NATIONAL REPORT ON THE SHRIMP FISHERY IN SURINAME

by

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1. PRESENT SITUATION OF THE SHRIMP FISHERY

The description prepared in January 1996 for the "CFRAMP Shrimp and Groundfish Subproject Specification Workshop & Fourth Meeting of the WECAFC ad hoc Shrimp and Groundfish Working Group on the Guiana-Brazil Continental Shelf" (Charlier et al, 1996), remains in general valid. The main features of the shrimp fishery in Suriname are:

- It is an all-industrial fishery, without a small-scale component in the exploitation.
- Two shrimp species (*Penaeus subtilis and P. brasiliensis*) make up most of the catch, complemented by two secondary species (*P. notialis and P. schmitti*).
- Extraction is carried out by a fairly stable fleet of 100 to 120 trawlers of the classic double rigged type. They belong to a number (20 to 25) of foreign owned fishing companies.
- Two main components can be distinguished in the fleet : a Korean fleet and a Japanese fleet. Numbers fluctuate from year to year, but the Korean fleet totals 70 to 90 trawlers, and the Japanese fleet remains at approximately 30 vessels. There is also a small fleet sailing under the Surinamese flag, which can be considered part of the Korean fleet, since it is operated by Korean fishing companies under chartering agreements.
- The differences between the fleets lie mainly in the fishing grounds. The Japanese fleet operates in deeper waters than the Korean fleet, and mostly at night. It targets one shrimp species *(P. brasiliensis*), while the Korean fleet does not show such a preference and exploits all species.
- Shrimp is processed at two plants, SAIL and SUJAFI. A new processing company has been established in 1996 (Guiana Seafoods). This plant processes finfish, sea bob and shrimp. The relative importance of shrimp in the landings, or their approximate volume, are not known as data collection by the Fisheries Department at the plant has not been arranged yet.

Besides the shrimp fleet, there is a growing number of trawlers operating mainly on finfish. Part of this fleet consists of former shrimp trawlers where the fishing gear has been modified in order to increase the finfish catch. The fleet also includes larger vessels (stern trawlers), with engine power generally higher between 500 and 1 000 HP. Finfish trawlers of the first type (former shrimp trawlers) deliver catches at SAIL and, recently, at Guiana Seafoods, while other types of finfish trawlers use other landing places.

2. RESULTS OF THE EXPLOITATION

The data available on effort include the number of boats licensed, the number of trips (deliveries) and the number of days at sea (Table 1). The number of days at sea has been obtained for the vessels landing at SAIL since 1983, but is not available for the vessels landing at SUJAFI. More accurate effort units, like the number of hauls or of trawling hours, could be extracted from logbooks submitted by part of the fleets (not done currently).

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Table 1: Annual fishing effort by fleet

Year	Number of deliveries				Number of days at sea (SAIL)
	SAIL	SUJAFI Korean	SUJAFI Japanese	TOTAL	
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
1995	214	115	228	557	15,691

Effort is evenly distributed over the months, as shown in the next table, as an example, for 1994 (Table 2). A slight peak is generally observed in April-May, corresponding to the best yields in the year.

Table 2: Distribution of fishing effort by month in 1994

Month	Number of deliveries				Number of days at sea (SAIL)
	SAIL	SUJAFI Korean	SUJAFI Japanese	Total	
January	18	10	20	48	1,574
February	18	8	22	48	1,236
March	19	9	15	43	1,418
April	18	8	20	46	1,648
May	22	6	20	48	1,762
June	21	7	19	47	1,735
July	18	7	17	42	1,108
August	26	13	19	58	1,961
September	23	8	21	52	1,555
October	18	8	20	46	1,359
November	18	10	18	46	1,378
December	16	11	20	47	1,052

The data on landings for each fleet, since 1973, have been compiled at the Fisheries Department. All figures presented in Table 3 are expressed in head-off equivalents (tail weight). Landings data prior to 1973 could not be located in Suriname, but global figures (annual production) can be found in the literature.

