12 ASSESSMENTS OF FISHERIES IN GUYANA FOR BANGAMARY (*Macrodon ancylodon*) AND BUTTERFISH (*Nebris microps*)

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12.1 Introduction

The pattern of growth of these fish species was modelled using the von Bertalanffy growth equation (VBGF). Length-at-age data generally provide the best estimates of the three VBGF parameters. Such data are commonly obtained from annual marks in the otoliths and these marks are taken as related to periods of rapid and slow growth over an annual cycle, in relation to seasonal fluctuation of the environment, providing estimates of the age of fish. However, in this case, length-at-age data were not available and length frequency data had to be used for estimation of growth parameters. Length frequency data, in addition to being easier to obtain than length-at-age data, have the advantage of being inexpensive since measured fish need not be purchased.

Length-based methods were used to study the growth and mortality rates of bangamary (*Macrodon ancylodon*) and butterfish (*Nebris microps*) in Guyana. Length frequency data was collected from the Chinese seine, nylon gillnet and trawl fisheries during January 1996 – March 1999 in order to estimate the length structure of the population. Length frequency distributions were analysed. Von Bertalanffy growth parameters were derived from the mean length of the normal distributions. The growth parameters obtained for *N. microps* were unrealistic, therefore values of K=1.18 yr^{-1} and L_∞= 49.57cm for *N. microps* were taken from Suriname.

Growth parameters of *M. ancylodon* estimated from previous assessments were K=0.66 yr^{-1} and L_∞ = 43.57 cm. Natural mortality rates of 1.20 yr^{-1} and 1.70 yr^{-1} and an average value of total annual mortality of 2.7 yr^{-1} and 9.3 yr^{-1} for *M. ancylodon* and *N. microps* respectively were estimated. These were used in the multispecies multigear yield per recruit analysis to evaluate the status of the fishery and forecast the effects of changes in the fishing pattern. Results indicate that *M. ancylodon* may be over-exploited.

Macrodon ancylodon (bangamary) is exploited by several fisheries and gear types in Guyana, including the Chinese seine, nylon gillnet, pin seine and shrimp trawl. Each of these gear types will have different size selectivities, where the selectivity is also a function of the species. It is essential to know the selectivity characteristics of a gear type before using catch and length frequencies of catches from that gear type for estimating abundance, size structure of the population, growth and length parameters.

The Chinese seine fishery accounts for 27% (354 vessels) of the artisanal fleet of Guyana based on the 1994 Artisanal Frame Survey. The Chinese seine is a funnel-shaped net, 16m long and 4-6m wide at the mouth. The mesh size at the mouth of the net is 8cm and gradually decreases as it proceeds to the bag of the net where the mesh size is 1cm. A flat-bottom dory vessel powered by sail, paddle, or small outboard engine is used in the fishing operations.

The vessels work according to the tide and spend between 6-12 hours per day fishing. The net is attached to poles (pens) and set on mud banks, mainly in river mouths, where tidal currents sweep the fish and shrimp into the seine. This operation is heavily dependent upon the influence of the river currents. These poles (pens) are set at depths between 2-4 fathoms (3.6-7.2m), at a distance of about one mile from the shore. Each vessel operates between two to ten seines. The crew size of these vessels ranges between 2-4. The Chinese seine fishermen used between 3-12 Chinese seines per fishing trip depending on the season for whitebelly (March-April).

The catch consists primarily of *N. schmitti*, *Xiphopenaeus kroyeri*, *Macrodon ancylodon*, and *Nebris microps.* In 1997, preliminary estimates of Chinese seine catch consist of 36.8% *M. ancylodon*, 12.5% *Nebris microps*, 13.4% *X.kroyeri*, 29.8% *N.schmitti* and 7.5% others. A large amount of juvenile fish is caught in the Chinese seine fishery and is discarded with 100% mortality or used to produce fishmeal (Chakalall and Dragovich, 1980).

The nylon gillnet vessels, which account for 18.6% or 244 vessels of the artisanal fleet of Guyana, are equipped with outboard motors up to 48HP, which fish and land their catch along the entire coast of Guyana. Some of the vessels, equipped with ice-boxes, remain at sea for 2-3 days, whilst those with old freezers with ice with go on one-day trips. A nylon gillnet vessel will have a crew of 4 consisting of a captain and three fishermen. Species caught by this gear includes *Macrodon ancylodon*, *Nebris microps*, *Cynoscion virescens*, *Cynoscion acoupa*, etc.

The Offshore Industrial Fishery consists of 125 shrimp trawlers. The trawlers are 48% foreign owned. Foreign trawlers mainly exploit penaeid shrimp (*P. brasiliensis, P. notialis, P. subtilis* and *P. schmitti*) with finfish and small amounts of squid (*Loligo spp.*) and lobster (*Panulirus spp.*) as bycatch. The locally-owned trawlers mainly exploit seabob (*Xiphopenaeus kroyeri*) and various finfish species (*Macrodon ancylodon, Micropogonias furnieri, Nebris microps, Arius spp., Cynoscions spp.*), with small quantities of penaeid shrimp as bycatch.

