ASSESSMENT OF BROWN SHRIMP (*Penaeus subtilis*) IN THE GUYANA SHRIMP FISHERY

by

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ABSTRACT

Monthly assessments of the brown shrimp, *Penaeus subtilis***,** for the period January 1996 to May 1997 are presented. The Ehrhardt and Legault (1996) generalized crustacean stock assessment algorithm was applied to ten months of biological data and seventeen months of landing data in the penaeid shrimp fishery of Guyana. Catch in weight by commercial size categories was first converted to catch at length in numbers of animals by integration of the biological data with the historical landings data. Length converted catch curve analyses were applied to those data to generate estimates of total mortality rates, Z, and fishing mortality rates, F. The F-estimates derived from the catch curve analyses were then used as "external" indices to "tune" or calibrate the initial F/Z values in length cohort analyses. Monthly stock biomass estimates ranging from 47 mt to 212 mt (tail weight) for females and 27 to 165 mt (tail weight) for males were obtained for the period studied. Fishing mortality rates by size classes were well within the range of natural mortality rate, an indication that the stock is being exploited at levels which do not represent biological overexploitation.

1. INTRODUCTION

The large penaeid shrimp resources of Guyana are exploited directly by 73 penaeid shrimp vessels and indirectly by the 48 locally owned seabob/finfish vessels (of which 15 are currently inoperative) of the industrial shrimp trawl fleet (Guyana Department of Fisheries unpublished statistics, 1996). These vessels are the standard Gulf of Mexico type trawlers and they operate at distances of 40 - 145 km offshore in waters 18 - 91 m deep (Draft Fisheries Background Report, 1994). They range in length from 18.90 to 20.42 m (62 - 75 ft), and use jib trawl nets with 4 to 5 cm (1.6 - 2.0 inches) stretched mesh in the wings and 2.5 to 3.5 cm in the cod-end (Draft Fisheries Background Report, 1994). The American shrimping fleet tows four nets at a time (twin trawling) while the Japanese and most of the local fleet vessels tow two nets at a time. Turtle Excluder Devices (TEDs) are mandatory for the entire shrimp trawl fleet. Most of the local penaeid shrimp vessels switch to seabob/finfishing in the seasons when the penaeid shrimp resources are scarce. A very small and as yet undetermined amount of penaeid shrimp are caught at some times of the year by the Chinese seine vessels of the artisanal fleet (Shepherd *et al*, 1997).

The majority of the penaeid shrimp trawlers are foreign owned and operated, and they essentially exploit four species of Penaeid shrimp *(P. brasiliensis, P. notialis, P. schmitti, and P. subtilis)* with fin-fish and small amounts of squid (*Loligo spp.*) and occasionally lobster (*Panulirus spp.*) as by-catch. The locally owned trawlers primarily exploit the Atlantic seabob (*Xiphopenaeus kroyeri*) and various fin-fish species (*Macrodon ancylodon, Micropogonias furnieri, Nebris microps, Arius spp., Cynoscion spp.*), with small quantities of penaeid shrimp being caught as incidental catch (Shepherd *et al*, 1997).

The average total annual production of penaeid shrimp tails was around 2800 mt for the period 1980 - 1985 and 2000 mt for the period 1986 - 1990. In recent years (1990 -1996), production ranged between 1500 and 1900 mt per annum (Draft Fisheries Background Report, 1994 & Guyana Department of Fisheries unpublished statistics, 1997). Based on the declining trend in the combined catches of penaeid shrimp resources *(P. brasiliensis, P. notialis, P. schmitti, and P. subtilis)*, even with a reduction in fleet size, it is presumed that these resources are being exploited either at or above MSY. While the results of the assessments suggest that the *P. subtilis* stock is not being overfished, the declining trend in catches for the combined penaeid shrimp resources would seem to indicate the possibility that one or more of the other large penaeids *(P. brasiliensis, P. notialis, and P. schmitti)* might be exploited at or above MSY.

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Thus even though there has been a reduction in fleet size over the years, there is still an overall declining trend in catches.

The assessment presented here is for the southern brown shrimp, *P. subtilis*. This shrimp is commonly found on mud and sandy mud bottoms (Cervigon *et al*, 1993) at depths from one to ninety meters, and occasionally at depths up to 190 m (Fischer, 1978). It occurs from the southern coast of the Greater Antilles and Honduras, along the Atlantic coast of Central America and the northern coast of South America, up to the State of Rio de Janeiro in Brazil (Cervigon *et al*, 1993). *P. subtilis* attains a maximum total length of 20.5 cm in females and 15.2 cm in males (Cervigon *et al*, 1993), and constitutes an estimated 25 % of the "pink" shrimp landings (combination of *P. brasiliensis, P. notialis,* and *P. subtilis)* in Guyana (Guyana Department of Fisheries unpublished statistics, 1997).