The annual production shows important fluctuations, with series of good years alternating with series of less favorable ones. After the last series of good years in 1986-1987, however, the production has not reached the level of 3,000 tonnes per year again. The production of the peak year of 1991 (2,828 tonnes) remained well below the level observed in earlier peak years, which was around 3,500 tonnes.
The best catch (landing) per unit of effort (cpue) data available for the entire fleet is the landing per delivery. Landings per day at sea are only available for the vessels landing at SAIL. Table 4 gives the average cpue 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 follows the same trend as the average landing per trip (for the whole fleet). The cpue's of all components of the fleet (Korean fleet landing at SAIL, Korean fleet landing at SUJAFI, Japanese fleet) also appear to follow parallel courses over the years.

Table 3: Annual landings at SAIL and SUJAFI (in kgs of tails)

Year	Head-off landings				Head-on landings	TOTAL landings (head-off + head-on)
	SAIL	SUJAFI		Total	SUJAFI (Japanese)	
		Korean	Japanese			
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 tonnes	544 tonnes	317 tonnes	2,410 tonnes	262 tonnes	2,672 tonnes
1993	1,486 tonnes	431 tonnes	171 tonnes	2,088 tonnes	346 tonnes	2,434 tonnes
1994	1,410 tonnes	444 tonnes	125 tonnes	1,979 tonnes	455 tonnes	2,434 tonnes
1995	1,428,197	540,658	228,358	2,197,213	414,501	2,611,714

Table 4: Annual CPUE per fleet

Year	Landings per delivery (kg tails)				Landings (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	2,474	4,300	83.3
1994	6,000	4,150	2,511	4,263	79.3
1995	6,674	4,701	2,783	4,689	91.0

The monthly cpue values are shown for 1994 hereunder (Table 5). The first part of the year has the highest yields, and the lowest yields are obtained from June to August, for both indexes (kg per day at sea and kg per delivery).

Table 5: CPUE per month, 1994

Month	Landings per delivery (kg)				Landings 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 6 presents the global parameters of the fishery since 1973 (total landing, total effort and average cpue per year). These data are also available by month.

Table 6: Annual landings, fishing effort and CPUE

Year	Total landings (kg of tails)	Total effort (number of deliveries)	CPUE	
			kg per delivery	kg 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 tonnes	659	4,055	75.0
1993	2,434 tonnes	566	4,300	83.3
1994	2,434 tonnes	571	4,263	79.3
1995	2,611,714	557	4,689	91.0

3. ASSESSMENT OF THE RESOURCES

3.1 Production modelling

Despite known limitations of this approach for the assessment of shrimp stocks, this exercise has been carried out several times in the region, and in Suriname, especially when only partial, non differentiated data were available. Table 7 shows an overview of results of the analyses performed before 1990, based on regional data, and based on data specific to Suriname.

The results of regional modelling have been used to estimate roughly the maximum sustainable yield and corresponding fishing effort in Suriname, based on the respective surfaces of the fishing grounds. Figures obtained in this way oscillated, for MSY, between 3,800 and 4,400 tonnes (tail weight). The fishing effort required would be of more than 200 boats. From the results of an earlier assessment by Venaille (1979), based on a shorter time series, comparable MSY estimates were obtained, with a corresponding fishing effort of little more than 35,000 days at sea. Assuming an average of 250 to 300 days at sea per boat, a “MSY fleet” of 117 to 142 boats was calculated (Charlier, 1989).

Using data on the fishery in Suriname only, lower MSY estimates were obtained (3,200 tonnes), but the corresponding effort was substantially higher. There were also years where MSY could not be achieved, whatever the effort. An attempt to apply production models to selected time series (separated into good and bad years) is also mentioned in the table.

From these results it was concluded that production keeps increasing with increasing effort, without a readable maximum. It is clear that there are annual factors influencing production, which are not accounted for by these models. One of them is certainly recruitment.

