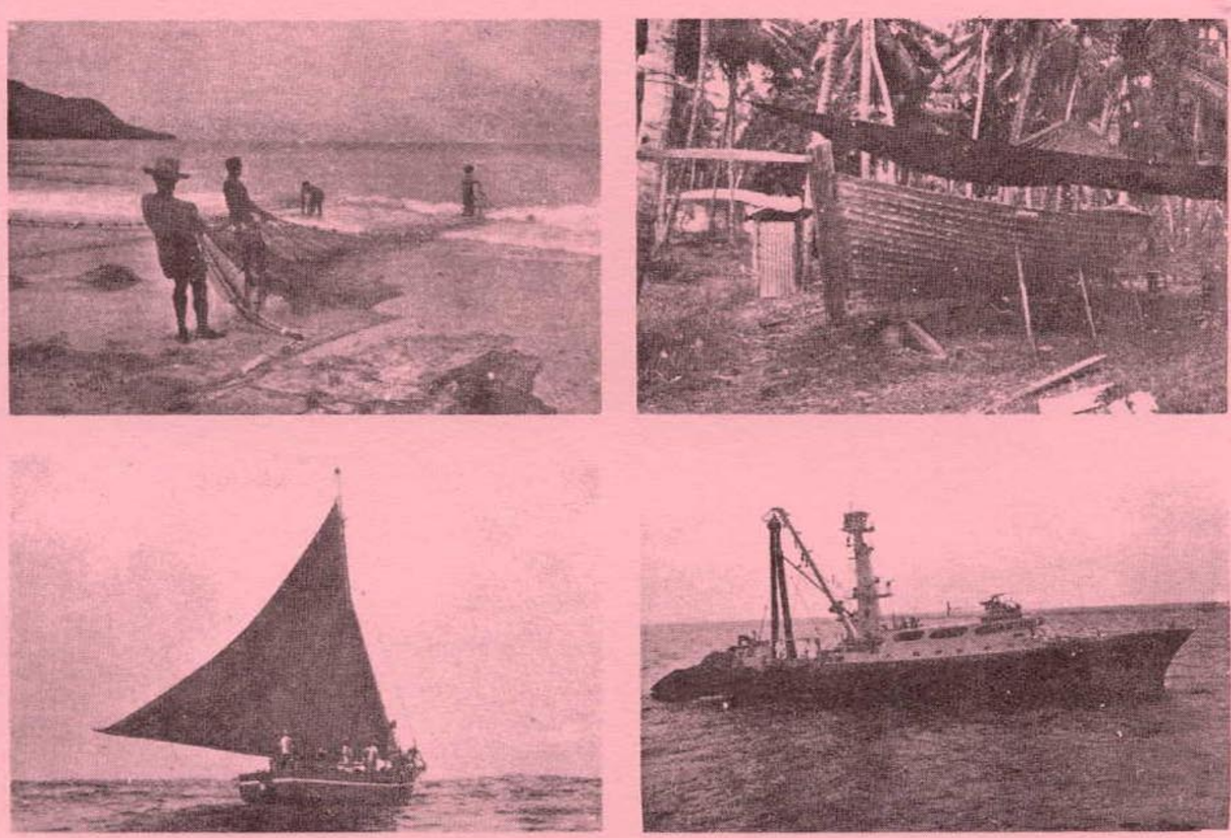
SEYCHELLES FISHING AUTHORITY

TECHNICAL REPORT

SEYCHELLES DEMERSAL FISHERY

AN ANALYSIS OF DATA RELATING

TO FOUR KEY DEMERSAL SPECIES



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(1992)

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ABSTRACT

Seychelles demersal fishery is described based on historic catch and effort data, and on biological studies of four key species : Batrican *(Pristipomoides filamentosus)*, Job Gris *(Aprion virescens)*, Bourgeois *(Lutjanus sebae)*, and Maconde (*Epinephelus chlorostigma*).

During the period 1985 - 1990 demersal species formed on average 33% of the total annual landings of the local fishing fleet. Schooners and whalers were the most important boat types engaging in this fishery, and more recently, a mothership dory fishing operation. Demersal species constituted 77% of all local fish exports over this period. In 1990 approximately 2,000 tonnes of demersal species were landed of which 500 tonnes were exported.

Lutjanids comprised 62% of the demersal landings, Lethrinids 22% and Serranids 16%. Of the Lutjanids the proportion of the catch represented by snappers tended to decrease whilst that of job fish increased over the period 1985 - 1990, partly explained by a shift to deeper fishing grounds. Catch composition varied according to boat type and location fished. Generally whalers are restricted in range to inshore areas (10 miles radius of granitic islands) and the middle ground (30 - 50 miles offshore), *Aprion virescens* is the predominant lutjanid, and lethrinids are relatively more important in the catch than is the case with schooners. Schooners have a greater range and fish offshore banks and the peripheric ribbon of the plateau, catch predominantly lutjanids, and *P. filamentosus* is more important than other job fish species.

Fishing locations were stratified by depth: shallow, 0 - 75 m; intermediate, 75 - 150 m; and deep, > 150 m. The shallow stratum of the Mahe Plateau was substratified into inshore, offshore and trawlable areas. The inshore areas (0-35m) correspond to the area within 10 miles radius of the Mahe Plateau; the offshore areas include banks and the peripheric rim of the plateau at 36-75m; the trawlable grounds are flat sandy or rubble substrates on the plateau itself. Some 40 % of the Plateau surface area is not accounted for and may contain fish at densities below that which may be exploited by handlines. The principal fishing areas for demersal species where stock densities are greatest are considered to be the offshore banks and peripheric rim and drop off.

P. filamentosus is caught in the intermediate depth range, whilst the other study species relate to the shallow strata. The maximum sustainable yield (MSY) for large demersal species available to a handline fishery (ie. not all demersal stocks) was determined by stratum from consideration of stock biomass determined from demersal trawling operations, from length cohort analyses of the key study species, and from stock depletion with intensive fishing on sea mounts and banks. Previous estimates of MSY are reviewed, and revised estimates are presented which supersede all previous estimates. Those given for the offshore banks are considered to be an underestimate, but insufficient data is available to determine to what extent the estimate should be increased.

CHARACTERISTICS OF THE DEMERSAL FISHING STRATA:

STRATUM	FISHING AREA KM2	MSY TONNES	CATCH 1990 MT	CATCH 1991 MT	EXPLOITED BY
MAHE PLATEAU					
0-75 M INSHORE	6000	1008	1353.0	1587.0	WHA/PIR/OB
0-75 M OFFSHORE	6500	1092	376.4	414.7	WHA /SCH
0-75 M TRAWLABLE	14000	2352			
75 - 150 M	374	514	216.4	68.1	SCH/GILL
> 150 M	374	120			
TOTAL	27248	4966	1945.8	2069.8	
OUTLYING AREAS					
0 - 75 M	4975	835		271.2	MOTHERSHIP
75 - 150 M	277	380		152.7	MOTHERSHIP
> 150 M	277	133			
TOTAL	5529	1215	0	423.9	
GRAND TOTAL	32777	6434	1945.8	2493.7	

In addition to the analyses relating to the whole demersal fishery, for each of the study species information is presented relating to the structure of the population (length frequency distribution, sex ratio, variations with depth, season and location), reproduction (timing of life cycle events, size at sexual maturity), growth, mortality, and production.