Nylon or polyethylene jib trawl nets are used in both the penaeid and seabob/finfish fleet (Guyana Department of Fisheries, 1994). Turtle Excluder Devices (TEDs) are mandatory for the entire shrimp trawl fleet. Penaeid shrimp trawl vessels normally have a crew of 5 while seabob vessels and finfish vessels carry 5-6 and 4-5 crew respectively.

12.2 Biology

Macrodon ancylodon was reported as one of the most abundant fishes off Guyana representing 18% of the catch (Lowe-McConnel 1966). *Macrodon ancylodon* is one of the major species caught by the Chinese seine fishery. It is also common in the pin seine, nylon gillnet and trawl fisheries.

Mature fishes were only seen from very inshore catches in 8 fathoms (15m) from the southeast in August, October and February. The estuarine and inshore zones appear to be principal nursery and rearing grounds for this species, demonstrated by the large numbers of immature *M. ancylodon* caught by Chinese seine in the inshore and estuarine areas. The young of *M. ancylodon* are said to be particularly abundant in the Chinese seine during the rainy season, but this may reflect greater attraction to estuaries when more fresh water is pouring out to sea. *Macrodon ancylodon* is said to move inshore during the rains and offshore during the windy weather (Lowe-McConnell, 1966). This species tend to move into offshore marine water when they reach the adult stage.

M. ancylodon are chiefly demersal feeding mainly on bottom dwelling organisms such as shrimp and small fish. The *Xiphopenaeus kroyeri (*seabob*)* is the main prey of this species (Bianchi 1992) and is closely associated with its distribution. The small specimens from the Chinese seine all had shrimp in their stomach contents; the larger ones from the trawl contained penaeid and mantis shrimp, small anchovies and *Stellifer spp. M. ancylodon* is in turn preyed on by *Cynoscion virescens* and has also been found in the stomachs of the barracuda, *Sphyraena guachancho* and the shark, *Carcharinus maculipinnis* (Lowe-McConnell 1966).

Nebris microps, much prized as food, is a distinctive orange-coloured sciaenid with a huge mouth and very small eyes. It is occasionally taken in large numbers in the trawl. They are most apparent when onshore winds are stirring the inshore waters, but they have been found down to 22 fathoms (40m) in the northwest in March. They are also caught in large numbers, together with their young stages, in Chinese seines in the river estuaries. Samples of trawl caught and market *N. microps* ranged in size from 15/16 cm to 28/31 cm. No ripe or ripening

Table 12.1 Length frequency data for *M. ancylodon* for the period January-March 1996

Size Class	Jan	Feb	Mar	Jan-Mar
6	0	0	6	6
7	0	0	50	50
8	0	0	130	130
9	0	0	502	502
10	0	14	657	671
11	0	0	663	663
12	0	0	792	792
13	20	22	317	359
14	4	215	174	393
15	40	160	194	394
16	48	127	52	227
17	20	362	31	413
18	66	234	29	329
19	28	121	56	205
20	36	154	94	284
21	52	73	46	171
22	12	81	12	105
23	10	13	21	44
24	12	63	15	90
25	10	130	5	145
26	6	0	15	21
27	0	40	10	50
28	2	19	0	21
29	2	26	10	38
30	4	33	0	37
31	0	28	10	38
32	0	47	0	47
33	0	33	5	38
34	0	26	20	46
35	0	0	5	5

N. microps has been observed in trawls. Small fish (11mm) from Chinese seines have a huge mouth in relation to the body size (Lowe-McConnell 1966).

12.3 Data used for the assessment

The data used for the assessment of *N. microps* were monthly length frequencies from Chinese seine and trawl data (January 1996-October 1997, March 1998-March 1999 respectively). The data used for the assessment of *M. ancylodon* (bangamary) were monthly length frequency from the Chinese seine and trawl samples from January-December 1998.

The samples were taken from unsorted landings and each fish was measured, to the nearest centimetre below, from the tip of the snout to the longest caudal fin. During the data collection exercise landing sites/wharves were visited three times per week. These sites were selected randomly. A minimum target of 150 fish lengths per gear type were required per month.

12.3.1 Approaches used for the integration of the data

For the given vessels, if the total landings (*M. ancylodon)* were not measured, the sample length frequency was extrapolated to account for the total frequency. Each size class was taken at 1cm intervals. The length frequencies were grouped into three monthly samples (Table 12.1) gives grouped length frequency of *M.ancylodon* and *N. microps* for the period April-June 1998 from the Chinese seine and trawl samples.

Table 12.2 Mean and standard error of mean (modal) length of *M. ancylodon* in each quarterly length frequency distribution obtained using the Bhattacharya method (FISAT, Sparre and Venema 1992)

Quarters	Obs	Date	Mean (cm)	Std.Dev.
Jan-Mar	1	15/01/96	12.00	0.849
Jan-Mar	2	15/01/96	15.02	0.726
Jan-Mar	3	15/01/96	18.38	1.149
Apr-Jun	1	15/04/96	24.08	1.628
Apr-Jun	2	15/04/96	26.77	0.524
Apr-Jun	3	15/04/96	29.66	0.738
Apr-Jun	4	15/04/96	34.23	0.852
Jul-Sep	1	15/07/96	29.50	0.256
Oct/Nov	1	15/10/96	27.80	0.801
Jan-Mar	1	15/01/97	17.91	1.402
Jul-Sep	1	15/07/97	23.48	0.972
Jul-Sep	2	15/07/97	27.15	1.910
Jul-Sep	3	15/07/97	31.80	0.636

12.4 Estimation of L_∞ and K parameters

Due to the small sample size in each month, the length frequencies for each year were grouped into three months intervals.