Table 7: *Evaluation of potential by production models*

Model	Years	Effort unit	Region		Suriname			
			MSY	Effort	MSY	F_{MSY}		
From data on the whole region (Charlier, 1989)						**# trips**	**# days**	**# boats**
Schaefer	65-85	# boats	11,800	570 boats	4,200			203
Fox	65-85	# boats	12,300	744 boats	4,400			265
From data on the whole region (Venaille 1979)								
Schaefer	64-76	# days	11,800	99,500 days	4,200		35,422	118 (1)
Fox	64-76	# days	10,700	98,000 days	3,800		35,173	117 (1)
From data on Suriname only (Charlier, 1989)					**MSY**	**# trips**	**# days (2)**	**# boats (1)**
Schaefer	78-87	# trips			3,200	900	58,500	195
Fox	78-87	# trips			3,200	990	64,350	214
Schaefer	79, 81, 86, 87 (good years)	# trips			3,700	974	63,310	211
Schaefer	78,80,82-85 (bad years)	# trips			3,100	1,106	71,890	240

= number of
(1) considering an average of 300 days at sea/boat/year
(2) considering an average of 65 days at sea/trip (SAIL, 1987)

3.2 Bio-economic modelling

Since no clear maximum is to be found on surplus production curves, it is difficult to recommend a MSY. What is wanted as a matter of fact is maximum benefit, that is maximum difference between production value and costs, rather than a maximum yield. Bio-economic models like those of the BEAM family investigate this. The BEAM I model was used in Suriname in 1983 (Willman and Garcia, 1985) and 1989 (Charlier, 1989). The following main conclusions were reached (see also Figure I) :

- The total net benefit drawn from the shrimp exploitation (fishing + processing) would not increase after the fleet had exceeded about 50 vessels; beyond 100 vessels it would actually start decreasing. The number of boats was remaining high as a result of competition between the fishing companies (overcapitalisation).
- At the current high levels of fishing effort, the impact of recruitment (variability) is such that the same fleet (level of effort) can operate profitably one year and lose money the next year.
- It was therefore recommended to use the following paths towards stock assessment and management :
    - understand shrimp recruitment variability, and its relation with production and cpue variability, requiring data which are differentiated by species, and these can only be obtained through sampling;
    - cohort analysis approach; (similar type of data required);
    - investigate further the economic factors of the exploitation, apply the different BEAM models now available, and consider management in accordance with bio-economic rather than purely biological criteria.

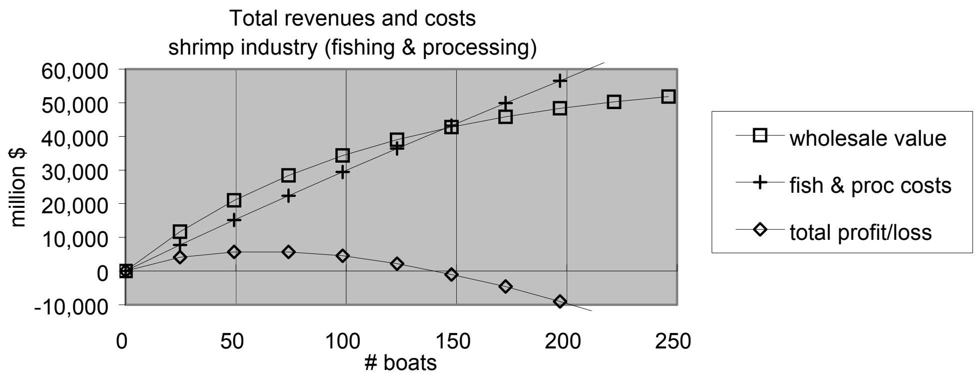

Figure 1: Total revenues and costs shrimp industry (fishing & processing)

3.3 Sampling the landings for species and size composition

After a few months of experimentation in 1984, systematic sampling of the landings at the plants started in 1985. This programme made use of the existing commercial size categories and aimed at establishing:

- the breakdown by species and sex in each commercial category ;
- the size distribution of each species/sex within each commercial category ;
- the size distribution of each species/sex, in the total landings, by combining the results of the two earlier analyses.

