STOCK ASSESSMENT OF *MACRODON ANCYLODON* IN SURINAME

by

Yolanda Babb-Echteld[40]

1. INTRODUCTION

1.1 Importance of *Macrodon ancylodon* in the fisheries

Macrodon ancylodon (local name Dagoetifi), a small demersal fish species, makes a great contribution to landings. The family (Sciaenidae) accounts for 85% of the landings of the trawl fishery and for about 60% of the pin seine landings. In the Chinese seine, where white belly and seabob shrimp are the most important species, the Sciaenids contribute 7%. If, however, Sciaenids are compared with other fish species caught in the Chinese seine fishery, they contribute 40% of the landed fish.

In Table 1 an overview of the landings per species is presented, showing Sciaenidae to be a very important family in Suriname fisheries. *Macrodon ancylodon* is the third most important species, by mass of landings, in this family.

Table 1: Total landings for sciaenids by gear in 1991(tonnes)

	Trawl	Pin seine	Chinese seine	Total
Cynoscion acoupa	2.9	79.7	0.7	83.3
C. virescens	247	20.3	185	452.3
C. jamaicens	58.8	44.5	0.5	103.8
Macrodon ancylodon	127	90	203	420
Nebris microps	352	66.7	54	472.7
Other Sciaenidae	11.8			11.8

1.2 Trawl Fishery

The trawl fishery became important in the early 1980's. In those days a few shrimp trawlers were used mainly to catch fish, while nowadays there is a new fleet of stern trawlers from the North Sea. These boats have a gross tonnage of 200 - 300 tonnes, length of 32 -35 meters and 750 - 1250 horsepower. The depth in which finfish trawlers operate ranges from 10 - 35 meters and a trip lasts for 10 - 14 days. *M. ancylodon* makes a bigger contribution to the landings of the older shrimp trawlers. By-catch from shrimp trawlers has been landed from the beginning, but it was not encouraged and, in fact, was partly forbidden to protect the landings of the small scale fishermen from competition.

1.3 Preliminary Assessment

Several assessments on groundfish species have been carried out in the last thirty years. The most recent assessments were carried out by Charlier (1989), the R/V Dr. Fridtjof Nansen (IMR, 1989), and Charlier (1993).

In the report ‘Fisheries in Suriname’ (Charlier, 1989), the results using different parameters for K indicated that the stock was underexploited (Table 2). Values of K = 0.281 and L_∞ = 50.88 had been estimated for the species by Vendeville from a French Guiana survey, but Charlier (1989) reported that L_∞ had been calculated as 40cm using Suriname data and this value was used for the calculations in Table 2.

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

Table 2: Estimates of rate of exploitation for *M. ancylodon* bycatch, assuming L_∞ = 40cm and for different values of K where K is the von Bertalanffy growth parameter (n = 6,932). E is the ratio F/Z. Results from Charlier (1989)

K	M	Z	F	E
0.20	0.57	0.81	0.24	0.30
0.28	0.71	1.13	0.43	0.38
0.35	0.82	1.41	0.60	0.42
0.50	1.03	2.02	0.99	0.49

In a separate study, reported by Charlier (1993), all demersal fish were first considered together. The MSY was estimated as 16,000 tonnes. For the small demersal species only, a MSY of 11,000 tonnes was estimated and an average MSY of 0.28 tonnes/km^2 was calculated. The report also indicated that the small demersal stocks were probably under exploited, but it was not possible to recommend specific increases in the level of exploitation because the amount of fish being destroyed by shrimp trawlers was difficult to estimate.

In the R/V FRIDTJOF NANSEN report, the survey indicated three main groups of demersal fish in Suriname waters, i.e. snappers, croakers and grunts. *M. ancylodon* was estimated as the third most important species in the inner shelf. A biomass estimate of 22,500 tonnes was calculated for the Sciaenids as a whole.

2. DATA

2.1 Catch and Effort of 1991 and 1992 by Fishery Type

Table 3 shows the catch and effort data for the Suriname fisheries according to fleet and/or gear.