2. DATA

2.1 Description of the Data Used

2.1.1 Biological data

(i) Length frequencies and average weights per length class of *P. subtilis* females and males found in commercial size categories for the months October 1996 through July 1997 were used in the analyses.

Table 1: Types of Biological data available

Year	Months	Length frequencies by commercial size category & individual tail weights		Source of data
		Pink[1]	White[2]	
1996	Oct.	Yes	No	In-plant shrimp BDC
	Nov.	Yes	No	In-plant shrimp BDC
	Dec.	Yes	No	In-plant shrimp BDC
1997	Jan.	Yes	No	In-plant shrimp BDC
	Feb.	Yes	No	In-plant shrimp BDC
	Mar.	Yes	No	In-plant shrimp BDC
	Apr.	Yes	No	In-plant shrimp BDC
	May.	Yes	No	In-plant shrimp BDC
	Jun.	Yes	No	In-plant shrimp BDC
	Jul.	Yes	No	In-plant shrimp BDC

Source: Guyana Department of Fisheries unpublished statistics, 1997

NB. Pink Shrimp[1] = combination of *P. brasiliensis, P. notialis,* and *P. subtilis*
White Shrimp[2] = *P. schmitti*

2.1.2 Catch and effort data used

(i) Total monthly landings of penaeid shrimp for January 1996 to May 1997. (See Figures 1A and 1B)

(ii) Monthly historical penaeid shrimp landings data (January 1996 to May 1997) in pounds of tails per commercial size category.

Figure 1: Landings of Penaeid shrimp species combined and landings of *P. subtilis*