The sampling programme was therefore carried out in two steps. The first operation was counting tails of each species/sex, and the second one was measuring the tail length of a sample of each species/sex in each category. While counting required little time and was repeated several times a week, measuring was much more lengthy, and length frequencies resulting from measurements taken in different weeks or months were pooled and used over extended periods. An assumption was made here that the size distribution of a given species/sex within a given commercial category is better described by averages based on repeated samplings than by measurements specific to one particular sample.

Most of the sampling programme took place at SAIL. Scattered samplings were also carried at SUJAFI and should be used to test whether extrapolation of the SAIL results to the total landings may be valid. The head-on landings at SUJAFI have been sampled on only two occasions. The form shown in Table 8 was used to record the results of individual first step samplings (countings), as well as the monthly averages, expressed in number of tails (of each species/sex) per kg of a given category. These figures are easily extrapolated to the number of tails present in the total landings (of a boat, a week, a month), by multiplying by the corresponding weight landed.

For the transformation of the numbers of tails by commercial categories into the numbers of tails by length intervals (second step), conversion tables have been calculated for each commercial category and each species/sex. An example is shown graphically in Figure 2, for *P. subtilis* females.

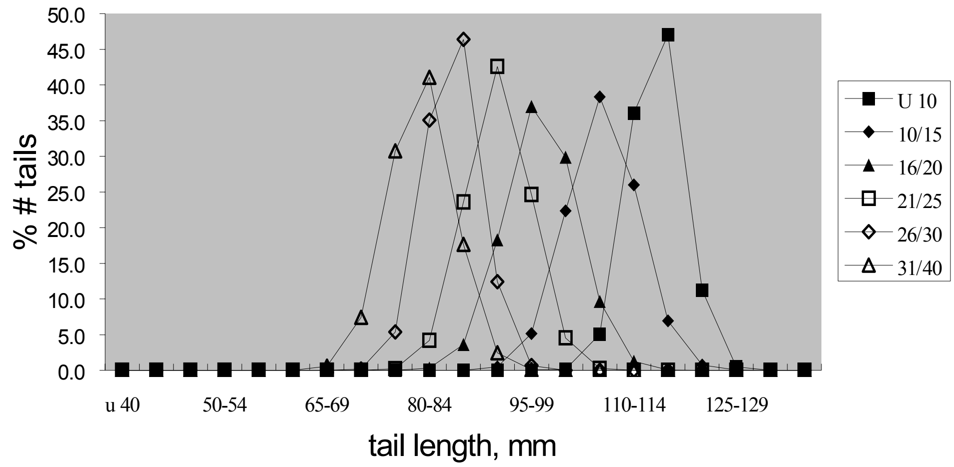

Figure 2: Relationship between commercial categories and tail length

Table 8: Form for sampling programme (see text for explanation)

Distribution by species/sex within commercial categories (number of tails per kg)																	
Boat sampled :													**Date :**		**Samplers :**		
	u 10	10-15	16-20	21-25	26-30	31-40	31-35	36-40	41-50	51-60	61-70	over 70	L P/O	M P/O	S P/O	culls	broken
Bf																	
Bm																	
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B = Brown shrimp (*P. subtilis*) ; H = Hopper (*P. brasiliensis*) ; P = Pink shrimp (*P. notialis*) ; W = White shrimp (*P. schmitti*)
f =female ; m = male ; o = sex undetermined.

The sampling programme was discontinued in 1992, as a result of lack of manpower. Data on landings by species remain necessary, however, for (almost) any future stock assessment attempt. Before the sampling programme can be resumed, several problems have to be solved and, in particular, the sampling scheme needs to be optimized. The optimal number of samples to be taken in the first step of the sampling programme (breakdown of the landings by species and sex) needs to be calculated, in accordance with the variance of the number of tails per kg. This variance depends on the species/sex as well as on the commercial category.

Figure 3 presents the coefficients of variation calculated from all data of the years 1986 and 1987, and shows that the same sampling intensity will not be required for all commercial categories. On the other hand, different species/sex show their highest coefficient of variation in different commercial categories.