Preliminary identification of modal lengths and standard deviations were done using the Bhattacharya method, using the FISAT software (Gayanilo *et al*. 1995). The results were used as starting values in the NORMSEP routine, which was also run using FISAT.

The mean lengths and standard deviations obtained from the Bhattacharya method were used as starting values in the NORMSEP routine. However, it was found that NORMSEP sometimes generated unrealistic modes in this way. In these cases, the starting values were adjusted until the modes identified by NORMSEP were considered to be biologically realistic.

The modes identified were then used in the Linking of Means routine of FISAT in order to generate a Gulland and Holt plot of growth increments against initial length (Sparre and Venema, 1992). This generated estimates of K and L_∞.

Reasonable estimates of K and L_∞ were obtained for *M. ancylodon* using this method (Table 12.2), but the values for L_∞ and K estimated for *N. microps* were very unrealistic (results are not shown). Therefore, estimates for L_∞ and K for *N. microps* were taken from Suriname.

12.5 Gear selectivity

The catchability of a gear usually varies with the size (therefore age) of the animal caught. Selection of a gear may be explained by a number of factors, of which the ability of the meshes (hooks) to retain the fish is only one. Another important factor is the availability of fish on the fishing grounds. Certain size groups may not be caught, simply because they are not present on the fishing ground. Often small (juvenile) fish are in near-shore nursery grounds, where they cannot be exploited with large industrial vessel. Large fish, on the other hand, may prefer deeper waters outside the reach of the artisanal fishery.

The best estimates of the selectivity characteristics of a gear type for a given species or community can be obtained if the catch composition can be compared with good estimates of the actual population or community composition. However, such comparative estimates are very rare and it is more normal to obtain estimates of size selectivity for a given species by comparing the size compositions from different gears fished in the same localities (see e.g. Sparre and Venema, 1992). However, examination of the length frequencies of landings for *M. ancylodon* and *N. microps* from the three major gear types, Chinese seine, gillnet and trawl, indicated that all of these gear had different selectivity characteristics and it was not possible to set one as a standard. (Fig. 12.1) Therefore, for the Chinese seine and trawl, the length at 50% selection was assured to occur where the frequency was 50% of the frequency of the first major mode (Fig. 12.1). No reduction in selectivity of older fish was assumed. This was done for the samples for *M. ancylodon* and *N. microps*. For nylon gillnet, it was assumed that the selectivity curve would be approximately a normal distribution.

The measured length frequencies of the nylon gillnet samples for *M. ancylodon* were grouped annually, to provide large enough sample sizes. Hence, the samples consisted of aggregated length frequencies obtained from landings by gillnet for the years 1997 and 1998. The frequencies for each length and year were not normalised.

Selectivity function was calculated for the nylon gillnet fishery. Three estimated selectivities (one for each year and 1997/1998 combined) were estimated (see Fig. 12.2 for the 1997/1998 combined). This was not done for *N. microps* since the data was not available at the workshop.

$$S''_l = \exp\left(\frac{(l - l_m)^2}{2\sigma^2}\right)$$

The selectivity function for gillnets can be described by a normal distribution:

where S''_l = the estimated selectivity of the gear for a fish of length, l_m = the length of fish for which the gear has the highest selectivity and σ = the selectivity standard deviation.