SOME KEY RESULTS RELATING TO THE STUDY SPECIES:

DETAILS		P.FILAMENTOSUS	L. SEBAE	A. VIRESCENS	E.CHLOROSTIGMA
POPULATION STRUCTURE					
MAXIMUM LENGTH	M	FL 77.6 cm	FL 86.0 cm	FL 93.3 cm	
	F	FL 77.6 cm	FL 78.2 cm	FL 97.5 cm	
	TOT	FL 79.8 cm	FL 86.0 cm	FL 101.0 cm	TL 65.4 cm
DIFF. FREQ. DIST M/F		NO	YES	YES	
SEX RATIO F : M		1:1.17 LF DATA 1:1.07 BS DATA	1 : 0.83	1 : 1.80	
REPRODUCTIVE BIOLOGY					
MIN SIZE AT MATURITY		FL 33.2 cm	FL 34.6 cm	FL 48.7 cm	
MIN SIZE AT SPAWNING		FL 38.1 cm	FL 51.2 cm	FL 56.6 cm	
SPAWNING PERIOD		OCT - APR WITH PEAKS NOV - DEC AND FEB - APR	ALL YEAR BUT PEAK OCT - NOV AND MAR - MAY	ALL YEAR BUT PEAK SEP - NOV AND MAR - APR	

Continued:

DETAILS	P.FILAMENTOSUS	L. SEBAE	A. VIRESCENS	E.CHLOROSTIGMA	
GROWTH					
K - MALES	0.30	0.380	0.29		
K - FEMALES	0.275	0.270	0.14		
K - TOTAL	0.420	0.307	0.26	0.175	
(non seasonal model)					
Loo - MALES	FL 85.5 cm	FL 95.12 cm	FL 95.0 cm		
Loo - FEMALES	FL 77.6 cm	FL 90.00 cm	FL 108.0 cm		
Loo - TOTAL	FL 74.25 cm	FL 84.00 cm	FL 104.0 cm	TL 64.45 cm	
MORTALITY					
				39-44TL	>39TL
M	0.534		0.496	0.438	
F	0.277 - 0.294		0.956 - 1.106	1.878	0.514
Z	0.811		1.602	1.440	0.076
PRODUCTION					
MSY (T) / SQ.KM	0.62 - 0.75		0.046 - 0.074	0.013 - 0.023	

The results as they relate to the individual species and to the demersal fishery as a whole are discussed. The major conclusions presented are:

1. - estimates of growth, mortality and production presented in this report are preliminary estimates based on a 12 month data set and will benefit from additional future data. These estimates should be refined.

2. - all study species are continual spawners with peaks of reproductive activity which coincide with the intermonsoon periods. These are also the times of peak fishing activity. Thus attempts to regulate the fishery by limiting effort at these times would meet significant resistance, and may not be justified anyway.

3. - the S.E. Trade wind period may not be considered a rest period for the fishery since reproductive activity is at its lowest and there is evidence that growth may also decrease at this time.

4. - The size at first capture is less than the size at which 50% of the population reach maturity for *P. filamentosus* and *L. sebae*, and is equal to this size for *E. chlorostigma*. The SMB pricing policy which pays a premium for small fish may exacerbate this problem, although it is not believed that small fish are specifically targeted.

5. - catches of *P. filamentosus* are below MSY and indicate the possibility for limited expansion of a fishery based on this resource. However, due to the small surface area of habitat afforded by the narrow band of fringing drop off (75 -150 m) the size of this resource and the total resource in this depth range are limited. It is suggested that a more

detailed survey of the periphery of Seychelles Plateaux would be useful to refine the estimated area of this stratum.

6. - catches of *A. virescens* in inshore areas equal or exceed the MSY but including all strata the catch is presently below the maximum yield. However, the population structure is biassed in favour of males and this may be a result of the heavy fishing pressure.

7. - whilst present catches of *Lutjanus sebae* are below the estimated yield of this fish there nevertheless appears to be cause for concern. The mean length of fish caught has decreased since the late 1970's and the population is composed chiefly of immature females.

8. - catches of *E. chlorostigma* are below MSY.

9. - For all species, the potential exists to more than double catches of demersal species from the Mahe Plateau if trawlable grounds are included, and to triple catches if all distant areas are included. By location, only the inshore areas of the Mahe Plateau appear to be overfished and in need of regulation. Outlying areas require development although there is the possibility that small isolated banks and mounts may have been overfished. The intermediate and deep water strata are also under-developed.

10. - options for regulation include an unfished nursery area such as the trawlable grounds. On balance it is suggested that it is better to maintain catches within estimates of MSY by location, and not to allow excessive fishing in the belief that stocks from the nursery grounds will replenish overfished areas. This opens up the possibility of exploiting the demersal resources on the trawlable grounds, which are important though insufficiently aggregated to be exploited by present handline technology. The total yield available is reduced by one third if these stocks are excluded. However, the desirability of exploiting these stocks needs careful consideration. A cost effective means of exploiting them would need to be developed (trawling is illegal) requiring research and development by SFA.

11. - a number of fundamental questions still remain to be answered in order to adequately devise regulatory guidelines for the demersal fishery. These include the dispersal mechanisms of the species concerned, in both the adult and planktonic stages of development. The answer to these questions will help to establish whether stocks in different geographical strata are the same stock at different times of the life history, are discrete populations or are overlapping populations that may be regarded as a single stock.

12. - overall, development rather than regulation of the demersal fishery is what is required at the present time, although the structure for regulating the fishery needs to be established, especially in the light of recent developments in technology (gillnets, droplines) and approach to exploitation (mothership ventures) of the

stocks. However, these developments are to be encouraged since they increase the efficiency of the fishery.

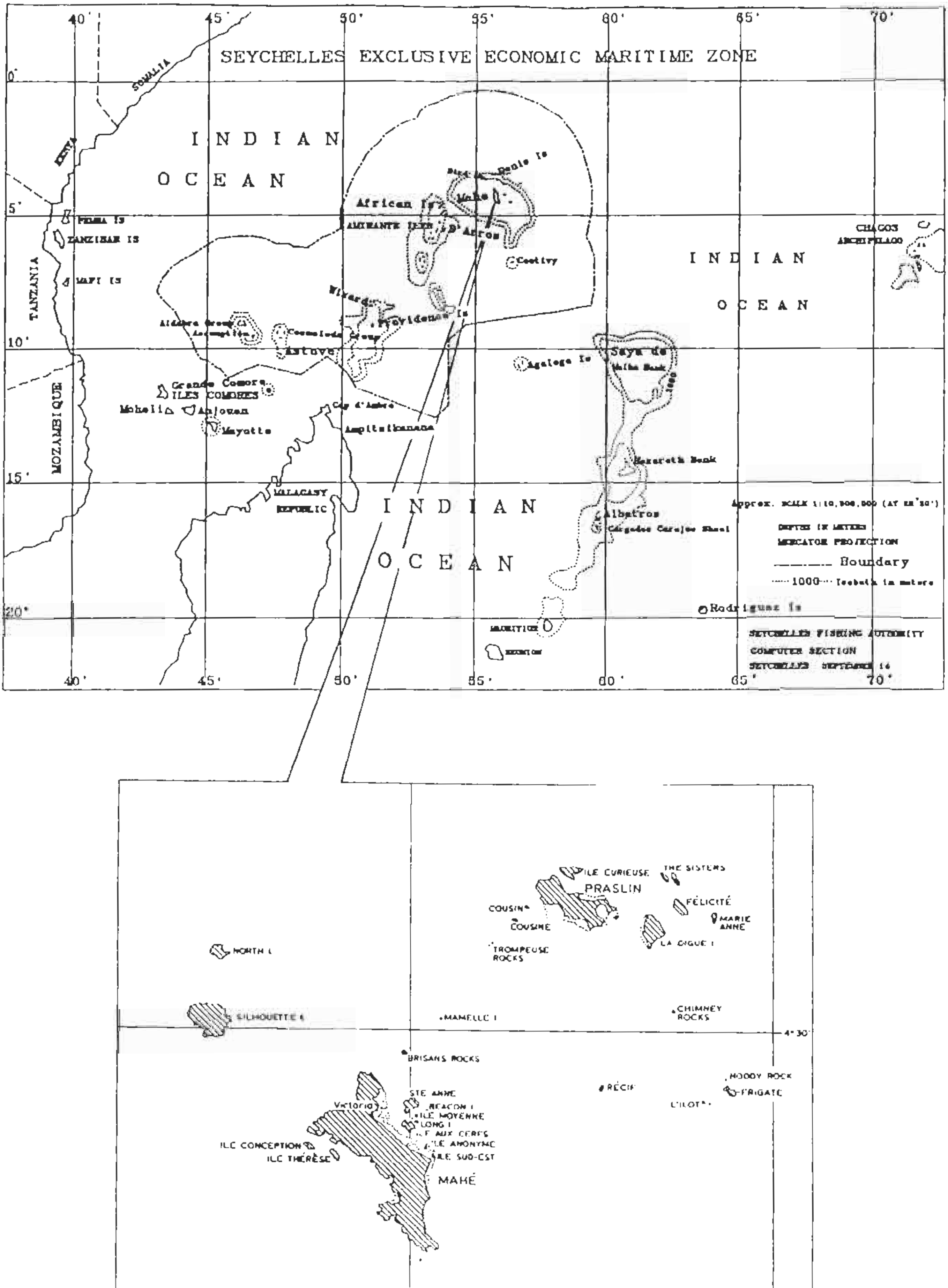
13. - close examination of the fleet structure is required in order to avoid overcapitalization in certain boat types and to promote the most appropriate vessels. Details of the maximum number of each boat type are presented.

