. It is targetted as a primary species for biological data collection.

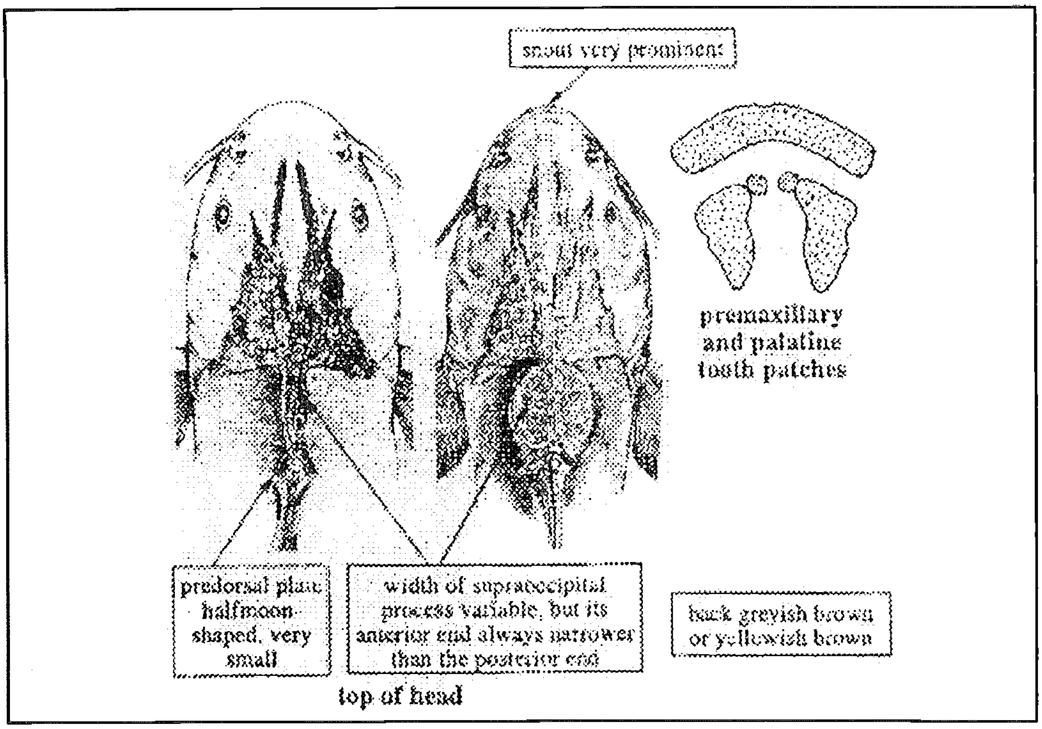


Figure 23: The catfish *Arius grandicassis*. This species is extremely variable in morphology, particularly with respect to the bony plates on the head, and may in fact be a complex of several closely related species, subspecies or popultons where environmental parameters (salinity, ood, temperature) have ifluenced morphological development.