Table 3: Estimated landings by fleet of 1991 & 1992 (tonnes)

Fleet	1991		1992	
	Effort (No. of licences)	Landings (tonnes)	Effort (No. of licences)	Landings (tonnes)
Fish trawlers	7	761	13	498
Shrimp trawlers	87	297	129	803
Decked Guyana gillnetters	47	1,585	60	1,352
Open Guyana gillnet	142	1,201	178	1,154
pinseiners	27	664	26	628
long liners	3	21	6	23
Fykenets				
large	}	474	}	686
medium	}301	230	}399	}
small	}	801	}	}1,402
Estuaries				
gillnet	91	700	136	813
long lines		131		181
Haritete	10	70	12	40
Lagoon gillnet	143	574	139	415
Others	40	19	89	15

2.2 Methods of Collection

Sampling was undertaken at four major landing sites, Paramaribo, Central Market, SAIL, Boomskreek, and SluisII. At the Paramaribo Central Market, landings were made of catches by gillnet (open and decked Guyana type), pin seine, by-catch of shrimp trawlers, and all gear of the estuarine fishery (in most cases as secondary landing). At SAIL, landings occurred by shrimp trawlers and some of the fin-fish trawlers. At Boomskreek and SluisII, there were mainly landings of decked Guyana type and some open Guyana type boats.

In the case of *M. ancylodon,* the sampling sites were Paramaribo Central Market and SAIL. Samples are also collected from the Chinese seine operating in the river mouth of the Suriname river. For all species, the target number was 200 specimens per month, but this could not always be obtained for several reasons.

2.3 Length Frequency Distributions by Month, Quarters and Year

Only length frequency distributions from trawlers at SAIL are presented here and were used in the assessment. In Table 4 the numbers measured in a size class are given. At that time the sample weight was not registered.

Table 4: . Length frequency distributions, SAIL, Feb 1991 - Sep 1992: *Macrodon ancylodon*

MdL	1991								1992							
	F	M	A	M	J	J	S	O	N	D	J	F	M	A	J	S
140										1						
150																
160								1								
170																
180																
190					1									1		
200					1											
210			4		1			9		2		1	2	4		
220	1	2	2					2		2			9	4		
230	2	6			1			5		2			10	7		
240	1	10	6	1				17	3	7		1	20	26	2	
250	2	20	11	2	5	2		29	8	19		4	26	36	13	
260	5	12	11	7	2	3		43	16	31		8	26	40	27	
270	10	21	13	20	16	13	1	34	19	36	4	22	26	40	39	4
280	14	26	33	31	14	13	5	26	24	35	4	52	34	26	27	12
290	18	19	20	45	16	38	17	19	32	37	9	43	23	27	19	25
300	7	23	27	42	13	47	28	26	26	24	8	32	14	21	21	50
310	7	20	27	58	34	37	42	12	26	22	13	35	8	15	18	49
320	9	20	22	35	38	30	52	8	21	16	31	14	6	9	10	43
330	6	21	20	29	23	12	53	6	14	8	33	7	2	10	4	23
340		7	7	26	20	9	35	1	12	5	22			3	5	14
350		1	10	14	14	3	33	1	15	3	23				1	14
360		1	1	9	3	1	9	1	3	1	27			1	1	1
370	1		1	3	4	1	4		2	1	23	1		1		
380			2	2	1		2	1	1		9			1		
390			1	2	1	1			2		6					
400							1		1		1				1	
410							1								2	

To estimate the sample weight by size class, the formula $W = a*L^b$ was used with parameters from a study on *M. ancylodon* undertaken in Brazil during 1984-1986 (Growth of the king weakfish by Univ. Rio Grande). For a and b the figures are respectively 1.5E-06 and 3.3168.

The total weight of *M. ancylodon* sampled in 1991 and 1992 was 125 000 kg.