14. - the present number of whalers exceeds the maximum number required to fully exploit inshore demersal fishery resources. As a result, and also from the pressure exerted by small outboard powered craft operating in this location, inshore stocks are presently overfished. However, whalers also fish the middle grounds and in the good weather the offshore banks. Thus whilst efforts could be made to reduce the size of the whaler fleet and/or discourage it from engaging in the demersal fishery, the extent of such action needs careful consideration. Nevertheless, it is considered that the expansion of the whaler fleet cannot continue totally unchecked. It is apparent from the species composition of the catch that they target different depths and fishing areas than the schooners. These areas are those most accessible on short fishing trips. As the number of whalers increases they will be forced further offshore. It is to be questioned whether this is desirable - whalers are uncomfortable and not suited to long trips; they would compete with more suitable boat types limiting their economic viability, and limiting the potential to expand the fleet size of other vessel types. Since whalers are also highly active in the carangue fishery it may be appropriate to restrict access to the demersal fishery by licensing only a limited number of the total fleet to engage in demersal handline activities though enforcing this may prove difficult.

15. Within the category 'Whalers' are traditional wooden boats, and fibreglass Lekonomie and Lavenir. Lavenir tend to fish more like schooners so the above applies principally to traditional and Lekonomie whalers which form the greatest proportion of the whaler fleet.

16. - a detailed social and economic appraisal is required based on different models of development for the demersal fishery, firstly on the Mahe Plateau and associated Banks, and secondly for the outer islands, in order to establish a development policy. The fleet composition required will become apparent from the policy guidelines.

SEYCHELLES DEMERSAL FISHERY



Map.1. SEYCHELLES EEZ INDICATING THE MAIN GRANITIC ISLANDS FROM WHICH FISHING ACTIVITIES ARE CONDUCTED.

1. INTRODUCTION

Seychelles unlike other oceanic island states has a relatively large continental shelf and thus has the potential for an important demersal fishery. Whilst certain areas are suitable to enable exploitation of demersal fish by means of a trawl fishery, in others the substratum is too uneven and fish are traditionally exploited with hooks and lines. Recent developments, still in the research stage, are the introduction of deep bottom set gill nets and drop lines to exploit demersal species.

Current legislation does not in fact allow trawl fishing, and, except for research activities, fishing on and up to five nautical miles beyond the edge of the plateaux (continental shelf, defined by the 200 m isobath) and within the territorial limits is exclusively reserved for locally owned and registered fishing boats. There consequently exists a substantial artisanal fishery, some of the larger boats of which may be considered to be operating in a semi industrial manner. Industrial fishing on the plateaux has also recently begun (March 1991) with a mothership - dory operation. Handlines are predominantly used to exploit demersal species but in recent years electrically powered fishing reels have also been introduced, increasing the efficiency of fishing operations.

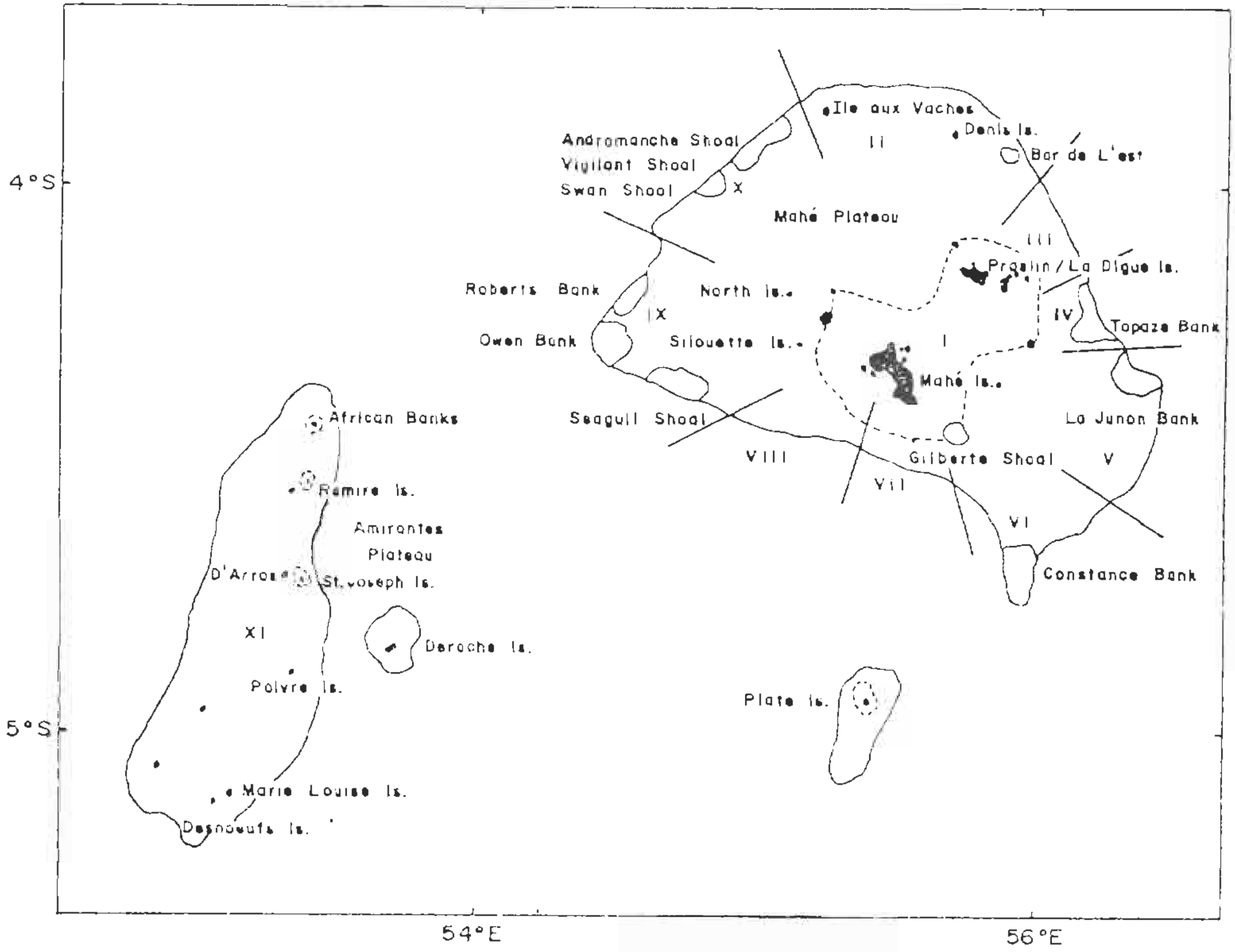
Seychelles is self sufficient in most of its fishery requirements Imports of some crustacean species are required to meet demand generated through the tourist industry, but for most finfish species a surplus exists and an export industry has developed based principally upon demersal species. The fish exported also tend to be the most favoured locally but exports generate a substantial amount of foreign exchange, and there are ample supplies of other species to meet local demand.