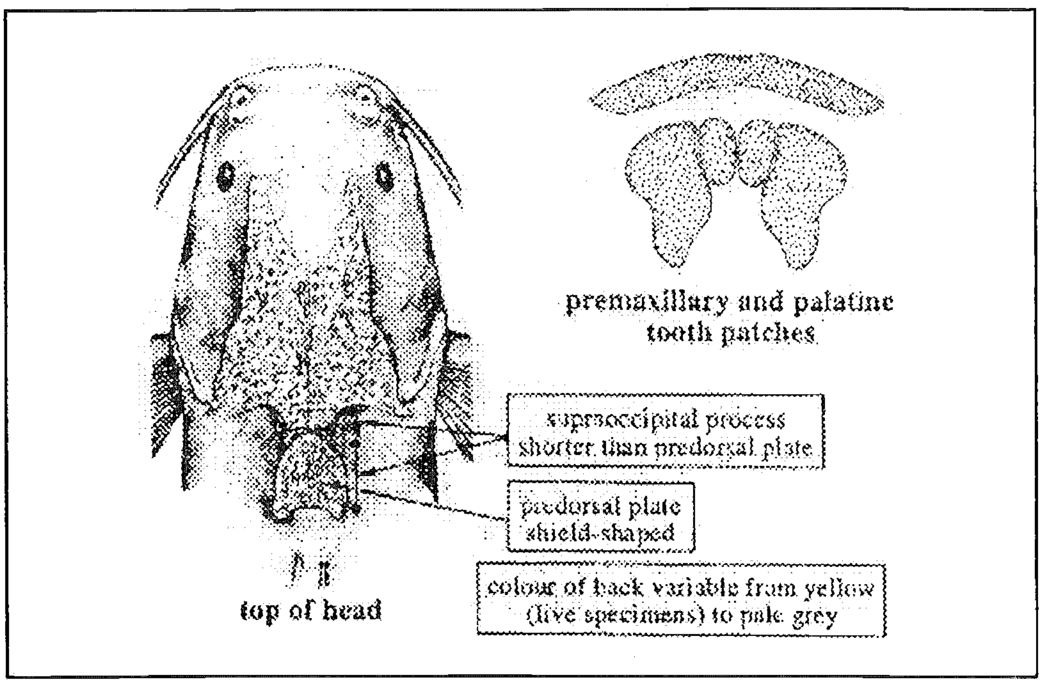
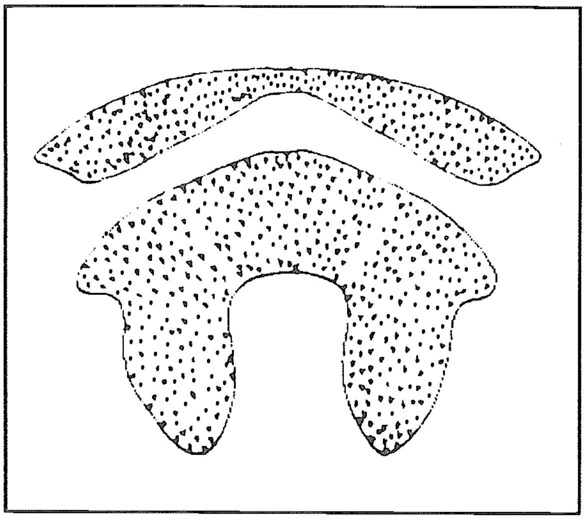


Figure 24: The Gillbacker *Arius parkeri*. This species is easily recognized when fresh because of its yellow colour, but less fresh specimens lack this colour. The square snout is also characteristic but can lead to confusion with several other species. The tooth patches and plate shapes are useful characteristics. This species is easily confused with ***Arius proops***, whose premaxillary and palatine tooth plate is shown below.



Bagre bagre

This species is caught predominantly by the artisanal fishery with gill nets and beach seines, but may also be caught in the by-catch of the industrial trawl fishery for shrimp and intercepted by the fixed gear fisheries in the estuaries (Chinese seines). It is less common than *Bagre marinus* in many areas and targeted as a species of secondary importance for biological data collection.

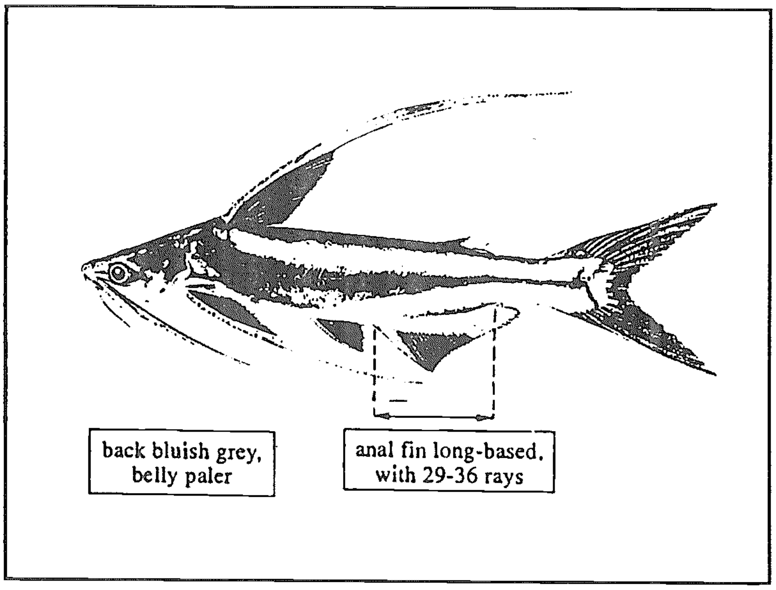


Figure 25: The marine catfish *Bagre bagre*. Note the very long dorsal spine and the forked caudal fin.