Table 5: Length frequency per size class per quarter (3 months) of *M. ancylodon* from Feb. 1991 until Sep. 1992. The length shown is total length at the midpoint of each 10 mm length class

	1991				1992		
Length (cm).	1	2	3	4	1	2	3
140	0	0	0	1	0	0	0
150	0	0	0	0	0	0	0
160	0	0	0	1	0	0	0
170	0	0	0	0	0	0	0
180	0	0	0	0	0	0	0
190	0	1	0	0	0	1	0
200	0	1	0	0	0	0	0
210	0	5	0	11	3	4	0
220	3	2	0	4	9	4	0
230	8	1	0	7	10	7	0
240	11	7	0	27	21	26	2
250	22	18	2	56	30	36	13
260	17	20	3	90	34	40	15
270	31	49	14	89	52	40	27
280	40	78	55	85	90	26	43
290	37	81	75	88	75	27	39
300	30	82	79	76	54	21	44
310	27	119	82	60	56	15	71
320	29	95	65	45	51	9	67
330	27	72	44	28	42	10	53
340	7	53	36	18	22	3	27
350	1	38	10	19	23	0	19
360	1	13	5	5	27	1	15
370	1	8	2	3	24	1	2
380	0	5	1	2	9	1	0
390	0	4	1	3	6	0	0
400	0	0	1	1	1	0	1
410	0	0	0	0	0	0	2
420	0	0		0	0	0	0

3. METHODS OF ASSESSMENT

For the assessment, length frequency distributions from January 1991 until September 1992 were grouped in quarters of a year, giving a total of 7 groups (Table 5). The estimation of modes within each length frequency was done using the Bhattacharya routine in FiSAT (1996). Modes were difficult to identify, but in most frequencies 2-3 modes could be found. With the 7 groups, 19 modes were found, respectively 3, 2, 1, 3, 5, 2 and 3 modes in each group. The mean and standard deviation of each mode estimated from the Bhattacharya method (Table 6) were also entered into FiSAT for the estimation of L_∞ and natural mortality (M).

A Gulland and Holt plot, based on the equation $dL/dt = k^* L_\infty - k^*L(t)$ (Sparre and Venema, 1992) was used to calculate L_∞ and K. The estimated values of L_∞ and K were used to estimate M, using Pauly's empirical formula:

$$\ln M = -0.0152 - 0.279^* \ln L_\infty + 0.6543 * \ln K + 0.463 * \ln T$$

where T = the mean water temperature (FiSAT, 1996)

3.1 Estimation of F in Length Converted Catch Curve by Size Interval

Z was estimated by catch curve analysis using the software described by Ehrhardt and Legault (1996) which uses the relationship (Sparre and Venema, 1992):

$$\ln \frac{C_{L1,L2}}{\Delta t_{L1,L2}} = c - Z * t(\frac{L1,L2}{2})$$

where

$C_{L1,L2}$	=	the catch of fish between lengths L_1 and L_2
$\Delta t_{L1,L2}$	=	the time a fish will spend within the size group L_1,L_2 (yrs)
c	=	the intercept of the relationship between the terms on the left and right of the equation
Z	=	the instantaneous coefficient of total mortality (per year)
$t(\frac{L1,L2}{2})$	=	the average age of a fish in the length class L_1 to L_2 (yrs)

A straight line of slope -Z is fitted to a plot of $\ln \frac{C_{L1,L2}}{\Delta t_{L1,L2}}$ on $t(\frac{L1,L2}{2})$.

This was done for each of the quarterly length frequencies shown in Table 5 and using the values of L_∞ and K estimated in this study.

Once an estimate of Z had been obtained, it was used with the value of M derived from the Pauly equation to estimate F at the time of sampling from the equation Z= F+M.

3.2 Estimation of Yield per Recruit and Biomass per Recruit for Knife-edge Recruitment

The yield-per-recruit and biomass-per-recruit analyses were undertaken using a spreadsheet package based on the method of Beverton and Holt (Sparre and Venema, 1992) and using the growth and mortality parameters estimated as described above. These calculations enabled estimation of F_{max} and of BPR at F_{max} and at other values of F. Such reference points could then be compared to the estimates of the current fishing mortality. L_{rec} (size at first capture) was estimated as 185 mm by looking at the length frequency graphs for the various intervals for the period of the study.

As the estimate of M is particularly prone to uncertainty, the sensitivity of YPR to different values of M was examined, as well as sensitivity to different ages at first capture.