Catch and effort data have been collected on the local fishery for a number of years, and key species from the demersal fishery have been identified for closer study. The present report examines this data as it relates to the demersal fishery. Catch and effort data are presented as background information (Sections 2.3 - 2.5) whilst the bulk of the report examines Stock Assessment Studies directed at the key demersal species (Sections 3 - 8).

2. BACKGROUND INFORMATION

2.1. GEOGRAPHY AND FISHING LOCATIONS

The Republic of Seychelles consists of around 100 islands with a total land area of only 453 square kilometres dotted across a 1,374,000 square kilometre Exclusive Economic Zone in the Western Indian Ocean (Map 1). Within this area only 48,019 square kilometres of ocean cover depths of less than 200 m, and the remainder is over depths of 1,000 - 1,500 m. The shallow areas are composed of plateaux and banks lying between latitudes 04^{o} South and 07^{o} South : the Mahe Plateau (38,690 sq. km in area); the Amirantes Plateau (4,260 sq. km); Fortune Bank (1,540 sq. km); and other smaller banks and plateaux totalling 3,430 sq. km..



Map. 2. Fishing sectors. I: Inner Islands area; II: Bird, Denis, North edge; III: NE edge; IV: Topaze Bank; V: La Junon Bank; VI: SE edge, Constance Bank; VII: South edge; VIII: SW edge; IX: Owen, Robert's, Seagull Banks; X: NW edge; XI: Amirantes Plateau. (From Lablache and Carrara, 1988).

All the plateaux are steep sided rising rapidly from around 1000m. The Mahe Plateau is encompassed by an incomplete shallow rim at around 10 - 20 m which surrounds a central area of about 50 - 65 m with subsurface granite and coral outcrops forming small banks. Two coral islands occur on the north of the rim and within the plateau are granitic islands. The majority of the population of 72,000 live on the three main granitic islands (Mahe, Praslin and La Digue) whilst the coraline islands on this and the other plateaux are sparsely inhabited.

The Amirantes Plateau to the west of the Mahe Plateau is shallow and coraline in the north whilst in the south two sandy basins surrounded and separated by coraline ridges occur. The basins are around 50 - 65 m deep whilst the rims are shallower forming numerous islands where the coral reaches the surface.

The Fortune Bank lies south of the Mahe Plateau and has no emergent features. The bank tends to be shallower and more coraline in the north dropping to about 25 m in the south where the substratum is composed of fossil coral pebbles densely covered with macrophytes, encrusting sponges and algae.

MAJOR FISHING LOCATIONS

The artisanal fishery is concentrated around the coastal areas of the three main islands and other nearby granitic islands on the Mahe Plateau. For the larger boats, fishing grounds further afield on the rim of the Mahe Plateau and on the Amirantes Plateau are accessible. However, climatic conditions and the sea-worthiness of most boats in the artisanal fleet restrict fishing activity in these outlying areas. The impact of the small populations on the outer islands is also expected to be negligible although this has not been evaluated. With the introduction of the industrial scale mothership - dory operation a greater fishing effort is anticipated in the outlying areas.

The major fishing sectors relate to the offshore banks of the Mahe Plateau and the outlying islands, and are indicated in Map 2. However, most fishermen when interviewed about fishing location will simply give a direction (from Mahe). The fishing grounds are :

TABLE 2.1. A DESCRIPTION OF FISHING GROUNDS EXPLOITED BY SEYCHELLES ARTISANAL FISHING FLEET

FISHING GROUNDS DIRECTION	DESCRIPTION	SECTOR
UNKNOWN	UNKNOWN LOCATION	0
OUTLYING ISLANDS		
ALP	ALPHONSE	XIV
AMI	AMIRANTES	XI
PLA	PLATTE	XII
COE	COETIVY	XIII
DES	DESROCHES	XV
P/F	PROVIDENCE/FARQUHAR	XVI
COS	COSMOLEDO	XVII

TABLE 2.1 Continued.

FISHING GROUNDS DIRECTION	DESCRIPTION	SECTOR
MAHE PLATEAU		
OUT	10 MILE RADIUS OF MAHE/PRASLIN GROUP	I
E	TOPAZE BANK	IV
ENE	TOPAZE BANK	IV
ESE	LA JUNON BANK	V
N	BIRD, DENNIS, NORTH EDGE	II
NE	NORTH EAST EDGE	III
NNE	BIRD, DENNIS, NORTH EDGE	II
NNW	BIRD, DENNIS, NORTH EDGE	II
NW	NORTH WEST EDGE	X
S	SOUTH EDGE	VII
SE	SOUTH EAST EDGE, INCLUDING BANKS	VI
SSE	SOUTH EDGE	VII
SSW	SOUTH WEST EDGE	VIII
SW	SOUTH WEST EDGE	VIII
W	OWEN, ROBERTS, SEAGULL BANKS	IX
WNW	OWEN, ROBERTS, SEAGULL BANKS	IX
WSW	OWEN, ROBERTS, SEAGULL BANKS	IX

The banks referred to in Sector VI (SE) refer to Fortune Bank, Small and Large Constant Banks and a number of small banks.

Fishing activities occur within 3 strata at each of these locations (see Section 8) in relation to the species which inhabit different depths. These are the shallow water strata, from 0 - 75 m on the surface of the various Plateaux, the intermediate depths from 75 - 150 m at the rim and drop off of the Plateau edges, and deep bottom resources at depths greater than 150 m. The shallow water stratum on the Mahe Plateau has been further sub-stratified into the inshore areas, corresponding with sector I in Table 2.1, the offshore banks and peripheral edge zone of the Plateau rim, and the smooth trawlable grounds.

A number of different estimates of the areas of these fishing grounds exist. Those considered to be the most recent and correct are given in Table 2.2. For the Mahe Plateau the sub-stratum 0 - 35 m is equivalent to the inshore areas, and 36 - 100m to the offshore banks and peripheral rim. A third sub stratum is introduced, the trawlable areas, where fish densities are insufficient to support a handline fishery. The total area of the Mahe Plateau given by Lablache *et. al*. (1988) given in Table 7.2 compares with 41,900 km^2 given by Navaratnasamy (1991, pers. comm.) of the Lands and Infrastructure Division. Although the shallow strata are regarded as being to 75m in this report, no adjustment is made of the area estimated to 100m since Navaratnasamy (pers. comm) estimates the area of the fringing drop off from 75 to 100m to be only 125 km^2 for the Mahe Plateau which is of the same order as the discrepancy in estimates for the total area.

Elsewhere, the area of the fringing drop off was calculated from the assumption that the width of the 75 - 150 m depth band was 250 m on average (Bean, pers. comm.), and the length of the 100m contour was estimated using a planimeter and Admiralty Chart 721. For the Mahe Plateau an estimate of the area of the fringing drop off from 75 - 150m and of the perimeter of the Mahe Plateau was also provided by Navaratnasamy (pers. comm.) shown in Table 2.2. These estimates compare to 1189Km for the perimeter and 297.3 km^2 for the area of drop off estimated by Mees on the above assumption.