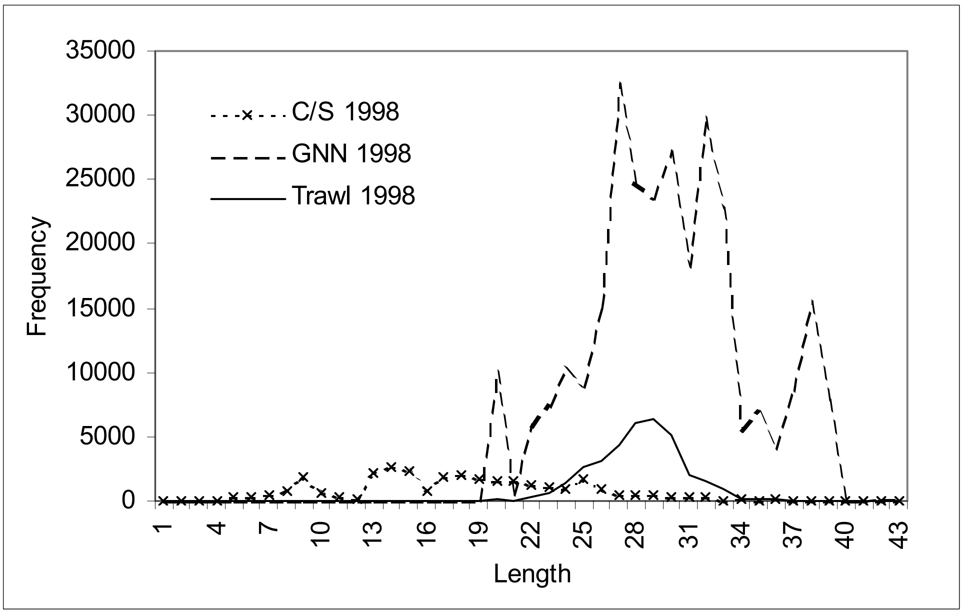

Figure 12.1 Length frequency of *M. ancylodon* for 1998 for Chinese seine (C/S) nylon gillnet (GNN) and trawl gears

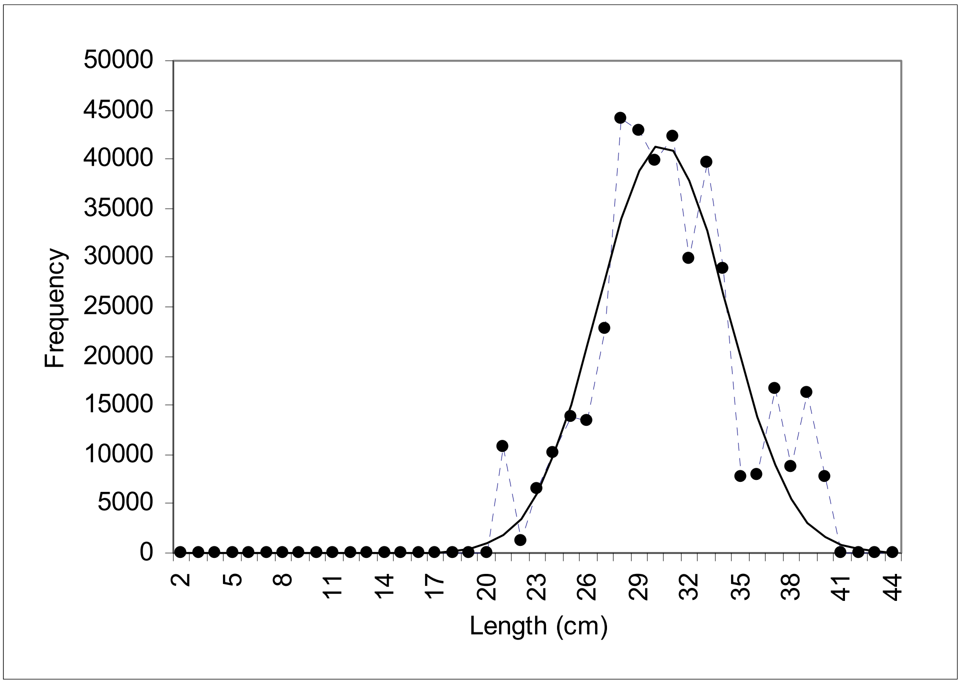

Figure 12.2 Observed (•) and predicted (—) *M. ancylodon* length frequency for nylon gillnet

12.5.1 Results Macrodon ancylodon

Using a non-linear minimisation routine, the parameters of the normal distribution and the scaling factors were estimated for the gillnet fishery (Table 12.3). Since the $L_{50\%}$ estimated were similar, but the combined sample had the largest number of points, it was suggested that the values for the 1997/1998 combination be used.

Table 12.3 Selectivity parameters of the normal distribution and scaling factor for the nylon gillnet fishery catching *M. ancylodon*

Parameters	1997	1998	1997/1998
$L_{50\%}$	30.1	30.5	30.3
SD	2.98	4.22	3.78
Scale	16106.6	26045.8	41491.9

Table 12.4 Selectivity parameters of the mean/age for trawl and nylon gillnet catching *M. ancylodon*. These values were taken from the Report of the Second CFRAMP / FAO / DANIDA Stock Assessment on the Shrimp and Groundfish Fishery on the Brazil-Guianas shelf where a start was made in applying the multi-species multi-fleet yield per recruit to the inshore fisheries of Guyana

Fishery	Length at 50% selectivity (cm)	Age yr^{-1}
Offshore Trawl	10.3	0.4
Nylon gillnet	26.2	1.4
Chinese seine	4.9	0.2

$L_{50\%}$ for Chinese seine was estimated at 16.2 cm at an age of 0.8 yr^{-1}. For the trawl fishery, a $L_{50\%}$ was estimated at 26.2 cm at an age of 1.6yr^{-1}. However, these values were not used in the per-recruit model as input parameters. It is believed that there are discards of small fish in the trawl fishery. Most of the time the trawl vessels would land fish of marketable size. Hence in addition to selectivity by the gear, there is also selectivity by the crew. This was supported by the results obtain from a trawl survey conducted in French Guiana by IFREMER, where there were smaller length classes in the catch as compared to those sampled by observers. With these biases in mind, alternative parameters were used as input parameters for the per-recruit modelling (Table 12.4).