Bagre marinus

This species is caught predominantly with gill nets and beach seines by the artisanal fishery, but may also be caught in the by-catch of the industrial trawl fishery for shrimp and intercepted by the fixed gear fisheries in the estuaries (chinese seines). It is a common species and targeted for biological data collection.

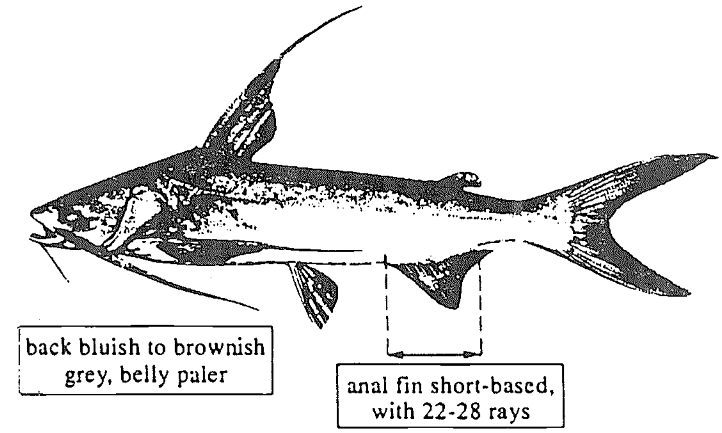


Figure 26: The marine catfish *Bagre marinus*. The dorsal fin is shorter but this is an ambiguous morphological characteristic to use unless both *B. bagre* and *B. marinus* are side by side. The characteristics of the anal fin are more useful if unsure.

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Transboundary Stocks/Fisheries: Fisheries at the Guyana/Suriname Border

R. Charles[1]

INTRODUCTION

Guyana and Suriname, two countries on the Atlantic Coast of South America, are connected by the Corentyne River. The border of Suriname is the high water mark of the Corentyne River on the bank of Guyana, that is, Suriname manages the entire Corentyne River.

Both countries have declared two hundred miles Fishery Zone or Exclusive Economic Zone (EEZ). Still to be resolved is a triangular area of overlap based on the EEZ established by both countries.

The area of the EEZ for Suriname is 129,500 km^2, while that of Guyana is 138,240 km^2. However, the average width of the continental shelf of Suriname is much wider than that of Guyana.

The marine resources of these two countries are contained in the management unit that extends from the mouth of the Amazon River to the mouth of the Orinoco River, which area is described as the Guiana Banks. A recent FAO/DANIDA Survey (1988) indicated that the fishery resources off Suriname are greater than those off Guyana. It also showed movement of some concentrations of a few species seasonally into the waters of both countries.

DESCRIPTION OF FISHERIES

The industrial fishery in Suriname has approximately 122 vessels exploiting large penaeids (prawns), twenty three (23) fin fishing trawlers and 57 snapper liners (Matroos, 1995) while Guyana's industrial fishery comprise at present 69 prawns trawlers and twenty-nine (29) seabob trawlers. The artisanal fishery of Guyana is decidedly very large, having over 1200 vessels, with the area having the second largest concentration of artisanal vessels being on the Corentyne Coast at the border with Suriname. Suriname's artisanal fishery has slightly over 1000 vessels. Both the shrimping fleet and artisanal fisheries of Suriname utilize a very significant number of Guyanese fishermen.

Both countries manage their fisheries by licencing their fishing vessels. The artisanal fishery in both countries is "open entry" for nationals of the respective countries. Against this background, one can recognize areas for cooperation and areas for constant conflict between fishermen and fisheries management authorities of these two friendly countries. The major problems come from the artisanal fishery.

GOVERNMENT INTERVENTION

Prior to the establishment of Fishery Zones and Exclusive Economic Zones in the late seventies (Guyana in 1977, Suriname in 1978) both industrial and artisanal fishermen of all the South American Atlantic states fished beyond the 12 mile territorial seas of any other state.

However, Guyana's artisanal fishermen always had an issue regarding fishing in the Corentyne River and the inshore waters of Suriname. This could be traced back to 1961 when the Government of Guyana represented the case of Guyanese fishermen to the Government of Suriname.

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[1] Fisheries Department, Guyana.