TABLE 2.2. THE AREA OF FISHING GROUNDS, AND PERIMETER LENGTH (AT 100 m CONTOUR) OF THE BANKS AND PLATEAUX.

FISHING LOCATIONS	SHALLOW STRATUM		INTERMEDIATE STRATUM	
	TOTAL AREA SQ.KM	FISHABLE AREA SQ.KM	LENGTH 100M CONTOUR-KM	AREA OF FRINGING DROP OFF
MAHE PLATEAU 0 - 35M		6000 [1]		
MAHE PLATEAU 36 - 100 M		6500 [1]		
TRAWLABLE AREAS		14000 [1]		
TOTAL MAHE PLATEAU	43300 [1]	26500 [1]	998.0 [4]	374.0 [4]
SMALL CONSTANT	170 [2]		55.6 [2]	13.8
BAR SAVAT + SEA MOUNT	48 [2]		50.0 [2]	12.5
CORREIRA BANK (3 MOUNTS)	17.4 [2]		33.3 [2]	8.3
ADELAIDE BANK	6.6 [2]		11.1 [2]	2.7
SEA MOUNT 20	6.6 [2]		11.1 [2]	2.7
CONSTANT BANK	590 [1]		114.8 [2]	28.7
FORTUNE BANK	600 [1]		120.4 [2]	30.1
AMIRANTES PLATEAU	3900 [1]		433.4 [2]	108.3
DESROCHES PLATEAU	400 [1]		77.8 [2]	19.4
PLATTE PLATEAU	340 [1]		63.0 [2]	15.7
COETIVY PLATEAU	420 [1]		83.3 [2]	20.8
PROVIDENCE/FARQHAR	1250 [3]			
COSMOLEDO	350 [3]			
ALPHONSE	190 [3]		55.6 [2]	13.8
GRAND TOTAL	51589		2107.3	651.3

1 = Lablache et. al. (1988), 2 = Mees, present report from Admiralty Chart 721, 3 = Tarbit (nd), 4 = Navaratnasamy (1991, pers. comm.)

For the purposes of this report the areas of the deep bottom fishing grounds are assumed to be similar to those for the intermediate stratum.

2.2. HYDROLOGICAL CONDITIONS

The climate of Seychelles consists of four seasons. The Northwest monsoon with wind speeds of 7-8 knots occurs from November to mid March and is followed by an inter monsoon period of light variable winds and frequent calms. The South East Trade Winds begin at the end of May and winds with an average rate of 12

TABLE 2.3 : A SUMMARY OF THE HYDROLOGICAL CONDITIONS OVER THE MAHE PLATEAU (ADAPTED FROM TARBIT, 1980)

DETAILS	OCTOBER	NOVEMBER	DECEMBER	MARCH	APRIL	JULY	AUG - SEP
CLIMATE	End of the SE Trades	NW Monsoon Begins	NW Monsoon	End of NW Monsoon	Inter-monsoon Period	SE Trades (from June)	SE Trade Winds
SEA SURFACE CURRENT	Eastwards over surface of Plateau.	Predominantly eastwards, but northern flowing components over S of Plateau.	Eastward counter - current in N, but NW Monsoon pushes counter current southwards in S of Plateau		Whole Plateau washed by Eastward equatorial counter current. Clockwise circulation occurs SE of Plateau	Mainly southerly modified to SE/SW by the edges of Plateau. A small clockwise circulation in S Plateau.	The southerly current now swings to the west.
UPWELLING / NUTRIENTS	In S and SE nutrient rich water is carried by counter current from intensive upwelling S of Plateau	Continues along S and SE edges of Plateau. Surface water between Mahe/Amirantes Plateaux nutrient rich. Algal blooms occur.			Upwelling associated with circulation in SE occurs. Enriched water carried over S surface of Plateau	Cold water with low oxygen levels leaks over southern edge of Plateau. 19^0C in S	Upwelling occurs along the southern edge of the Plateau
THERMOCLINE	A dome of cold water occurs south of Plateau, thermocline at 20 - 30 m.	Over Plateau between $18\text{-}27^0C$; cool water, 16^0C at 75m below S edge of Plateau		Surface and bottom temperatures over Plateau similar. No definite thermocline		A well defined thermo-cline occurs at 75-100m N and E of Plateau and <35m S and W	Thermocline stabilises at 35 - 40 m.
TEMPERATURE SURFACE	26 - 28^0C	26.5 - 29^0C		28.5 - 31^0C	29 - 31^0C	26^0C	25^0C
20 - 29 m		26.4^0C		28.6^0C		25.7^0C	
30 - 39 m		24.3^0C		28.0^0C		25.0^0C	
40 - 49 m		23.3^0C		27.1^0C		23.2^0C	
50 - 59 m		21.8^0C		25.8^0C		23.7^0C	
60 - 69 m		20.2^0C		24.5^0C		23.2^0C	

knots frequently limit fishing activity during this period. A second intermonsoon period occurs during October.

The air temperature varies little throughout the year, between a mean daily maximum of 27-30°C and minimum of 24-25°C. Rainfall may occur throughout the year but is greatest in December and January.

The hydrology of the Seychelles is affected by the eastward flowing equatorial countercurrent and the westward flowing currents to the north and south. These are modified to a certain extent by the onset of the different monsoon periods. Since Seychelles economic zone is large the hydrology may be expected to differ according to location. For the Mahe Plateau Tarbit (1980) described the prevailing conditions which are summarised in Table 2.3.

2.3. THE ARTISANAL FISHERY.

CATCHES

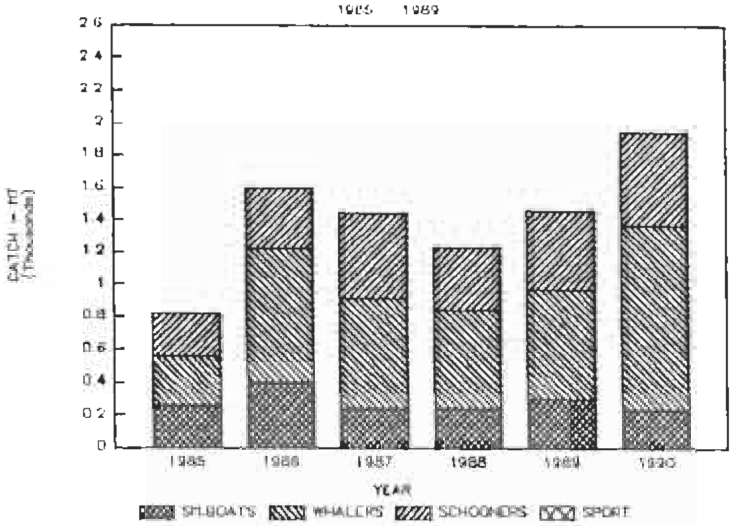
Seychelles artisanal fishery has been described by Lablache *et. al.* (1988) and Mees (1989a; 1989b). Around 4000 - 5000 tonnes of fish are landed annually. Over the period 1985-1990 small boats (fishermen on foot, pirogues, outboard powered vessels) accounted for 38.1% of the catch; whalers (inboard undecked vessels) 49.0%; schooners (larger decked inboard powered vessels) 12.6%; and sports fishing boats 0.3%, although some annual variation occurred. The small boats use a variety of fishing gears including harpoons, traps, nets and lines. The whalers and schooners employ handlines and some have electric fishing reels. The sports fishing boats use trolling lines.