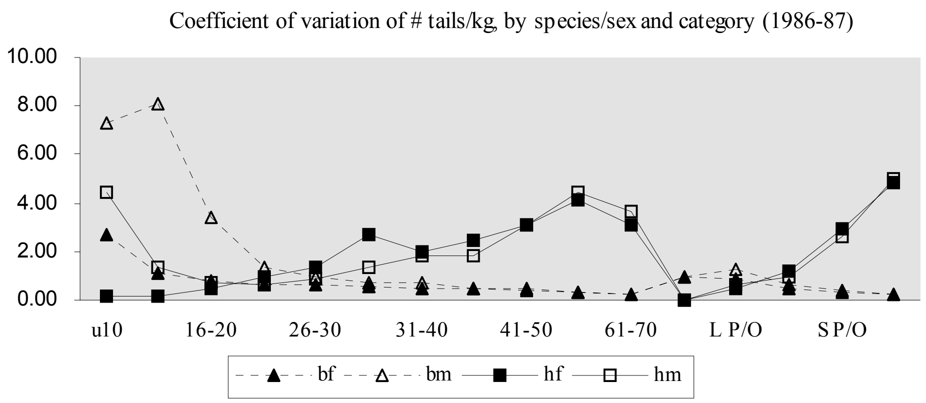

Figure 3: Coefficient of variation of numbers of tails/kg, by species/sex and categories (1986-87)

Figure 4 suggests a way to select an optimal sample size for a particular species/sex in a given commercial category, by bringing the maximum relative error to an acceptable level.

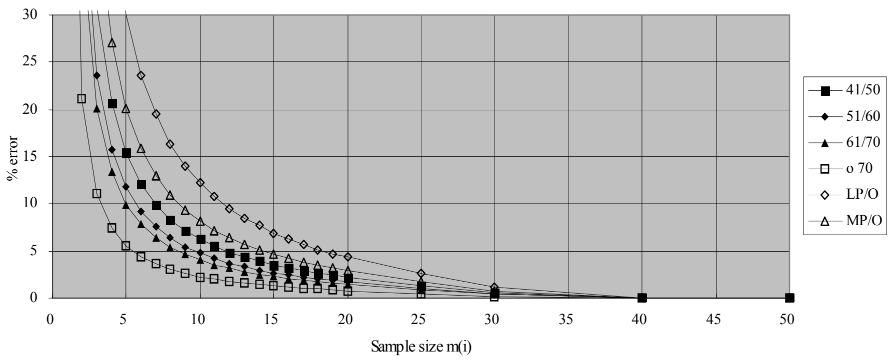

Figure 4: Maximum relative error (90%) of the average number of tails/kg brown shrimp, female;
M: 32 boats landing per month

The conversion tables (commercial categories to tail length categories) used in the second step of the programme should be recalculated at regular intervals. In practice, it is difficult (time consuming) to obtain satisfactory length frequency distributions for all species/sex/categories, especially where the numbers of a given species/sex are small. Consequently, the same set of tables, derived from all available measurements, has been used from 1985 to 1992. The validity of these length frequency distributions over longer periods of time should be investigated, and the optimal interval between two rounds of measurements should be established.

This is an important point, since step 1 (counting tails by species and sex) is much faster than step 2 (measuring them). The time/effort necessary to perform more frequent measurements would have to be deducted from the effort/time dedicated to sampling more landings.

3.4 Cohort analysis

Length-based cohort analyses have been carried out on female brown shrimp data over the years 1985 to 1991. It should be quickly mentioned that the data used did not represent the totality of the landings, since the landings at SUJAFI were not included. The results are therefore nothing but indicative, even though SAIL is considered to account for at least 65% of the total brown shrimp landings (see Table 3).

The exercise was carried out on the annual landings, on the total landings during the life-span of annual cohorts (as identified by eye), and on the average landings over the years 1985-1991. The average length frequency distribution over the period considered is shown in Figure 5.