Guyana and Suriname started discussions on a Reciprocal Fishery Agreement following the establishment of Fishery Zone and EEZ by the countries. This agreement which addressed fisheries in the Atlantic Ocean but not in the Corentyne River, was completed by the negotiating teams in 1979 but the appropriate steps to put the agreement into operation were not taken. Since then, there have been approaches to restructure the agreement and to reopen negotiations. Suriname, in 1995, suggested that the agreement be put on hold and that other arrangements permitting fishing be explored.

In the arrangement, Suriname offers licences directly to 50 Corentyne vessels to fish off the Suriname Coast (SK licences) and another 50 licences to fish in the Corentyne River (BV licences). The value of the licences was negotiated between Suriname's fishery authorities and the Corentyne fishermen. This arrangement has the following advantages:

- the expensive deals between Guyanese fishermen and Surinamese nationals would be significantly reduced.
- the requirement of landing fish in Suriname would no longer exist, thus vessels will not be arrested for smuggling fish from Suriname to Guyana.
- the Government of Suriname earns revenue.
- the fisheries authorities in Suriname would now obtain data on fishing activities in their waters.

This new arrangement was put into force in mid-1995 and still has a lot of teething problems. The question of the identification number of the vessels still has to be resolved. Also, the total number of licences offered is inadequate for the size of the fleet in the area. However, some fishermen are apparently continuing with the old system because they disagree with the value of the licences or because of habit.

Government has also been encouraging cooperation at the technical level to enhance management of the resources. The countries are members of the WECAF Ad Hoc Shrimp and Groundfish Working Group on Shrimp Fisheries of the Guianas-Brazil Continetal Shelf.

REVIEW OF PROBLEMS

Evidence confirms that Suriname's industrial fishermen (shrimp trawlers) fish illegally in Guyana's waters while Guyana's artisanal fishermen fish illegally in Suriname's waters. The Corentyne coast artisanal fishermen do face a serious problem since the waters surrounding them belong to Suriname.

Corentyne fishermen evolved innovative means of dealing with their situation. It should be noted that over the years there had been significant migration across the Corentyne River of Guyanese moving to Suriname. Corentyne fishermen make deals with Suriname nationals who would assume ownership of the Guyanese fishing vessels, obtain a Suriname fishing licence as a Surinamese national and thus earn the vessel the right to fish in Suriname's waters. Problems attendant to this arrangement include the requirement to land fish in Suriname, marketing arrangements and the reaction of Surinamese authorities.

The changing economic fortunes of the countries further complicate the situation. There has been a high degree of smuggling in the Corentyne River and fishermen are accused of being involved although they claim that the smugglers pose as fishermen to transfer the blame.

The new arrangement does not solve some chronic problems. Some of these are discussed below:

- Arrest and trial procedures differ in the two countries. This has led to accusation of harassment and diplomatic interventions.
- The "Harbour licences" requirement in Guyana has not been demanded by Suriname. Guyanese fishermen fishing in Suriname do not see the need to satisfy this requirement.

- Inevitably there are disputes in the fishing grounds, e.g. destruction of fishing gear, rights to fish in certain areas, etc. There is a procedure in Guyana involving the Fisheries Department acting as arbitrator that attempts to solve these issues before the matter, if necessary, gets to the court. Guyanese fishermen in Suriname, partly because of the illegal arrangements that existed, could not seek the assistance of the Fisheries Department. This issue should be addressed under the new arrangement.
- There has been an increasing number of incidences where fishermen gear (nets) have been stolen at sea while deployed to catch fish. It is suspected that fishermen from both countries are involved. The presumed arrangement is that Guyanese fishermen living in Suriname join with Surinamese fishermen to steal nets, etc. from Guyanese waters. The reverse situation is also presumed. There is no formula at present to stop this practice.
- Piracy at sea is also a disturbing feature. Fishing vessels are approached by another apparent fishing vessel whose crew, when up close, relieve the fishing vessel at gunpoint of outboard engines, catch, fuel or gear. Increased surveillance and cooperation between the countries are necessary since again it is assumed that the perpetrators of the crime in Guyana reside in Suriname and those of the crime in Suriname reside in Guyana.
- Some Guyanese fishermen on the Corentyne Coast not licenced in any of the arrangements to fish in Suriname's waters, do not fish in Suriname waters. They however have to travel in Suriname's waters on the way to and from the fishing grounds. While in Suriname's waters, they could be arrested. There has been very few incidents of this reported, but the two countries would have to address this issue.
- Data Collection is also an issue for both Suriname in terms of their management of their resource and Guyana in terms of socio-economic issues. A program to obtain this information through log books is being introduced by Guyana. Suriname would have access to this information as required by the new arrangement.
- Guyana has the additional concern of their fishermen not purchasing licences because they "fish in Suriname's waters."
- Fishing in the overlapping triangle is now surfacing as an issue, since red snapper is abundant in the area and fishermen could be arrested by both countries.