12.5.2 Results Nebris microps

$L_{50\%}$ for Chinese seine was assumed to be 16.1 cm and for the trawl to be 26.0 cm. These values were similar for *M. ancylodon*. However, with the problem mentioned above, input parameters for the per-recruit models would be based on those collected from the French Guiana trawl survey. These estimates will be refined when data is gathered from the Trawl Observer programme, which will start during the later part of 1999 in Guyana.

12.6 Catch Curve Analysis (Ehrhardt and Legault 1996)

Estimates of Z were obtained from the catch curve analysis using the software described by Ehrhardt and Legault (1996). This was done for each quarterly length frequency sample of the Chinese seine and Trawl catches. Hence, an assumption of equilibrium was made in determining Z. The inputs for this routine were the pooled quarterly length frequencies for the study period, along with the L_∞ and K values estimated for *M. ancylodon* (43.57cm and 0.66yr^{-1}) and *Nebris microps* (49.57cm, 1.18yr^{-1}).

Growth parameters (L_∞ and K) for *M. ancylodon* were estimated from the previous assessment on this species at the previous workshop in May 1998. The maximum age of the fish was estimated at 7 yr^{-1}, the length of maturity used was 21 cm with a corresponding age of 1 year (McConnell 1966).

Sensitivity analyses of estimates of F and of yield-per-recruit (YPR) and biomass-per-recruit (BPR) results were undertaken on 0.5 and 2.0 of the estimated M. The values of M and Z were used to estimate F at the time of sampling from the equation: Z = F+M.

Natural mortality, M, was obtained using Pauly's empirical equation as contained in FISAT, using the K and L_∞ values estimated and a value of mean temperature 27°C. FISAT does not include estimates of the confidence intervals of the estimated M.

12.6.1 Results Macrodon ancylodon

By looking at the length frequency samples for the two fisheries, it seems as if the Chinese seine were not selecting the larger fish in the population, which are found to some extent in the trawl fishery and to a larger extent in the gillnet fishery. The larger fish may not be fully represented in the Chinese seine, either because they are not commonly found in the shallow waters or because they avoid or escape from the gear.

A length-converted catch curve was fitted to the quarterly samples for the trawl and Chinese seine catches with an L_∞ of 43.57 cm and K of 0.66 yr^{-1} (Fig. 12.3). An average fishing mortality F of 1.5 yr^{-1} was estimated using the Chinese seine samples whilst an average fishing mortality F of 2.9 yr^{-1} was estimated for the trawl fishery (Table 12.5).

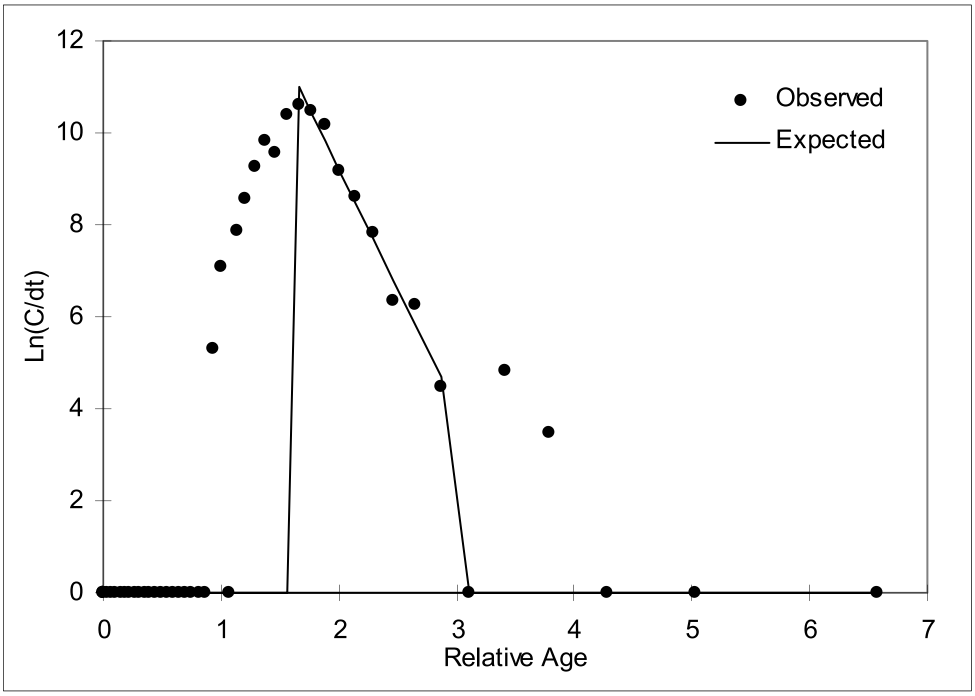

Figure 12.3 Length converted catch curve for *M. ancylodon* for July- September 1998 from the Chinese seine fishery

The fishing mortality was estimated to be higher in the trawl than in the Chinese seine. The Chinese seine seems to be selecting the medium size fish but at a relatively low level of F, while the trawl seems to be selecting the medium fish at a high level of F. The high fishing mortality in the trawl fishery also may be due to the larger fish escaping the gear.