4. RESULTS

The growth and natural mortality calculations, based on the results of the Bhattacharya analyses (Table 6) produced the following results:

L_∞ = 489 mm;
K = 0.55; and
M = 1.03

The samples obtained for the different quarters generated different estimates of F (Table 7). In 1991, there appeared to be two different values of Z, for different length groups. This could have been a result of migration of the species out of the trawling grounds at larger sizes, or the ability of fish of the larger sizes to avoid capture, as it is known that the fish trawl net is selective. This phenomenon did not occur in 1992.

Table 6: Mean and standard deviation (sd) of the mean (modal) lengths in each quarterly length frequency distribution obtained using the Bhattacharya method (FiSAT, 1996; Sparre and Venema, 1992)

	Obs.	Date	Mean (mm)	s.d
1th quarter	1	15/2/91	248.88	14.069
	2		281.44	11.409
	3		315.88	16.208
2nd quarter	4	15/5/91	225.333	21.930
	5		307.35	28.319
3rd quarter	6	15/8/91	315.82	23.610
4th quarter	7	15/11/91	269.14	16.819
	8		306.67	19.517
	9		348.29	7.736
5th quarter	10	15/2/92	226.05	10.029
	11		258.54	15.647
	12		288.48	12.079
	13		320.60	15.253
	14		362.66	11.609
6th quarter	15	15/5/92	261.89	16.197
	16		304.76	10.795
7th quarter	17	15/8/92	272.01	12.725
	18		310.08	4.119
	19		345.70	6.822

Using the results F-1, for the lengths prior to possible movement out of the trawling grounds, the mean F for the seven samples was 1.84 (Standard Error = 0.18).

Table 7. F-values in trawl samples for *Macrodon ancylodon*

Sample period	F-1 value	Age F-1 obtained	F-2 value	Age F-2 obtained	Migration rate out of gear
Jan/Mar 91	1	1.502 - 1.777	9.286	1.878 - 2.222	8.016
Apr/Jun 91	2.0192	1.777 - 2.222	2.001	2.353 - 2.814	0
Jul/Sep 91	1.9316	1.878 - 2.222	5.178	2.101 - 2.814	2.217
Oct/Dec 91	2.2287	1.589 - 2.222	2.526	2.101 - 2.998	0.297
Jan/Mar 92	1.2978	1.589 - 2.814	0		
Apr/Jun 92	1.926	1.419 - 1.986	0		
Jul/Sep 92	2.4645	1.777 - 2.353	0		

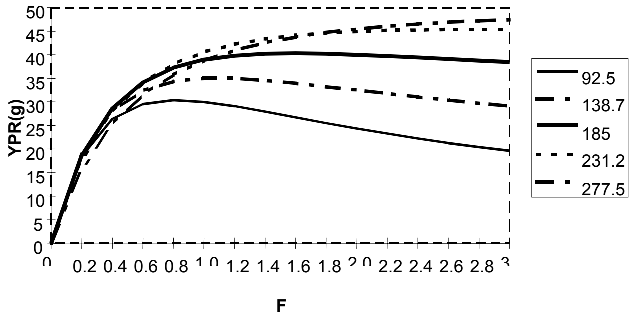

Figure 1: Yield per recruit (g) for *M. ancylodon* at different lengths at first capture and for different values of F.

Table 8: Yield per recruit (g) of *M. ancylodon* for different lengths at first capture (L-capt), age in years at first capture (T-capt) and F
.

T-capt	**0.38**	**0.61**	**0.86**	**1.16**	**1.52**
L- capt	**92.50**	**138.75**	**185.00**	**231.25**	**277.50**
F					
0.5	28.39	30.55	31.76	31.33	28.68
1.0	29.97	34.97	38.91	40.52	38.72
1.2	29.06	34.93	39.79	42.20	40.89
1.4	27.91	34.52	40.19	43.32	42.50
1.6	26.69	33.91	40.28	44.08	43.73
1.8	25.48	33.20	40.19	44.58	44.67
2.0	24.31	32.46	39.99	44.91	45.41
2.2	23.22	31.72	39.71	45.11	45.99
2.4	22.20	31.01	39.41	45.23	46.46
2.6	21.26	30.32	39.08	45.29	46.84
2.8	20.40	29.67	38.74	45.31	47.15
3.0	19.60	29.06	38.41	45.29	47.40