RECOMMENDATION

Guyana and Suriname have established a Guyana/Suriname Cooperation Council in which there is a Fisheries Committee. Fisheries problems should be brought to the Committee for resolution. However data gathering and analysis may require more specific collaboration between the fisheries departments of the two (2) countries.

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Review on the Use of Devices to Prevent Undesired Captures in Shrimp Trawl Nets

L.A. Marcano[1], J.J. Alio[1]

INTRODUCTION

Trawling nets for shrimp have been traditionally poor selective devices, due to the small mesh size required in them. Nevertheless, the concern among fishermen for the undesired by-catch is an old issue that is gaining momentum nowadays (Murray *et al.*, 1992), as fish resources dwindle and more strict conservation norms are being applied by different governments. The principle of Responsible Fishing, under progressive adoption by the governments, as a recommendation from the United Nations Organization, is leading to the implementation of alternatives to reduce by-catch in the shrimp fishing industry. However, many of the by-catch reducing devices tested so far, perform the exclusion by allowing the escape of the undesired fauna from the net, rather than by preventing the by-catch from entering it. In this respect, Main & Sangster (1993, quoted by Conolly, 1986) argue that once the fish enter a trawling net and reach the cod end, they are either too stressed or too tired and then their escape response is seriously impaired, or their susceptibility to predation increased.

International events have been the scenario for presentations on the use of alternative and more selective harvesting gear for shrimp (traps, pots, cast nets, etc.), the modification of the trawl gear, the change of fishing practices (Fabres, 1995), or the installation of devices that allow the escape of the by-catch, with emphasis on the non-commercial component (Conolly, 1986; Coreil, 1989; Watson & Taylor, 1991; Alió et al., 1995).

The purpose of this report is to present a review of the state in which the use of devices to prevent the capture of by- catch is found in the shrimp trawl industry.

ORIGIN AND COMPOSITION OF THE BY-CATCH

One of the most effective gear for shrimp harvesting is the trawl net, used in the most important shrimp fleets of the world; thus, a major emphasis is being put in the development of devices that reduce by-catch in this type of gear. The marine turtle conservation measures, imposed by the United States Government on those countries wishing to export shrimp to that country, is forcing the adoption of sorting devices in the nets (like the Turtle Excluder Device, TED, or its less accepted name, Trawl Efficiency Device), that not only allow the escape of sea turtles, but also of finfish (particularly the large ones) and shrimp (Matsuoka & Kan, 1991; Marcano & Alió, 1995).

A net, in order to be effective for the capture of a particular resource, should be constructed taking in consideration, among other things, the habitat of that resource, the escape responses (if any) of the animals, and the minimum legal size of the individuals allowed for commercial exploitation. During the use of trawl nets for shrimp, two major inconveniences arise: the small size of the targeted animals that forces the use of a small mesh-size, and the habitat where shrimps are found which is shared by a diverse fauna. This situation leads to the fact that by-catch in shrimp trawl operations is normally large.

[1] FONAIAP, Venezuela.

The composition of this by-catch has been studied in many countries. As a reference, the data collected in Venezuela (Valdés, 1985; Marcano et al., 1985; Marcano, 1989) show that close to 95% is formed by a diverse group of fish juveniles, returned dead to the sea. The other 5% is a group of crustaceans, echinoderms and mollusks, which frequently are returned live to the sea.

The amount of by-catch varies according to the shrimp and fish abundance in a site, and the use made with the material in the catch. In Venezuela's shrimping areas, the proportion of by-catch varies between 94-95% of the capture. From the total capture, 30-33% is normally landed, whereas the rest is dumped back in the sea. The amount of non commercial by-catch dumped mostly dead in Venezuelan waters reached about 66,300 mt in 1994 (Marcano, 1995), for a commercial capture of shrimp and fish of 4,400 mt and 24,000 mt, respectively (MAC-SARPA, 1995).