Pelagic species are predominantly caught (52.1% of the catch between 1985 -1990), followed by demersal species (32.8%) and others miscellaneous species (15.1%). The order of importance of the species groups differs by boat category. Small boats catch principally pelagic species (47.0%) and others (such as trap caught fish, 36.0%), whilst demersal species are less important (17.0%). Whalers catch predominantly pelagic species (mostly *Carangidae*, 65.7%) and some demersal species (33.1%) with limited amounts of other species (1.2%). Schooners by contrast catch predominantly demersal fish (79.7%) and both pelagic species (13.8%) and others (6.5%) are less important. Sports fishing boats catch almost exclusively pelagic species (95.3%), and demersal species account for only 0.8%; others, 3.9%

Thus it may be seen that in relation to the demersal fishery the most important boat types are the schooners and whalers. This is illustrated in Figure 2.1. which also indicates that despite the fact that demersal species dominate the catch of schooners, the volume landed by whalers is greater due to their greater number (49.5% of total demersal landings cf. 30.7% for schooners). Small boats land 19.8% of the demersal catch and sports boats less than 0.1%. Figure 2.1 also indicates that the landings of demersal species have increased recently. In this context it should be noted that in 1990 a new Catch Assessment procedure was introduced for whalers. Prior to 1990 the demersal species catch by this boat type had been underestimated so the increase in catch volume during that year is not as significant as indicated.

FIGURE 2.1.

DEMERSAL FISH CATCHES BY BOAT TYPE



POTENTIAL YIELDS

The potential fishery yields available to the artisanal fishery are presented in Table 2.4. A more detailed analysis of the yield available to the demersal fishery is presented in Section 8 of this report. At present, catches are within the values derived for the most recent estimates of resource availability.

TABLE 2.4 :POTENTIAL YIELD PER ANNUM (MSY) FOR THE ARTISANAL FISHERY, PRINCIPALLY MAHE PLATEAU (Tonnes)

RESOURCE	LOCATION	POTnl YIELD	PRINCIPAL SPECIES	FISHg METHd
1.REEF				
TRADITIONAL	COASTAL AREA	600[1]	*Siganidae, Scaridae, Lethrinidae, Mullidae, Haemulidae*	trap
POTENTIAL	MAHE PLATEAU	1160[2]		
TOTAL REEF RESOURCES		1760		
2.DEMERSAL				
INSHORE	MAHE PLATEAU	1008[3]	*Serranidae,Lethrinidae, Lutjanidae*	hand-line, reels and deep water gill nets
OFFSHORE-75m	MAHE PLATEAU	1092[3]		
OFF. 75-150m	MAHE PLATEAU	514[3]	(*Pristipomoides filamentosus*)	
TRAWLABLE	MAHE PLATEAU	2352[3]		
DISTANT -75m	AMIRANTESetc	835[3]		
DIST.75-150m	AMIRANTESetc	381[3]		
TOTAL DEMERSAL RESOURCES		6182		

TABLE 2.4. Continued.

RESOURCE	LOCATION	POTnl YIELD	PRINCIPAL SPECIES	FISHg METHd
3.PELAGIC				
COASTAL	MAHE PLATEAU	?	*R. kanagurta, S.crumenopthalamus, A. sirm*	nets
LARGE	MAHE PLATEAU	1000[4]	*Scombridae, Istiophoridae, Xiphidae*	trolling
SMALL	MAHE PLATEAU	93500[1]	*Clupeidae, Decapterus*	
SEMI-PELAGIC	MAHE PLATEAU	?	*Carangidae, Sphyraenoidei, Elasmobranchii*	hand lines
TOTAL PELAGIC RESOURCES		?		
4.MISCELLANEOUS				
INVERTEBRATES		?	Crustaceans, Molluscs, Turtles	hand collect
DEEP BOTTOM		?	*Lutjanidae, Serranidae,* Crustaceans	

1. Lablache, Moussac and Jivan-Shah, 1988
2. Potential trap fishing / reef area is 1700km² (Lablache and Moussac, 1987). The exploited area is 580km² and the MSY from this area is 600 tonnes (Lablache et. al. 1988). By extrapolation, the MSY in the remaining potential areas is 1160mt.
3. Mees, 1991 (see Section 8)
4. Lablache and Moussac, 1987

For the reef fishery, 1990 catch data (284 tonnes landed) would tend to indicate that there is potential to expand the inshore reef fishery. However, in 1988 the catch was similar to the yield and in previous years exceded it, and overfishing may have occurred. Thus the precise status of this fishery is questionable. For both the demersal and pelagic fisheries there is, however, potential to increase the catch. In 1990 the landings from these two fisheries were 1942 t and 2877 t respectively. For the demersal fishery the greatest unexploited potential is considered to exist at the more distant fishing locations and in the intermediate fishing depths. Subtracting the yield available from trawlable grounds results in 3,830 t available to a handlne fishery (stocks on the trawling grounds are too dispursed to permit viable handline fishing). Thus there is potential to approximately double present catches. However, it should be noted that the present catches are approximately equal to the yield available in the shallow areas of the Mahe Plateau which is therefore fished to its maximum.

EXPORTS

Exports from the artisanal fishery are indicated in Table 2.5. It may be seen that demersal species feature predominantly in the exports, comprising 77.2% of all exports over the period 1985 -

1990. In relation to the catch of these species, exports account for 28.3% of the demersal landings from 1985 - 1990 (Table 2.6.). Owing to the potential to generate foreign exchange and income for the country, the demersal stocks are of considerably greater economic importance than the pelagic species, despite the lower volume of demersal species caught.

TABLE 2.5 : TOTAL EXPORTS (FRESH AND FROZEN) BY SPECIES GROUP PER ANNUM (Tonnes)

SPECIES	1985	1986	1987	1988	1989	1990
CARANGUES	4.78	2.32	4.55	14.92	2.43	1.66
MACQUEREAUX DOUX	0.00	0.00	0.00	0.00	0.00	0.00
OTHER MACQUEREAU	0.00	0.00	0.00	0.00	0.00	0.00
BONITE	0.18	0.27	0.00	0.25	0.15	0.04
OTHER PELAGIC	42.18	86.28	103.80	94.30	73.48	31.88
BECUNE	0.57	0.75	3.82	5.56	0.87	0.34
CORDONIER	0.21	0.38	4.42	5.50	2.76	1.66
OTHER TRAP FISH	1.61	3.60	23.48	42.30	35.12	11.91
RED SNAPPER	64.14	99.42	226.97	123.92	201.01	120.63
VARA VARA	6.05	1.85	2.66	6.66	3.76	26.23
JOB	25.46	14.55	55.82	92.99	158.04	210.57
MACONDE	29.56	42.28	130.32	66.79	79.64	54.25
OTHER VIELLE	21.79	23.33	49.19	40.57	30.54	26.23
CAPITAINE	1.45	3.17	37.99	68.51	112.48	59.13
SHARKS AND RAYS	0.57	15.34	6.71	3.46	4.54	0.93
OCTOPUS	0.00	0.01	16.91	2.25	0.10	0.00
OTHERS	0.51	1.62	7.91	6.60	2.09	8.71
TOTAL	199.06	295.17	674.55	574.58	707.01	554.17
% OF WHICH DEMERSAL SPECIES	74.58%	62.54%	74.56%	69.52%	82.81%	89.69%

TABLE 2.6. : PROPORTION OF THE CATCH OF DEMERSAL SPECIES EXPORTED

SPECIES	1985	1986	1987	1988	1989	1990	MEAN
RED SNAPPER	51.27%	18.28%	49.83%	43.71%	50.27%	50.16%	40.81%
VARA VARA	33.24%	2.78%	2.91%	7.28%	4.05%	7.44%	6.62%
JOB	20.89%	4.88%	16.31%	25.06%	37.53%	26.61%	23.76%
MACONDE	56.52%	30.29%	104.26%	68.86%	60.65%	43.09%	60.03%
OTHER VIELLE	82.54%	14.96%	40.19%	45.84%	29.54%	20.92%	30.81%
CAPITAINE	0.78%	0.80%	12.34%	22.78%	36.42%	19.32%	15.66%
TOTAL DEMERSAL	28.06%	11.53%	34.82%	32.42%	40.17%	25.60%	28.25%

A high proportion of the catch of Maconde (*Epinephelis chlorostigma*) has consistently been exported (1\), and also red snapper (predominantly *Lutjanus sebae*). The lutjanids and serranids appear to be favoured with the exception of Vara Vara (*L. bohar*) which in other parts of the world is reknowned for its potential for ciguatoxic fish poisoning, not reported in Seychelles. Lethrinids are a less important export species group.