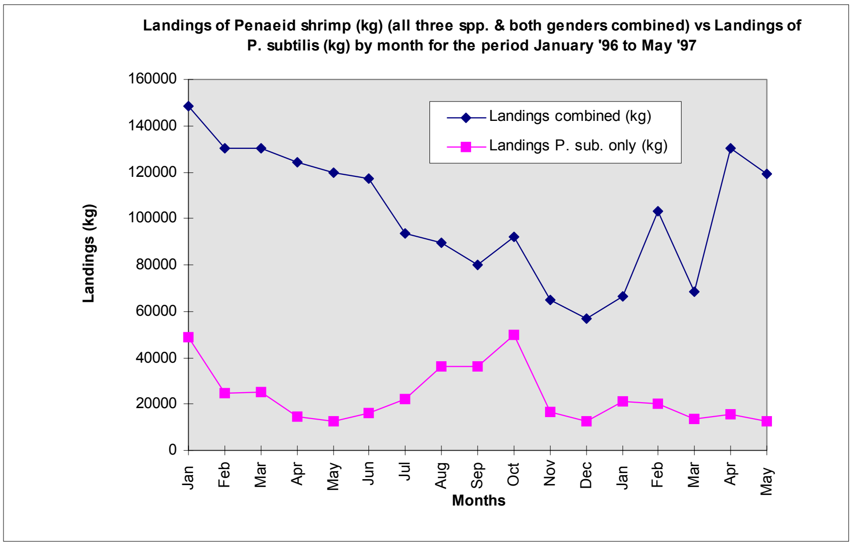

Figure. 1A

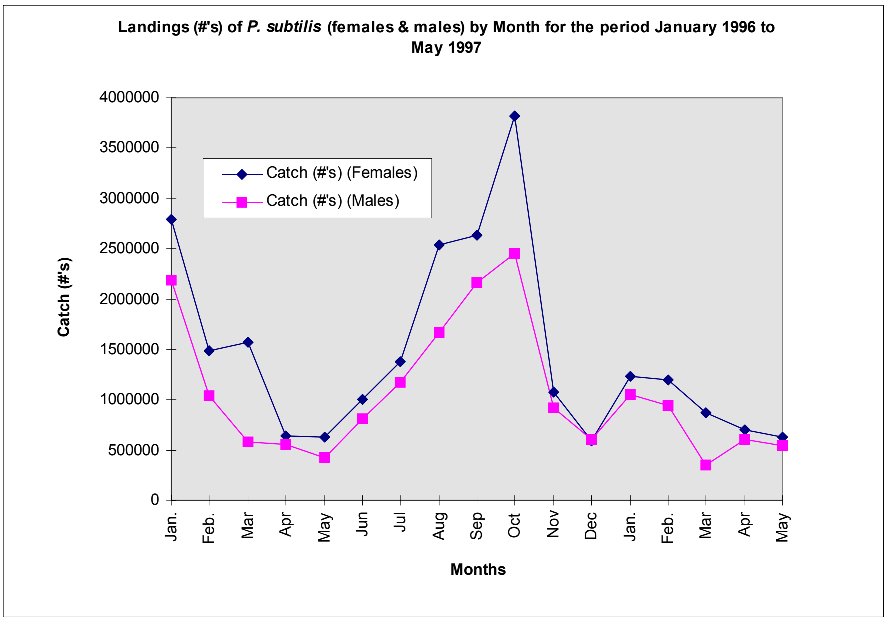

Figure 1B

Those landings are recorded in 2 species groupings:

(a) Pink shrimp, which are comprised of three species (*P. brasiliensis, P. notialis* and *P. subtilis*) and
(b) White shrimp (*P. schmitti*).

There are also categories in which “head-on-equivalent”, “pieces”, “shrimp not sized”, and “sour shrimp” are recorded.

Table 2: Types of Catch & Effort data available for the period studied

Year	Months	Types of Data Used				
		Effort			Catch	
		Number of Vessels	Number of Trips	Number of Landings	Landings/Catch of shrimp tails by commercial size category	
					Pink Shrimp[1]	White Shrimp[2]
1996	Jan. - Dec.	Yes	Yes	Yes	Yes	Yes
1997	Jan. - May.	Yes	N.A.	Yes	Yes	Yes

Source: Guyana Department of Fisheries unpublished statistics, 1997

2.2 Sampling Methodology (in-plant BDC)

The biological data used were collected via a stratified and intensive in-plant shrimp biological data collection programme, which began in October 1996 and is scheduled to continue until the end of September 1997. The recommended sample size per week for the commercial size categories U-12 to 26/30 is 4 boxes (at 5 lbs each) for each of those commercial size categories. The recommended sample size per week for the commercial size categories 31/40 to 71/90 is 2 boxes (at 5 lbs each) for each of those commercial size categories (Ehrhardt, 1996).

All sampling was stratified by commercial size categories. The tails were first separated by species based on the characteristics of the dorso-lateral groove and the presence or absence of a dark reddish lateral spot at the junction of the third and fourth abdominal segments. They were then further separated by gender based on the presence or absence of the petasma. Individual tail lengths and individual tail weights (by species and gender) were then taken for the first box (box #1) of each commercial size category, while for boxes 2, 3, & 4, only individual tail lengths (by species and gender) were taken. (Ehrhardt, 1996 and Ferreira & Kuruvilla, 1996).
Data were collected from the major penaeid shrimp processing plant for all ten months, and from the other major processing plant for one of those months. Note at this point that no data were collected from the "head-on-equivalent", "pieces", "shrimp not sized", and "sour shrimp" categories of landings, and in some of the weekly sampling exercises, targets were not always realized. Length frequencies and individual tail weights by species, gender, and commercial size categories were generated from the in-plant shrimp biological data collection programme.

2.3 Approaches used for integration & interpolation

2.3.1 Landings data

The "head-on-equivalent", "pieces", "shrimp not sized", and "sour shrimp" landings were re-distributed over the range of commercial size categories based on the percentage which each contributed to the total landings. Monthly length frequencies and average weights per length class were generated by species and gender within each commercial size category. The combined length frequencies of July and October were used to extrapolate for the months of August and September, since data to generate actual length frequencies for those months were not yet available.

The missing weights by length class for a given commercial size category were obtained from the corresponding length class of the commercial size categories immediately above and below as follows:

$$\bar{w}_{sl} = \frac{\bar{w}_{(s-1)l} + \bar{w}_{(s+1)l}}{2}$$

Where that was not possible, the missing weights by length class were obtained as follows:

$$\bar{w}_l = \frac{\bar{w}_{(l-1)} + \bar{w}_{(l+1)}}{2}$$

The monthly length frequencies obtained from the in-plant shrimp data collection were used to "re-construct" the length frequencies by equally spaced intervals in the corresponding months of 1996.