From the length frequency samples for 1996-1997 from the Chinese seine catch, there are high numbers of large fishes (20-39 cm) during the month of June. For the trawl, the larger fishes were occurring in the months of October and November. The Chinese seine samples showed the smaller fishes occurring in larger numbers during the month of February. This is consistent with the observation that *M. ancylodon* tends to move inshore during the rainy season (June-July) into the estuaries. Here they are caught by the Chinese seine in the estuaries during the rains, the time of the year at which they are thought to spawn. The young in particular are abundant in the Chinese seine catches during the rainy season. They tend to move off-shore during the northeast trade winds in January-March.

Using the results obtained in Table 12.5, the following mortality estimates were derived by taking the arithmetic averaging over the three/four samples:

Average F (Chinese seine) = 1.5 ± 0.9 yr^{-1}

Average F (Trawl) = 2.9 ± 1.34 yr^{-1}

Average Z (Chinese seine) = 2.7 ± 0.9 yr^{-1}

Average Z (Trawl) = 4.1 ± 1.34 yr^{-1}

Table 12.5 Estimates of fishing mortality (F) and total mortality (Z) of *M. ancylodon* landed by the Chinese seine and trawl vessels operating in Guyana during January-December 1998. The coefficient of determination (R^2) and the points used for estimation of Z (Range) are also shown. Other parameters were M= 1.20 yr^{-1}, L_∞= 43.57cm and K= 0.66 yr^{-1}

Sample Period	Chinese Seine Fishery				Trawl Fishery			
	F (yr^{-1})	Z (yr^{-1})	R^2	Range	F (yr^{-1})	Z (yr^{-1})	R^2	Range
Jan-Mar 1998	2.4	3.60	0.54	15-25	3.6	4.81	0.8	27-34
Apr-Jun 1998	1.4	2.62	0.87	24-34	3.1	4.3	0.8	29-36
Jul-Sep 1998					3.7	5.0	0.9	29-36
Oct- Dec 1998	0.57	1.78	0.23	15-30	0.8	2.1	0.6	30-34

12.6.2 Results Nebris microps

Results from the catch curve analysis (Table 12.6), show high fishing mortality values for both fleets. By looking at the catch curve, it appears that the gear is only capturing the fish at a selected length range, after which the fish is disappearing more or less at age one year. The only explanation for this is that with a high K value of 1.18 the fish seems to be reaching its maximum length very quickly. By substituting lower values for K in the model, the F values are reduced.

Table 12.6 Estimates of fishing mortalities (F) and total mortality (Z yr^{-1}) of *N. microps* landed by the Chinese seine and trawl vessel operating in Guyana during January-December 1998. The coefficient of determination (R^2) and the number of points (n) used from the length-converted catch curves are also shown. Natural mortality (M) was assumed as 1.7 yr^{-1}. Values of L_∞ and K were 49.57 and 1.18 yr^{-1} respectively

Trawl Fishery					Chinese seine Fishery				
Sample Period	**F (yr^{-1})**	**Z (yr^{-1})**	**R^2**	**Range**	**Sample Period**	**F (yr^{-1})**	**Z (yr^{-1})**	**R^2**	**Range**
Jan-Mar 98	1.7	3.4	0.09	30-35	**Jan-Mar 97**	0.1	1.78	0.04	16-21
Apr-Jun 98	13.6	15.3	0.90	31-38	**Jul-Sep 97**	15.1	16.8	0.88	28-33
Jul-Sep 98	7.5	9.2	0.89	29-36					
Oct- Dec 98	2.5	4.2	0.47	28-33					
Jan-Mar 99	7.6	9.3	0.75	30-35					

Using the results in Table 12.6, the following mortality estimates were derived by averaging over the samples' estimates:

Average F (Chinese seine) = 7.6 ± 10.6 yr^{-1}

Average F (Trawl) = 6.6 ± 4.8 yr^{-1}

Average Z (Chinese seine) = 9.3 ± 10.6 yr^{-1}

Average Z (Trawl) = 8.3 ± 4.8 yr^{-1}

12.7 Catch per unit of effort (CPUE) trends

Trends in CPUE were examined for *M. ancylodon* for the period 1996-1998. This was also in keeping with the recommendation made at the last workshop to monitored the stock using CPUE data.

The landings of *M. ancylodon* of all Chinese seine vessels sampled for the month was summed and divided by the total effort (# of seine) for that month to obtain the monthly CPUE. This was done with the data collected from 1996-1998. Annual CPUE was also calculated using the formula:

$$\text{Annual CPUE} = \frac{\text{Total landings of } \textit{M. ancylodon} \text{ per year}}{\text{Total effort (\# of seine) per year}}$$

From the plot of the CPUE for *M. ancylodo*n from the Chinese seine fishery for the period 1996-1998, there seems to be similar trend in CPUE for 1997 and 1998 except for the last three months of the year. There were similar peaks in March and may for 1997 and 1998 with similar downward trends in April, June and August although the latter was not so pronounced. The annual CPUE for the same period (i.e.1996-1998) showed a reduction in CPUE in the year 1998 (Fig. 12.4). It is not known whether this reduction in the CPUE is due to the El Niño effect. Further investigation should be carried out by use of rainfall data.