1\ In 1987 the amount exported was apparently greater than the catch indicating either that the catch was underestimated that year or that the export volume was misreported.

2.4. KEY DEMERSAL SPECIES

Species represented in the landings from Seychelles demersal fishery derive from the families *Lutjanidae* (snappers and job fish), *Serranidae* (rock cods) and *Lethrinidae* (emporers). Analysis of data relating to both the catch volumes and the economic importance of the species caught indicated that the following fish should be the subject of further studies : *Lutjanus sebae* (Bourzwa), *Pristipomoides filamentosus* (Batrikan), *Aprion virescens* (Zob gri), and *Epinephelis chlorostigma* (Maconde). *P. filamentosus* was singled out for more detailed study.

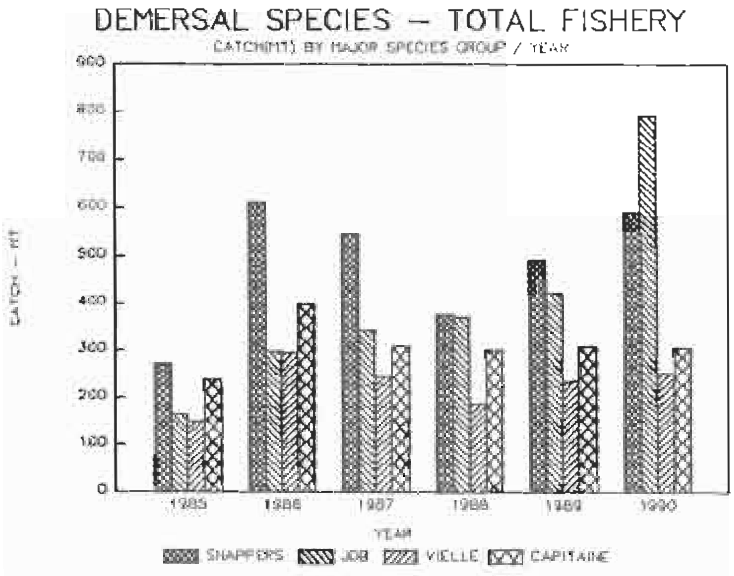
This choice of key species does not include any member of the *Lethrinidae*. *Lethrinus enigmaticus* (Laskar) would appear to be the most suitable representative for future study, but because several species share this local name and because of problems in distinguishing between species Capitain Rouge (*Lethrinus nebulosus*) should be chosen.

2.5. THE DEMERSAL FISHERY

SPECIES COMPOSITION

The composition of the demersal landings from Seychelles artisanal fishery is indicated in Fig. 2.2 by major species group. The *Lutjanidae* comprised 62.1% of the demersal catch over the period 1985 - 1990 of which snappers accounted for 34.0% and job fish 28.1%. *Serranidae* (rock cod or vielle) accounted for 16.0% and *Lethrinidae* (emporers or capitaine) 21.9%. The volume of *Serranidae* and *Lethrinidae* caught remained similar each year throughout the period at around 230 tonnes and 310 tonnes per annum respectively, but with some annual variation for the former. Snappers, however, decreased in volume to 375 tonnes in 1988 and have increased to 593 tonnes in 1990, whilst job fish have steadily increased throughout the period from 164 tonnes in 1985 to exceed the catch of snappers at 791 tonnes in 1990. This reflects both increased targeting on these fish, especially *Pristipomoides filamentosus*, and the introduction of electric fishing reels on schooners (see Mees, 1990).

FIGURE 2.2.



The species composition of catches varies by boat type and relates to differences in fishing method and location. The small boats which fish in the near shore areas around the main granitic islands catch predominantly *Lethrinidae* (38.3%), then snappers (24.9%), *Serranidae* (19.3%), and job fish (17.6%). Whalers and schooners catch mostly the *Lutjanidae* (68.2% and 65.0% respectively) and for both boat types the tendency has been for the volume of Job fish to increase over the period 1985 - 1990, although the predominant species in each case is different (see below). The schooners catch a greater proportion of *Serranidae* than whalers (19.1% cf. 12.8%) but a smaller proportion of *Lethrinidae* (15.9% cf. 19.0%). Both schooners and whalers use handlines and fish further offshore than the small boats. Demersal catches for sports fishing boats are negligable.

The total landings of *Lethrinidae* per year are indicated in Fig. 2.3. After a peak of 397 tonnes in 1986 the volume caught has remained stable at about 300 tonnes, 43.0% of which was landed by whalers, 34.6% by small boats and 22.4% by schooners. Catches of both snappers (Fig. 2.4.) and *Serranidae* (Fig. 2.6.) reached a maximum in 1986 and declined therafter, recovering again in 1990. The proportion of the total landings of these species caught by boat type are 53.8% whalers, 32.7% schooners, 14.5% small boats for snappers, and 39.6% whalers, 36.6% schooners, and 23.8% small boats for *Serranidae*. The landings of Job fish are indicated in Figure 2.5. As previously discussed catches have increased with time. Whalers landed 56.1% of this species group, schooners 31.6% and small boats 12.4%.

FIGURE 2.3.

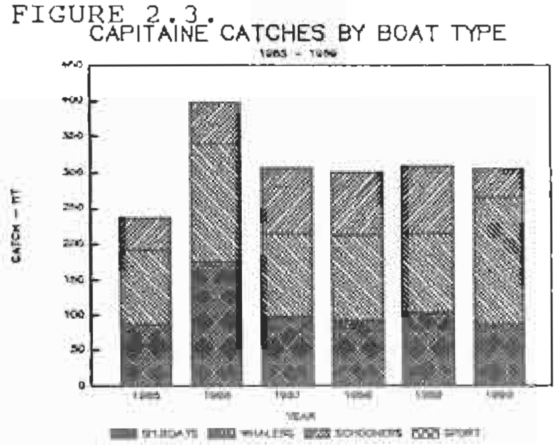


FIGURE 2.4.

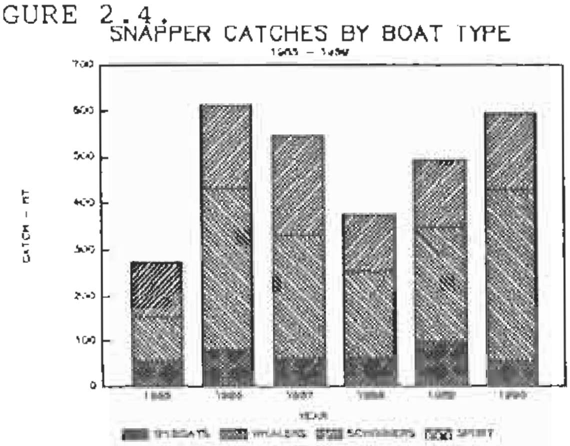


FIGURE 2.5.