The weight per length interval within each commercial size category was calculated as follows:

$$W_{sl} = f_{sl} * \bar{w}_{sl}$$

while the percentage weight per length interval by commercial size category for that gender was calculated as

$$P_{sl} = \frac{W_{sl(fem.)}}{SW_{s(fem.+mal.)}}$$

The next stage was the "re-construction" of the length frequencies within the commercial size categories of the landings data. The landed number of tails per length interval by commercial size category for that month were obtained using the expression :

$$N_{sl} = \frac{P_{sl} * C_s}{\bar{w}_{sl}}$$

The total catch at length by equally spaced length intervals by gender for that month. was obtained as follows

$$N_{l(fem.)(month)} = \sum_{s=1}^{j} N_{sl(fem.)(month)}$$

where

s	= 1,...j are the commercial size categories
l	= 1,...m are the distinct length intervals for the animals
f_l	= 1,...p are the frequency of occurrence of a given length interval
$\bar{w}_l$	= average weight by length interval
$\bar{w}_{sl}$	= average weight by length interval and commercial size category
W_l	= total tail weight by length interval
W_{sl}	= total tail weight by length interval and commercial size category
C_s	= catch (landings) by commercial size category
N_s	= number of tails by commercial size category
N_{sl}	= number of tails by length interval and commercial size category
P_{sl}	= percentage weight by length interval and commercial size category
$SW_{s\,(fem.)}$	= sample weight of females by commercial size category
$SW_{s\,(mal.)}$	= sample weight of males by commercial size category

3. METHODS

Growth parameters for *P. subtilis* were obtained from a review of the existing literature. The average asymptotic carapace length (L_∞) values estimated were 219.0 mm and 176.8 mm for females and males respectively. Asymptotic tail lengths of 135.8 mm and 109.6 mm for females and males respectively were estimated from asymptotic carapace length - carapace-tail length relationships. The estimates of K used were 1.062 per annum for females (0.088/month) and 1.168 per annum for males (0.097/month) as adopted in this Workshop (FAO, 1997). These estimates were obtained from a negative exponential relationship found between asymptotic lengths and K for the species. The average natural mortality rates used were 0.146/month for females and 0.163/month for males as obtained for the species in the Brazil shrimp fishery.

The generalized crustacean stock assessment algorithm of Ehrhardt and Legault (1996) was used in this study to estimate cohort abundance and instantaneous total and fishing mortality rates. The algorithm is essentially a two-stage procedure, with the first stage involving the use of length converted catch curves to estimate Z-values, from which F-values are subsequently estimated as Z-M. In the second stage, a tuned length cohort analysis is performed to estimate abundance in numbers and fishing mortality rates by length classes using the F's estimated in the first stage as a tuning index.

3.1 Length Converted Catch Curve Analysis:

The estimated monthly catch at length data by equally spaced length intervals (by gender and month) were input into gender specific seasonal length converted catch curves. Therefore, the logarithm of the number of animals caught in each size class (N_l) divided by the time it takes the animal to grow through the size class (dt) was plotted against the corresponding relative age (t) at the mid-point of the length class l. The slope in this relationship is an estimator of the total instantaneous mortality rate Z.

Since not all the size classes are equally selected by the gear, regressional ranges were chosen which gave the best fit to the data points, excluding those in the left ascending arm of the curve, because they represented animals which were not fully recruited or selected to the fishery. Data points to the extreme right of the curve were also excluded because they were too close to L_∞, at which point the length-age relationship becomes uncertain (King, 1995). That is because the larger, slower growing animals which are close to L_∞ take a longer time to grow from the lower to the upper boundary of a given length class (Sparre and Venema, 1992). Since the total instantaneous mortality rate (Z) is the sum of the instantaneous fishing (F) and natural mortality (M) rates, F was calculated as F **=** Z – M**.** Thus, F**-**values were generated over the range of size classes that were included in the regression ranges selected in the length converted catch curve analyses.

3.2 Tuned Length Cohort Analysis

In length cohort analysis, the historic landings in numbers of animals per length class (N_l) are used to estimate historic fishing mortality rates and stock abundance by length class. Tuned length cohort analysis is necessary due to the uncertainty in the initial F/Z estimate required to estimate abundance of the largest size class included in the analysis (Ehrhardt & Legault, 1996). Thus, using the F-values obtained from the length converted catch curves analyses, the initial F/Z values in the tuned length cohort analyses were calibrated to make the equivalent range of size classes in the cohort analyses have F-values equal to the "external" estimates of **F** that were generated from the length converted catch curve analyses. Thus, the number of animals in the oldest age class A was estimated using the following equation :

$$N_{(A)} = \frac{C_{(A)}}{F_{(A)} / Z}$$

where

$F_{(A)}/Z$ = exploitation rate of the oldest length class A

$N_{(A)}$ = numbers of animals in the oldest length class of the catch, and

$C_{(A)}$ **=** the catch of the oldest length class

In this equation, $F_{(A)}/Z$ is changed systematically in the tuning process, using the Excel Goal Seek routine, until the average F from a specified range of size classes in the length-based cohort analysis, weighted by the number of animals in each size interval included in the specified range, equated with the F estimated from the catch curve analysis corresponding to a similar size range (Ehrhardt and Legault, 1996).