The mortality and growth parameters used were those recommended during the workshop held in 1988 in Cayenne:

- M = 0.20 per month
- K = 0.190
- L_∞ = 129 mm

Results were series of fishing mortalities by size, for different assumptions on the final F/Z. Figure 6 gives as an example outputs of the cohort analysis on the data illustrated above (average 1985-1991). The curves resulting from the different assumptions appear very similar. The size suffering the highest fishing mortality remains 95-100 mm, beyond which fishing mortality smoothly decreases, for final F/Z lower than 0.4. A higher assumed final F/Z would produce a relative jump in the fishing mortality of the largest sizes.

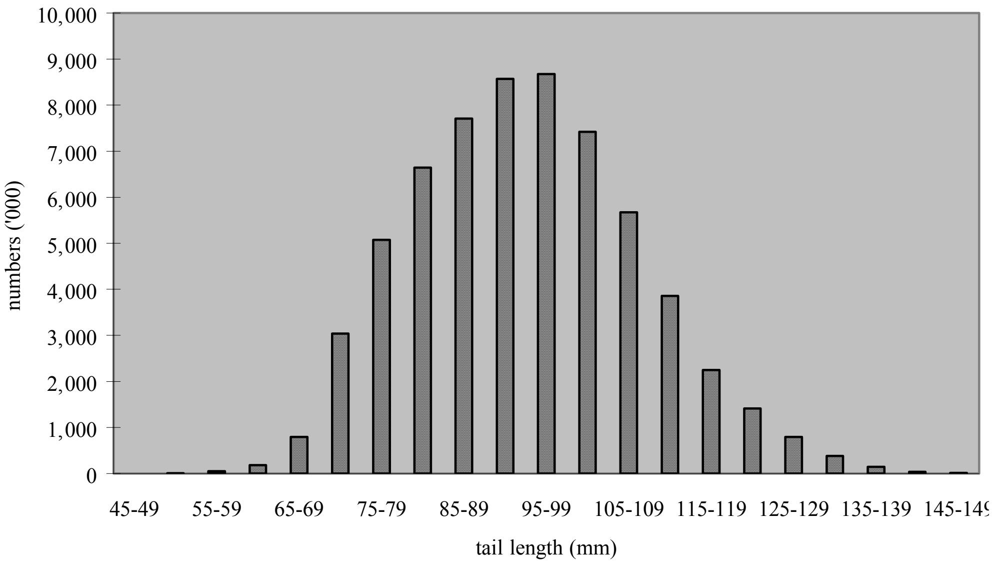

Figure 5: Average length frequency distribution, brown shrimp female, 1985-91

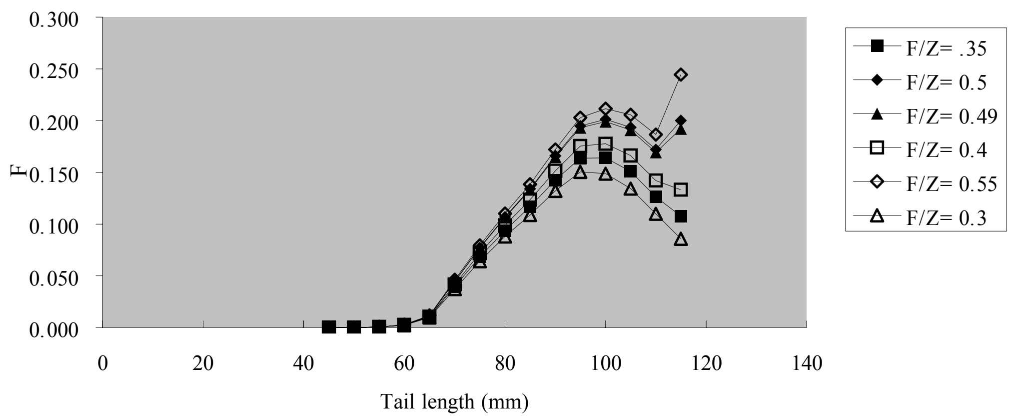

Figure 6: Fishing mortality by size, for various final F/Z

These results can be used to attempt catch predictions for various levels of fishing mortality, with results shown in Figure 7. While the catch, expressed in numbers of individuals or in weight, seems to keep increasing for fishing mortalities up to three times higher, its value soon reaches a maximum, and starts decreasing if F increases further than 1.5.