4.1 Yield per Recruit and Biomass per Recruit

The yield per recruit of *M. ancylodon* was estimated with the length at first capture (L_c) = 185 mm, M = 1.03, t_0 = 0, L_{rec}= 0.4 and the growth and length:weight parameters as discussed earlier. With these values, it was found that F_{max} is equal to approximately 1.6 and that the yield per recruit at this value is just over 40g. F_{max} and the associated yield decreased for lower values of L_c and increased for higher values (Table 8 and Figure 1). The yield-per-recruit was also found to be sensistive to the assumed value of M, and for M of 75% of the estimated value (1.03), the maximum yield per recruit was found to be approximately 61 g at F = 1.0, while at an M of 125% of the estimated value, the maximum yield per recruit was found to be only 28g at an F of about 2.4 (Figure 2). In view of the uncertainty in the estimate of M, caution should therefore be applied in setting a target value of F.

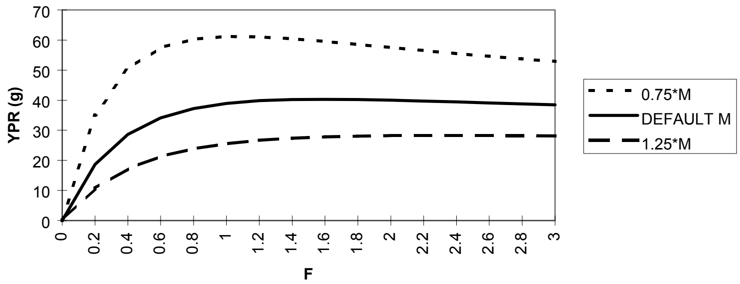

Figure 2. Yield per recruit (g) for *M. ancylodon* for different values of M, as a proportion of the 'default' M = 1.03 and for different values of F

In setting a target value of F, attention also needs to be given to the biomass per recruit, and a minimum level of spawner biomass per recruit has been suggested to be 30% of unexploited spawner biomass ($F_{30\%}$; Mace and Sissenwine, 1993). While this reference point refers to spawner biomass per recruit, it is applied to biomass per recruit in this paper, until such time as spawner biomass per recruit estimates are available. At F_{max}, estimated with the standard parameters given in the paragraph above, the biomass per recruit was estimated to be only 20% of the unexploited biomass per recruit (Table 9; Figure 3), which is lower than recommended by Mace and Sissenwine (1993). An F value of approximately 1 results in a biomass per recruit of 30% of the unexploited condition.

Table 9: Biomass per recruit (g) of *M. ancylodon* for different lengths at first capture L-$_{capt}$ (mm), age at first capture T-$_{capt}$ (yrs) and F

T-capt	0.38	0.61	0.86	1.16	1.52
L- capt	92.50	138.75	185.00	231.25	277.50
F					
0	135.19	132.85	127.23	116.86	100.74
0.5	56.70	61.01	63.44	62.57	57.28
1	29.93	34.92	38.86	40.46	38.67
1.2	24.18	29.07	33.12	35.12	34.03
1.4	19.91	24.62	28.67	30.90	30.32
1.6	16.66	21.16	25.14	27.51	27.29
1.8	14.13	18.42	22.30	24.73	24.78
2	12.14	16.21	19.97	22.42	22.67
2.2	10.54	14.40	18.03	20.48	20.88
2.4	9.24	12.90	16.40	18.82	19.33
2.6	8.17	11.65	15.01	17.40	17.99
2.8	7.28	10.58	13.82	16.16	16.82
3	6.53	9.67	12.79	15.08	15.78

This limit reference point (F=1.0) needs to be compared with mean value of F of 1.84 estimated from the catch curve analyses. This mean value is higher than both F_{max} and $F_{30\%}$, which suggests that the *M. ancylodon* stock in Suriname may have been considerably over-exploited during 1991 and 1992 when the samples were obtained. These results need to be treated with caution because of the small samples