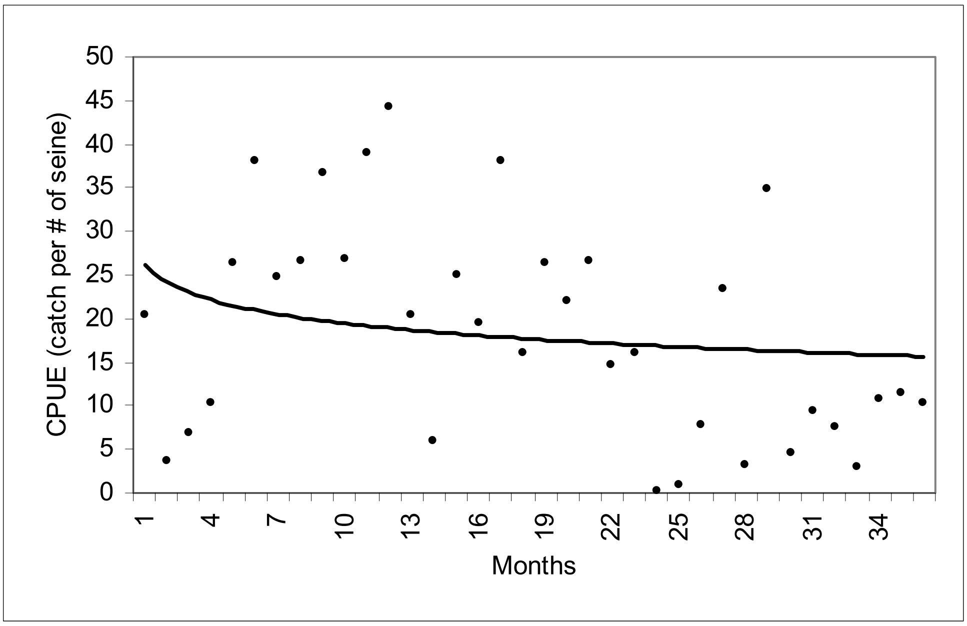

Figure 12.4 A plot of monthly catch per unit of effort (CPUE) of *M. ancylodon* for 1996-1998 with a fitted logarithmic trendline

12.7.1 Estimation of the catchability coefficient by fleet for M. ancylodon

The fishing mortalities estimated for the Chinese seine and the trawl fishery from the catch curve analysis were used in turn to estimate the catchability parameter. The total fishing mortality was distributed over the three fleets (Chinese seine, trawl and nylon gillnet) as follows:

$$F_f = F * (L_f / TL)$$

where F_f = fishing mortality of fleet f, F = total mortality (F=1.5), L_f = total fleet landing of species and TL= total landings of species for all fleet. Catchability coefficient (q) of each fleet was calculated as follows:

$$q = (F_f / E)$$

where q = catchability coefficient and E = effort (number of vessels).

Table 12.7 Results of the catchability coefficient of various fisheries on M. ancylodon.

Fleet Type	***Catchability coefficient (q)***
Chinese seine	*0.001*
Nylon gillnet	*0.003*
Trawl	*0.004*

12.8 Multifishery-multispecies per-recruit modelling (Booth 1999)

The fisheries of the sub-region are complex with a variety of the gear, all of which catch a number of different species. Hence single species assessment can provide only partial answers in terms of optimal management and additional studies need to be made to investigate the interactions between different types of fisheries and the impacts of them on the communities of resources. This requires multi-species and multi-fleet assessments. With data available, a multi-fleet per recruit approach was adopted for the multi-species and multi-fleet assessments.

The multispecies-multifishery per-recruit method is an extension of the traditional per-recruit models and is described in Section 5 of this report.

12.8.1 Results

The nylon gillnet fishery on it owns has a maximum yield per recruit of approximately 62g which occurs at a value of F greater than 3 yr^{-1} (Table 12.8). The nylon gillnet gear is selecting the fish after maturity at a specified range and over. In contrast, because it catches a large number before they have completed the period of relative rapid growth, the inshore Chinese seine fishery has a maximum yield per recruit at only 32g which occurs at an F above 0.75 yr^{-1}. For the offshore trawl fishery, the maximum yield per recruit was only 37g, which occurs at F of 0.93 yr^{-1}. Although the yield in this fishery is higher than that of the inshore Chinese seine, it is evident that the capture of many juvenile fish by the Chinese seine fishery has an impact on the yield of the trawl fishery. This will also affect the yield of the nylon gillnet fishery since with the high mortality of juvenile fish, less recruits would be made available to the other fisheries, resulting in growth overfishing. Although the Chinese seine is capturing a large amount of juvenile fish, the yield is not high since the fishes are not given the opportunity to grow and mature in size and weight to substantially contribute to the biomass.

Similarly the spawner biomass per recruit using the nylon gillnet fishery is reduced to 40% of its unexploited level with an F of 1.89. For the offshore trawl fishery, the spawner biomass per recruit is reduced to 40% of its unexploited level with an F of 0.54. The inshore Chinese seine fishery would deplete the stock to 40% of its unexploited level with an F of 0.48.