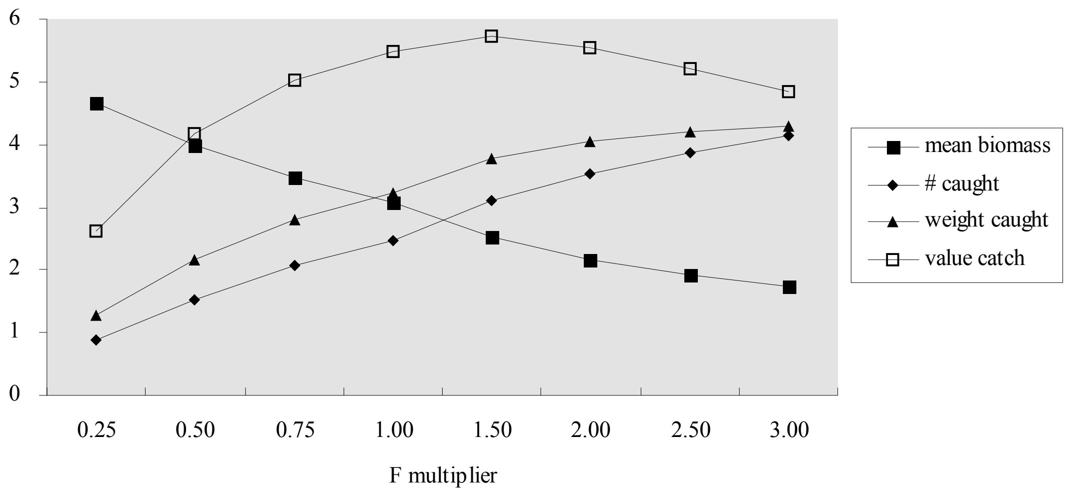

Figure 7: Catch production for different levels of fishing mortality

This analysis has not been further developed, because it was felt that the results were very dependent on input parameters (growth and mortality). Since there are no reliable, locally determined parameters available, it was necessary to select from a rather wide range of values calculated in the region, or even outside the region. On the other hand, the impact of the variations in recruitment is so important, that it is difficult to provide and substantiate advice on optimal levels of fishing mortality or effort, as long as this factor (recruitment) has not been taken into account in the predictions.

4. CONCLUSIONS

A comprehensive data base is being built up on the shrimp fishery in Suriname. Landing and effort information covers the totality of the fleet. Biological information (essentially the size structure of the landings by species) has been collected from 1985 to 1991 and, even though part of the production could not be included in the sampling programmes, the available material seems suitable for various stock assessment approaches. Several of these approaches have already been experimented with, and the results as well as the procedures used could be worked out at this workshop.

- Sampling methodology : the problems associated with the sampling programme at landing have been presented in 3.3. A methodology should be proposed to assess the value of results obtained until now by this programme, specifically :
  - optimization of the first step of the sampling system (number, size and distribution of the samples);
  - validity through time of the conversion tables (commercial categories to tail length categories) ;
  - determination of an optimal periodicity for the reassessment of these tables.
- The possibility (usefulness) of resuming a sampling programme (on a new basis) should then be discussed.
- Cohort analysis : results should be compared with those obtained elsewhere in the region. A discussion should take place on how to select input parameters from the wide range of values proposed in the literature. Further interpretation and application of cohort analysis techniques, with their limitations, should be debated.
- Analysis at regional level : as far as national data and results allow.

On the longer term, studies oriented towards the variations in recruitment, including the linkages with environmental parameters, should give the most useful keys for the management of the shrimp resources. It is also considered that bio-economic approaches should receive more attention in Suriname as well as, probably, in the rest of the region.

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