4. RESULTS

4.1 Description of the Results Obtained:

Monthly estimates of average stock abundance in numbers and biomass in kilograms, and corresponding average monthly fishing and total mortality rates obtained from the application of the “tuned” length cohort analyses to the monthly catch at length data, are presented in the Table 3. The graphs showing the abundance, biomass, catch, and fishing mortality estimates by month and gender are presented in Figures 2A-2F.

Table 3: Results of the cohort analyses of *P. subtilis* (Females & Males) for the period January '96 to May '97

Months	Abundance (numbers)		Biomass (kg)		Average Fishing Mortality Rate (F.month^{-1})			Total Mortality Rate (Z.month^{-1})
	Females	Males	Females	Males	Females	Males	Females	Males
January	29596079	31105176	212374.90	165205.69	0.094333	0.070028	0.240333	0.230028
February	14568695	12944425	96734.28	65885.426	0.101824	0.079873	0.247824	0.239873
March	17933312	9063176	117751.32	46770.97	0.087422	0.063525	0.233422	0.223525
April	9050775	12094697	67344.15	73444.64	0.070896	0.045262	0.216896	0.205262
May	8568665	7695620	65197.82	44508.249	0.073451	0.054662	0.219451	0.214662
June	11438336	10525394	80529.05	56790.571	0.087652	0.076476	0.233652	0.236476
July	11765415	10803091	83337.06	56279.403	0.116694	0.108971	0.262694	0.268971
August	18784945	15411243	120352.68	81588.503	0.135328	0.108385	0.281328	0.268385
September	16125634	15361294	98657.22	75663.145	0.163604	0.141202	0.309604	0.301202
October	24005172	19244055	145925.36	96976.895	0.158926	0.127529	0.304926	0.287529
November	8330214	9275523	60511.53	51546.979	0.129131	0.098445	0.275131	0.258445
December	6733108	8675533	47114.49	45135.156	0.087307	0.070038	0.233307	0.230038
January	13141184	13169374	97992.41	68241.62	0.093472	0.079415	0.239472	0.239415
February	11754749	11275962	80130.22	57149.068	0.101824	0.083296	0.247824	0.243296
March	9429027	5348432	60459.97	27422.753	0.092289	0.063950	0.238289	0.223950
April	9191942	12670983	66662.03	75969.08	0.075548	0.047672	0.221548	0.207672
May	7302267	8006445	54329.13	44418.891	0.085244	0.067626	0.231244	0.227626

5. CONCLUSIONS AND MANAGEMENT IMPLICATIONS

5.1 Interpretation of Results - Validity, Uncertainties, Biological Conclusions and Implications

Natural mortality rates of 0.146/month and 0.163/month for females and males were assumed constant throughout the time period assessed and for all length classes. This condition may not be fully supported by the general dynamics of the annual cohorts recruiting to the fishery. However, no information is presently available to corroborate or determine dynamic changes in M with size or seasons. Furthermore, environmental changes greatly impact the seasonal and inter-annual variability of penaied shrimp recruitment, and none of the environmental effects on M are understood at this time. Similarly, average K-values were used for all months when in fact growth changes seasonally.

Figures 2A-F: Abundance (#'s), Biomass (kg), Catch (#'s), and Fishing Mortality by Month for the period January 1996 to May 1997