A considerable time and effort must be allocated by the crewmen to the culling of the catch for shrimp and marketable fish from the non-commercial by-catch, besides of the effort to throw the latter overboard. In spite of this fact, most fishermen have shown a passive attitude towards the use of implements to exclude the non-targeted species from the nets. Among the exceptions, Coreil (1989) reported that prior to 1978, shrimp fishermen in Louisiana were already using excluder devices for the non-target species from the trawl catches, made with bars of PVC and later with aluminum rods.

THE EXCLUDER DEVICES

The types of excluder devices, proposed or in use, in the shrimp trawl industry can be grouped according to the strategy used by the designer. The categories can be named as "blocking" or "behavioral".

The "blocking" type of excluder device intends to sieve the catch *in situ*, allowing the passage towards the net of the shrimp and small-size by-catch, and preventing the access of the larger organisms. The blocking implement can be made of soft material (polyamide net), or with hard parts, like rods of aluminum or PVC. It can be installed in the entrance of the net (Conolly, 1986) or in the tunnel, before the end sac (like in the TED; Watson *et al.*, 1986). The latter case requires the installation of a special opening to discard out of the net the material unable to pass the barrier.

In all cases, the "blocking system" has had the same type of problems. Among them, the loss of shrimp and commercial fish, due to the clogging of the blocking device by large organisms (Conolly, 1986; Marcano & Alió, 1995) or because the large organisms will not be able to pass through the blocking device. Another inconvenience with this type of device is the frequent breakage of the net by excessive abrasion, or the destruction of the blocking device because of impacts with rocks or branches entering the net from the sea bottom.

The Turtle Excluder Device (TED) intended for the exclusion of sea turtles using the "blocking" system, would theoretically allow the passage of all shrimp. The use of the implement has been successful in the reduction of the incidental captures of marine turtles (Henwood, *et al.*, 1992). However, since no considerations for the by-catch were taken in its design (Rulifson *et al.*, 1992), its use in trawl fisheries leads to large losses in this component of the capture. This is particularly serious in countries where the landing of by-catch is important because of its volume and the fact that the fish is consumed mainly by the low income portion of the population.

Considering the economic impact of the TED on shrimp trawling fisheries, it is found that the reduction in fish capture with the use of this device in Venezuela was about 45%, that of octopus reached 56%, whereas the capture of shrimp, squid and small sharks was not significantly affected, when comparing the net with and without the device. An average reduction of 28% in non commercial by-catch was also observed in the net where the TED was installed (Marcano & Alió, 1995).

In another study, Robins-Traeger (1994) reports that during a trial with the Morrison soft TEDs in Australia, the effect of the TED upon catch rates was highly variable; he found reductions in shrimp capture in the TED equipped net between no significant to 29%, depending on location or season; the capture of portunid crabs was reduced by 50%, whereas that of commercial fish was not significantly affected. Large by-catch animals, like rays or turtles, were absent in the TED equipped net, but were occasionally caught in the control net.

The "behavioral" type of devices were developed based on SCUBA observations of fish and shrimp behavior before and after entering the net (West et al., 1984; Boddeke, 1986; Wardle, 1986; Watson et al., 1986; B). Shrimps are bottom dweller organisms that make occasional swims and small jumps when disturbed. Most demersal fish thrive above the bottom, with the exception of flat fish or those inhabiting in holes or crevices. Observations of the shrimp and fish behavior inside the net show that fish keep swimming until the reach the end sac; on the other hand, shrimp jump inside the net and are carried passively by the inner currents to the end sac.

One of the excluder devices in this category was described by West et al. (1984). It was intended to scare fish away from the mouth of the trawl net by a sound emitting implement towed in front of the net. Their success was limited and no information was provided on its use in commercial operations.

Based on the different vertical distribution of fish and shrimps on the ocean bottom, a french design of net was tested using two compartments, an upper one with large mesh size intended for the capture of swimming fish, and a lower one with fine mesh for crustaceans and flat fish. No data was available on the testing of this net in commercial operations (Anonymous, 1988).

Some of the best results so far obtained in the process of excluding undesired finfish by-catch from trawl nets, has been found with the use of hatches located in the tunnel of the net. According to the behavior of fish and shrimp inside the net, openings in the sides of the net would be accessed more easily by swimming fish than by shrimp. In this respect, there have been several tests of gear modification intended to the reduction in finfish by-catch, while maintaining to a minimum the loss of shrimp.