The interaction of the offshore trawl and inshore Chinese seine fisheries was examined. The presence of the Chinese seine fishery reduces the potential yield of the combined fishery (Table 12.8). Since the Chinese seine is capturing the fish in its juvenile state, then less fish would be available to the trawl fishery. In combining the trawl and nylon gillnet fisheries and running the model, the potential yield of the combined fishery is reduced with the presence of the trawl fishery. In combining all three fisheries, a potential maximum yield was recorded at 39.9g at F of about 1.2 yr^{-1}. The presence of both the Chinese seine and the trawl fisheries has a somewhat double effect on the reduction of the potential yield of the combined fishery.

Table 12.8 Results of the multifishery-multispecies analysis of *M. ancylodon*. (Yield per recruit values are in parenthesis)

Values	Chinese seine Fishery	Trawl	Nylon Gillnet
F_{max}, YPR	0.75 , (32.4g)	0.93, (37.1g)	>3 , (62g)
$F_{50\%}$	0.35	0.39	1.14
$F_{40\%}$	0.48	0.54	1.89
$F_{30\%}$	0.65	0.74	3.7
$F_{0.1}$	0.5	0.6	1.33

Table 12.9 Results of the multifishery-multispecies analysis illustrating the interaction of various fisheries on *M. ancylodon* (Yield per recruit values in parenthesis)

Values	Chinese seine / Trawl fishery	Trawl / Nylon gillnet Fishery	Combined Fisheries
F_{max}, YPR	0.88, (35.7g)	1.4, (42.1g)	1.2 , (39.9g)
$F_{50\%}$	0.39	0.57	0.53
$F_{40\%}$	0.52	0.81	0.73
$F_{30\%}$	0.72	1.1	1.03
$F_{0.1}$	0.6	0.8	0.7

12.9 Discussion

The main analytical steps covered in this investigation were:

(i) To estimate growth and mortality rates of *N. microps* and *M. ancylodon*;

(ii) To estimate the selectivity of the gear for both species;

(iii) To examine the impact of more than one fishery on *M. ancylodon* and on the yield by undertaking multi-species and multi-fleet assessments for *M. ancylodon*;

(iv) To estimate other biological parameters for input into a bio-economic model.

Due to the high uncertainty in the value of K for *N. microps*, the per-recruit model was not applied to this species, however with improved estimates the model could be applied. High values of fishing mortality in the trawl fishery were observed. This was similar for other species of sciaenids investigated during the workshop.

The selectivity results indicate that a narrow size range of *M. ancylodon* is retained by the nylon gillnet gear. Fish of 30.3 cm were optimally selected yet selectivity is reduced substantially in fish larger or smaller than the mean. A fish of 25 cm, for example, is only as vulnerable to the gear as a 30 cm fish, etc. As a result, length frequency data obtained from nylon gillnet catches will reflect the selection properties of the gear more than the length composition of the population. This characteristic excludes the possibility of using the samples for estimating growth or mortalities rates. The gear unfortunately only gives an indication, itself affected by selectivity, of the abundance of fish between approximately 25 and 38 cm.

The Chinese seine and trawl fisheries seem to be capturing the juvenile *M. ancylodon* hence reducing the number of recruits to other fisheries. The trawl fishery also seems to be catching the medium size to large fishes which results in a reduction of the spawner biomass. The two fisheries are competing for the stock.

There seems to growth overfishing taking place in the Chinese seine and trawl fisheries. Also in the trawl and gillnet fisheries there seems to be recruitment overfishing taking place. These phenomena can have serious effect on the stock in the future and cannot be overlooked

Catchability coefficient (q) values obtained are preliminary values since there is some uncertainties in the nylon gillnet landings of *M. ancylodon* for 1997.

12.10 Conclusion

The collection of length frequency data from nylon gillnet fisheries should be reduced to a lower level priority as compared to the priorities given to Chinese seine and the trawl gears. Greater effort should, however, be placed into sampling the other two gears for length frequency samples.

Due to the high values of F estimated for *N. microps* based on the high K value used in the analysis, no management measures would be suggested for this species. Refined estimates of L_∞ and K should be obtained from the literature or by combining the data from Guyana and Suriname and applying it to the model in some future workshop.

The following conclusions are drawn from the results of the multispecies multifleet per recruit model:

(i) For the seabob fleet, restrict the trawling for seabob to the area of high adult abundance with the view of reducing the conflict with the artisanal fishermen and damage to nursery areas and juveniles.

(ii) For the finfish fleet, mesh size regulation and appropriate finfishing trawl

(iii) For the Chinese seine fleet, determine at what level this fishery is becoming mainly a finfish targeting fleet instead of a whitebelly shrimp fleet and institute a mesh size regulation.

Since the Chinese seine and trawl fisheries are contributing to growth overfishing and the trawl and gillnet fisheries to recruitment overfishing, then studies should be conducted to ascertain at what time of the year the species spawn and also the age of spawners. It would be very important to gather some knowledge on which gears are capturing the spawners at what age. This would require the collection of gonads and otoliths for this species.