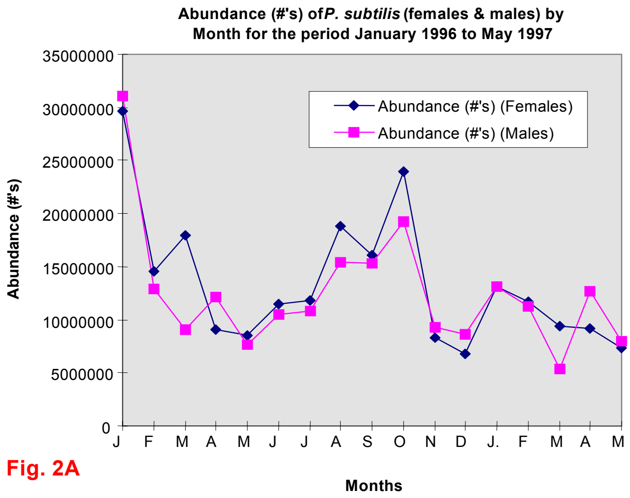

Fig. 2A

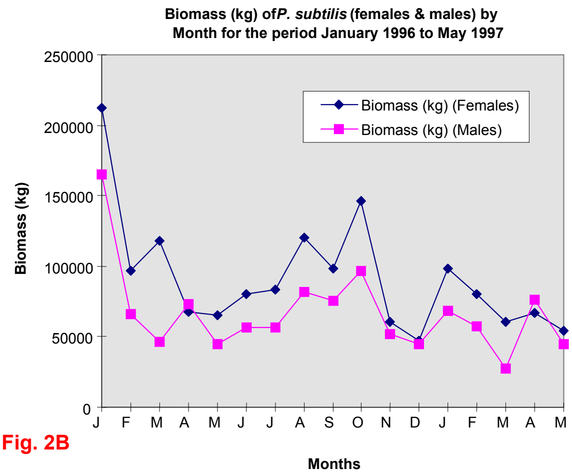

Fig. 2B

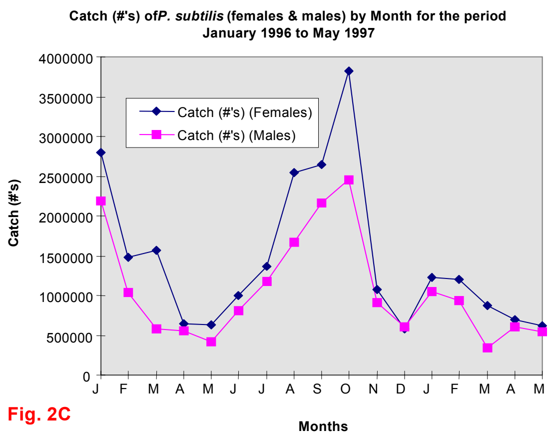

Fig. 2C

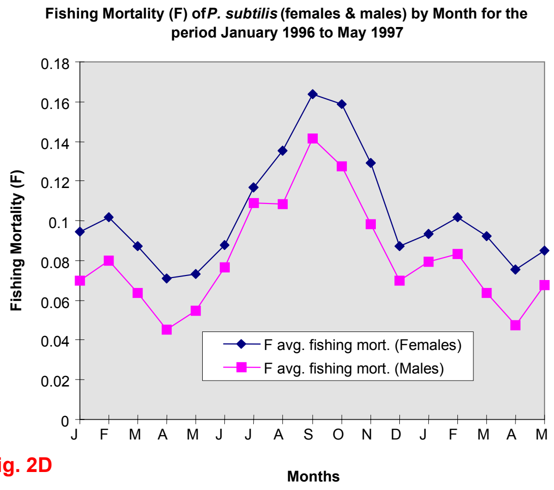

Fig. 2D

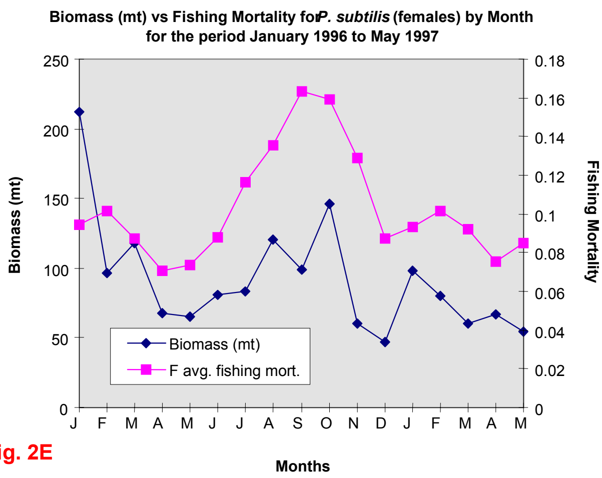

Fig. 2E

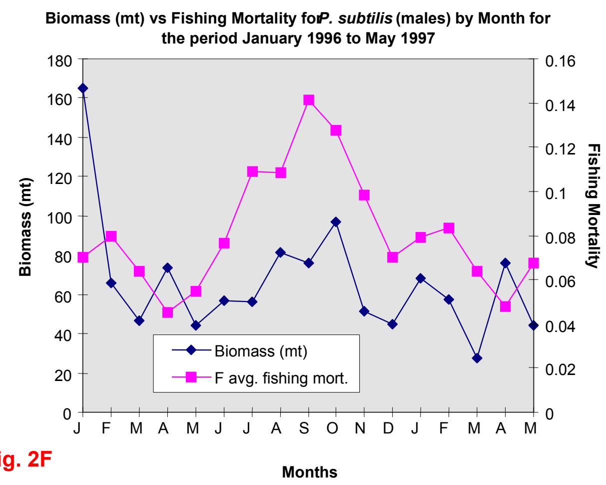

Fig. 2F

Again no information is available at this time on *P. subtilis* to enable incorporation of seasonal changes in the growth parameter K.