Conolly (1986) tested the installation of a circular escape opening all around the tunnel of the trawl net. A funnel of net accelerated the capture in its way towards the end sac, trying to prevent the escape of shrimp. Although a 40% reduction in finfish by-catch was observed, the 25% decrease in shrimp capture was unacceptably high with this type of gear modification. Valdemarsen (1986) tested a similar device with two funnels in the trawl nets for deep pandalid shrimp in Norway. The exlusion rate for the two major species in the by-catch, haddock and cod, reached 70%.

These results support the hypothesis that fish access lateral openings in the net more easily than shrimp; thus, a more restrictive mechanism preventing shrimp from reaching the escape openings would solve the problem of excessive shrimp losses. In this sense, Alió *et al.* (1995) tested the use on an upper opening in the tunnel of the trawl net, installing underneath an inclined plane of net that reached to the middle of the tunnel. The plane forced all the catch to reach the end sac close to the floor of the net and away of the opening. The fish would be able to return and move up towards the escape opening, helped by the inner currents in the net. The opening could be covered only by ropes, allowing the escape of any fish reaching it, or by square mesh with sizes adjusted accordingly for the retention of commercial fish. Fin-fish by-catch was reduced by 35% when the opening was covered by square mesh and 51% when ropes were used. Average shrimp capture was not affected, although wide fluctuations were observed when comparing the modified and the control net. Fish captures consistently increased by an average of 30% in the modified net, for a reason not clearly established.

Finally, the use of TEDs in shrimp trawl nets has been tested in connection with escape openings for fish by-catch reduction. Matsuoka & Kan (1991) evaluated the use of openings in a single net with a TED installed. The openings could be close and opened in different trials. The capture of shrimp was not affected, but the escape of fish was species related, 76% in javelinefish to nil in ponyfish, when windows were opened. Rulifson *et al.* (1992) tried a design with different type of windows (square mesh, rhombic openings, square mesh in connection with a Parrish TED). The Parrish TED, modified with square mesh windows, was the only by-catch reducing device that had a significant reduction ($P< 0.05$) in the percent difference in total biomass compared to the control net. By-catch reduction was not consistent for other designs. The escape results for each design was species related. The goal of reducing by 50% the by-catch with a shrimp loss of less than 5% was not consistently reached.

The last authors also indicate calculation problems due to the differential fishing capacity of the two boards of the vessel. This same problem was found by Alió *et al.* (1995) and was solved through an standardization process using two similar nets in both sides of the vessel.

In a trial still in progress in the Gulf of Venezuela, Pomares et al. (in preparation) have tested the use of the Super Shooter TED along with the escape panel designed by Alió *et al.* (1995) in shrimp trawl nets. The escape openings are being covered with square mesh. The results indicated that the non commercial by-catch reduction reached 48%, but the commercial by- catch was reduced by 49%; the shrimp loss was large at the beginning of the trials, but has reached -1% to 4% during the latest tows on May 1995, reducing the mesh size which covered the escape exit.

CONCLUSION

The process of by-catch reduction in shrimp trawl nets has as major goals: to achieve a reduction in by-catch (by a reasonable 50%) while maintaining the loss of shrimp capture to a minimum (expected to be no more than 5%). In order for the gear modification to be accepted by the crew members of different fleets, the device should be made using easily found, low-cost materials, introducing the least possible modifications in the customary management of the fishing gear.

Among the by-catch reduction devices tested during the last ten years, those designed based in the behavior of fish and shrimp inside the trawl nets have been the most effective in the fulfillment of the aforementioned goals. However, the variation is still large among the tows made with a similar design. From the causes associated to this phenomenon, it can be mentioned: different seasons, locations, species in the catch, or even the board of the vessel where the experimental net is placed. As with the use of the TED, the variation problems will most probably find different solutions when the use of by-catch reduction devices in commercial operations becomes common.

The forced use of TEDs in the trawl nets of several shrimp fisheries has resulted in a substantial reduction of the incidental capture of marine turtles and by-catch, at the expense of large economic losses due to the significant escape of commercially important shrimp and fish from the nets. The use of TEDs has also disrupted the implementation of other type of by-catch reducing devices, that could be more effective in the exclusion of finfish by-catch from shrimp trawl nets.

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