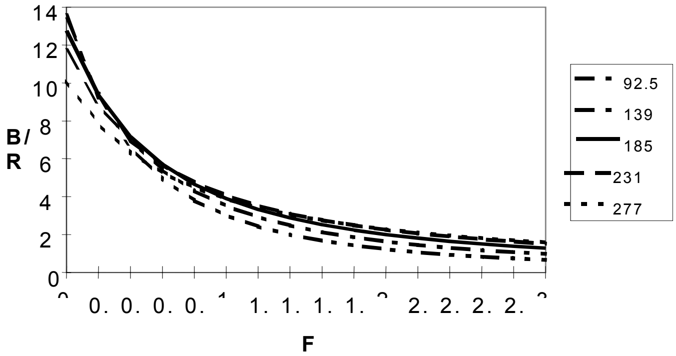

Figure 3: Biomass per recruit (g) for *M. ancylodon* at different lengths at first capture and for different values of F

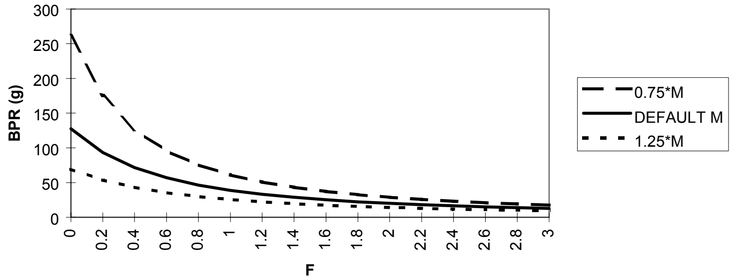

Figure 4: Biomass per recruit (g) for *M. ancylodon* for different values of M, as a proportion of the 'default' M = 1.03 and for different values of F

sizes and other assumptions, such as treating males and females together, hence assuming that they have the same growth rate. Nevertheless, they do indicate that some caution may be required in the fishery and that improved assessments must be undertaken to check these results.

5. CONCLUSIONS AND MANAGEMENT OBJECTIVES

a) The estimates of L_∞ compare with those reported in section 1.3, but the K is considerably higher than that reported from French Guiana. However, the data used in this study give reason for some confidence in these results.

b) A study of the growth of the species from a survey in Brazil (1984-1986) calculated L_∞ males = 348 mm and L_∞ females = 420 mm. In our assessment L_∞ was estimated at 489 mm for both genders, possibly indicating that the fish grow to larger sizes in Suriname waters.

c) Comparing the results of the assessment of fishing mortality with those of Charlier (1989), the new results are higher indicating that exploitation may have increased from the period reported in the 1989 report.

d) Assessment of the stock must be continued and improved for better understanding. Data collection can also be improved, resulting in better assessment.

e) Migration rate out of the gear could also be a result of selectivity by the fishermen. It is known that fish brought by trawlers are selected for commercial purposes. These effects need to be studied and quantified.

f) To achieve a higher yield and biomass per recruit, a possibility could be to increase the mesh size of the cod end, allowing the smaller fish to escape.

6. REFERENCES

Charlier, P. 1989. Fisheries in Suriname. Current status and potential for development. EDF project no 6605.36.39003. pp132

Charlier, P. 1993. Preliminary analysis of first year results and guidelines for fisheries management. Suriname Fisheries Report no 2 pp 76.

Ehrhardt, N.M. and C.M. Legault. 1996. Crustacean stock assessment techniques incorporating uncertainty. Report of the FAO/CFRAMP Stock Assessment Workshop, Port of Spain, Trinidad and Tobago, 8-12 January, 1996. FAO Fisheries report 544, Supplement. 111-131.

FiSAT. 1996. FAO-ICLARM stock assessment tools. User's manual. FAO, Rome. 126 pp + 3 discs.

Haimovici, M. 1988. Growth of the King Weakfish. volume 4 pp 99-105

IMR. 1989. Final Report. Surveys of the fish resources in the shelf areas between Suriname and Colombia 1988. IMR, Bergen.

Mace, P. and M.P. Sissenwine. 1993. How much spawning per recruit is enough? In S.J. Smith, J.J. Hunt and D. Rivard eds. *Risk evaluation and biological reference points for fisheries management. Can.Spec.Publ.Fish.Aquat.Sci.* **120.** 101-118.

Sparre & Venema. 1992. Introduction to tropical fish stock assessment FAO Fisheries Technical Paper 306/1. pp 376.