The landings of *P. subtilis* during the period studied showed a generally decreasing seasonal trend from January to May for both of the years considered, with a significant increase from July to October, while the overall penaeid shrimp landings for the period studied showed a generally decreasing trend from January to December of 1996, and a generally increasing trend from January to May 1997. (See Figures 1A and B). As explained below, these trends may be related to the relatively higher abundance estimated for females and males in January 1966 compared with similar estimates in January 1997. The difference between the two months may be partly due to lower fishing effort and approximately 40% of the Georgetown Seafoods & Trading Company Ltd. penaeid shrimp trawlers (which represent approximately 75% of the penaeid shrimp trawl fleet) were docked for the period November 1996 through March 1997, so the low nominal fishing effort of January to March 1997 relative to the corresponding period of 1996 may have been an important factor in the differences between these two years.

The trends in abundance in numbers, biomass and fishing mortality closely followed the general trend of the *P. subtilis* landings, ie. generally decreasing from January to May of 1996 as a consequence of the higher abundance estimated for males and females in January 1996 relative to January 1997, increasing from July to October of 1996, and gradually decreasing from November 1996 to May 1997, also as a consequence of the relatively lower abundance of males and females in January 1997 relative to the same month in 1996. March to May is generally the period when *P. subtilis* is least abundant. (See Figures 2 A-D). Significant increases in abundance and biomass are observed for the July to October period, which occurs shortly after the May - June rainy season, and these increases are probably due to recruitment. It is not known, however, to what extent the rainy season influences abundance and biomass.

Females are generally more abundant, have higher levels of biomass (See Figures 2A and B) as they are heavier per unit length, and are subjected to slightly higher levels of fishing mortality than the males. The higher levels of fishing mortality inflicted on the females are most likely because the females are more available or selectable to the gear than males. Also, there is an apparent increase in the difference in fishing mortality estimates between males and females during some months. This may be due to seasonal changes in catchability as a consequence of differences in the seasonal behaviour by gender.

Generally, it has been observed that during the period of November to March, the catch rate for large penaeids decreases, and a number of the shrimp vessels would be drydocked to facilitate maintenance work. This is even more conspicous during the first two months of the year, when the water and the winds are very high and the seas are rougher. (Charles and Shepherd, 1996). There would therefore be a decrease in fishing effort in those periods, which seems to be supported by the decreased levels of fishing mortality obtained for those periods. The fishing effort increases in response to the increasing abundance during the July - October period, which subsequently results in decreasing levels of abundance from November through May. The fishing effort and the associated fishing mortality then decrease as the resource becomes less abundant.

The trends in biomass for both female and male *P. subtilis* indicate a definite positive correlation with the levels of fishing mortality to which the stock was subjected. (See Figures 2E and F).

5.2 Status of Stock and Relationship to the Fishery; Management Implications and Possible Recommended Management Implications:

The assessments done covered a seventeen month period (January 1996 to May 1997), which was not a sufficiently long period of time over which to arrive at valid scientific conclusions about the overall long term biological status of the stock. Analyses of a longer time series of the historic levels of stock abundance and the associated fishing mortalities should be carried out to determine the trends in population dynamics of the stock and the possible effects of environmental changes on abundance, recruitment and catchability of the stock. However, monthly fishing mortality estimates were well below the monthly natural mortality rates adopted in the analysis with the exception of September and October 1996 in females when fishing mortality exceeds natural mortality. Thus, under these conditions, it appears that the stock is not presently being subjected to the high levels of exploitation that may compromise its overall productivity.

5.3 Recommendations for Future Work

5.3.1 Data collection

It is vitally important that the in-plant shrimp biological data collection activities continue up to the end of September 1997 to ensure that a full one year time series of those data are available to reconstruct catch length frequencies from statistics reported by commercial size categories. It is also considered important to corroborate statistically the possibility of seasonal changes in the biological (length and weight) data within commercial size categories so as to detect possible changes due to seasonal changes in the biological condition of the stock.

Collection of social and economic data should also be initiated with a view to performing bioeconomic and socioeconomic analyses of the fishery; and would form a basis for considering economic optimization of the fishery.

5.3.2 Use of additional data

The environmental data available, i.e. rainfall data from 1960 to 1997 and river discharge data from 1981 to 1995, should be used in future analyses to determine the degree of correlation, if any, of recruitment with rainfall and with river discharge. Attempts should also be made to determine the spatial and temporal variations of penaeid shrimp stock abundance with rainfall and river discharge.

5.3.3 Additional analyses and assessments

Stock assessment analyses should be performed for all three species *(P. brasiliensis, P. notialis,* and *P. subtilis)* for which length frequency data are now available. Attempts should subsequently be made to determine the seasonal biomass assemblages available to the fishery. Studies on recruitment should also be carried out for all three species. Once these analyses are available, combined analyses of the penaeid shrimp fisheries on the Guiana-Brazil Shelf should also be performed, since those resources are presumably shared and thus there is a need for collaboration between those countries in fisheries research, resource assessment and management.

The existence of complete monthly length frequency databases for *P. subtilis* should encourage the possibility of exploring estimation of catch-at-age matrices sliced from growth equations. These matrices could then be used in age-based cohort analysis. In this way, information on trends in numbers at age from one month to the next may be obtained, thus adding a temporal dynamic character to the equilibrium estimates obtained in the length-based cohort analysis. This approach, however, will require estimates of monthly relative abundance estimates as a calibration index in the age-based cohort analysis procedure. Catch-per-unit-of-effort (cpue) is usually defined as an index of relative abundance in stock assessment work. Consequently, it is also recommended that fishing effort be appropriately standardized according to fleets, areas and seasons in order to develop a more accurate cpue estimate.

6. REFERENCES

Cervigon, F., *et al*. 1993. Field Guide to the Commercial Marine and Brackish Water Resources of the Northern Coast of South America. FAO. Species Identification Sheets for Fishery Purposes. Rome, FAO. 513p.

Draft Fisheries Background Report for Guyana Fisheries. 1994. Guyana Department of Fisheries and GTA Consultants Inc., Technical Assistance Project.

Ehrhardt, N.M. 1996. Technical Report. CFRAMP Contract consultant end of mission report on preliminary assessment of the Guyana Shrimp Fishery, Guyana, July 8th - 12th, 1996. 9 p.

Ehrhardt, N.M., and Legault, C.M. 1996. Tuned Length-based Cohort Analysis (TLCA) Computer Program. Crustacean Stock Assessment Techniques Incorporating Uncertainty. Report of the CFRAMP/FAO/DANIDA Stock Assessment Workshop on the Shrimp and Groundfish Fisheries of the Guiana-Brazil Shelf, Port of Spain, Trinidad, January 8th - 12th, 1996. *FAO Fish. Rep.* 544. Supplement. 111-131

FAO. 1997. Meeting Report of the CFRAMP/FAO/DANIDA Stock Assessment Workshop on the Shrimp & Groundfish Fishery of the Brazil-Guianas Shelf, Port of Spain, Trinidad, April 7th -18th, 1997. 33 p.

Ferreira, L. and Kuruvilla, S. 1996. Report on Training Mission in Shrimp Species Identification and Biological Data Collection, Guyana, September 3rd - 6th, 1996. 39 p.

Fischer, W. 1978. FAO Species Identification Sheets for Fishery Purposes. Western Central Atlantic Fishing Area 31. Volume VI.

King, M., 1995. Fisheries Biology, Assessment and Management. 341 p.

Ministry of Agriculture, Department of Fisheries, 1996. Annual Report 1995. 42 p.

Charles, R. and D. Shepherd, 1996. National Report Guyana. Paper presented at the joint CFRAMP Shrimp & Groundfish Subproject specification Workshop and 4 th meeting of the WECAFC ad hoc working group on the Biological and Economic modeling of the Shrimp and Groundfish Resources on the Guiana-Brazil Shelf, Trinidad, January 8th - 12th. *FAO Fish. Rep. 544, Supplement.* 111-131.

Shepherd, D., Hackett, A., and Charles, R., 1997. National Report Shrimp and Groundfish Fisheries of Guyana. Paper presented at the CFRAMP/FAO/DANIDA Stock Assessment Workshop on the Shrimp and Groundfish Fisheries of the Guiana-Brazil Shelf, Port of Spain, Trinidad, April 7th - 18th, 1997. 25 p.

Sparre, P. and Venema, S.C., 1992. Introduction to tropical fish stock assessment. Part I - Manual. *FAO Fish. Tech. Pap.* 306/1. 375 p.

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