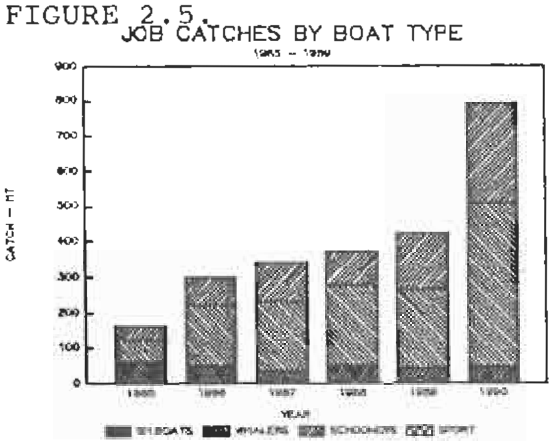
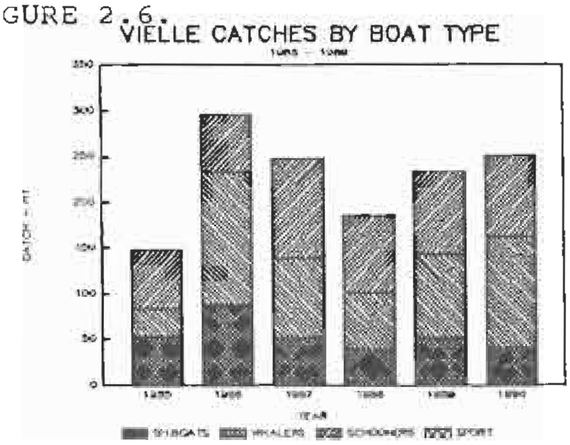


FIGURE 2.6.



KEY SPECIES CATCH DATA

Detailed information relating to key species catches is not available for the small boat fishery or for the whaler fishery prior to 1990. Thus a more detailed analysis of demersal catches by individual species is only possible for schooners (1985 - 1990) and whalers (since January 1990). The details relating to the schooner fishery were the subject of a separate report in which analyses of catch and effort statistics relating to the key species were presented (Mees, 1990). This report should be refered to for further detail which will not be reiterated here. Data relating to the geographical distribution of key species derived from Mees (1990) for the schooner fishery is also presented in Section 7.3 of this report.

The catch of each species by boat type is indicated in Table 2.7. for 1990. The figures in parentheses for small boats are estimates of the catch based on the assumption that all the job catch was *Aprion virescens*. For *P. filamentosus* (Batrican) it is assumed that the small boats have zero catch, since they are a deep water species.

TABLE 2.7. : DEMERSAL AND KEY SPECIES CATCHES DURING 1990 (MT)

SPECIES GROUP	SMALL BOATS	WHALERS	SCHOONER	SPORT	TOTAL
BOURGEOIS	36.000	213.200	103.200	0.000	352.40
TOTAL SNAPPERS	56.600	372.900	163.500	0.000	593.00
JOB GRIS	(46.900)	422.400	63.400	0.000	(532.7)
BATRICAN	(0.000)	38.500	195.300	0.000	(233.8)
TOTAL JOB	46.900	464.700	279.800	0.000	791.40
MACONDE	27.100	60.000	39.400	0.000	126.50
TOTAL ROCK COD	40.380	122.700	88.300	0.000	251.38
EMPORERS	87.200	178.800	40.100	0.000	306.10
TOTAL DEMERSALS	231.080	1139.100	571.700	0.000	1941.88

Of the key species, the greatest single catch relates to *A. virescens* (532.7 MT), then *L. sebae* (352.4 MT), *P. filamentosus* (233.8 MT) and *E. chlorostigma* (126.5 MT). *Lutjanus sebae* (Bourgeois) forms 59% of the total snapper catch, the remainder being mostly *Lutjanus bohar* and *L. coccineus*. Figure 18 indicates that 61.0% of this species catch is landed by whalers, 29.5% by schooners and 9.5% by the small boats.

Aprion virescens (Job Gris) form 66.8% of the job fish catch and *Pristipomoides filamentosus* (Batrican) a further 29.6%, the balance consisting mostly of *Apharaeus rutilans*. The proportion of these two species caught by whalers and schooners, however, differs considerably. Whalers land 79.9% of *A. virescens* but only 16.5% of *P. filamentosus* whilst schooners land 12.0% and 83.5% of these species respectively. This reflects the fact that schooners are equipped with fishing reels and can more easily exploit the deeper habitats, whilst whalers with handlines fish in shallower areas and less so on the edge of the plateau. Small boats land only 8.1% of the *A. virescens*.

Epinephelis chlorostigma (Maconde) form 50.1% of the catch of vielle, the remaining 50% being composed of a number of species including *E. multinotatus* (Vielle platte), *Cephalopholis sonnerati* (Monsieur Hangard), *Variola louti* (Croissant) and others. The small boats land a greater proportion of *E. chlorostigma* than they do of the other key species (21.0%), but whalers land the greatest proportion (47.6%) followed by schooners (31.4%).

3. OBJECTIVES AND METHODOLOGY

The objectives of the stock assessment studies directed at the identified key demersal fish species are:

1. To collect and analyse catch and biological information on important demersal fish species in Seychelles in order to provide basic scientific data for the future management of the demersal fishery.

2. Specific objectives:

   (i) To collect catch and effort data by species on the landed catches

   (ii) To estimate natural and fishing mortalities, and growth rates, and to determine the population dynamics of the stocks

   (iii) To apply stock assessment models to assess stock sizes

   (iv) To verify age estimates employing otoliths

   (v) To employ morphometric indices to determine whether stocks are discrete

   (vi) To examine reproduction and the timing of life cycle events

DATA COLLECTION

Data relating to catch and effort are derived from the Artisanal Catch Assessment Survey. A full description of the methodology employed is presented in SFA (1990). A summary of the findings of this Survey as it relates to the demersal fishery are presented above (Section 2.3 - 2.5).

Data relating to the Stock Assessment Studies are derived from the commercial fishery, and consist of two data sets: Length frequency measurements; biometric studies (ie. morphometric measurements and observations of the reproductive biology). These data relate only to the key species identified from the demersal fishery (see 2.4.).

Length frequency measurements were recorded for fish (all 4 key species) landed at the Seychelles Marketing Board Fish Division in Victoria. Boats land directly to the centre. The fish, sorted by species and size (large / small) are weighed then transferred to a chute into the preparation area. If possible all boxes of fish are measured, otherwise complete boxes are set aside for study - the number of boxes sampled relating to large and small fish is in proportion to the number landed. The fish are gutted, but sufficient gonad tissues often remain to allow sexing of the fish and assessment of maturity stage. Information recorded is: sex (male, female, juvenile or undetermined); maturity stage for females (1-5, see below); fork length (to 0.1 cm, except E. chlorostigma where the total length was measured) and any observations. Where possible the skipper of the boat is interviewed to determine the fishing grounds and depth range fished. Target numbers of 500 specimens of each sex per month were set, except for *E. chlorostigma* for which, being hermaphroditic, a total of 500 specimens was set.

Biometric studies were performed only on *Pristipomoides filamentosus*. A target of up to 100 whole fish were purchased each month by arrangement with certain boats or the FRV Etelis, and information was recorded relating to the fishing grounds and depth range fished. Measurement of certain body parts (to 0.1 cm) and body weight (to 0.001 Kg) was performed before and after evisceration in the wet laboratory at SFA. Sex, gonad and liver weights (to 0.1g, using an electronic balance) and maturity stages of females were recorded at evisceration. Otoliths were removed from a representative size range of specimens of each sex (see Appendix 1, data collection form). After the study the fish were sold to SMB.

Fish for the biometric studies were not a random sample, but were selected to represent the full size range of specimens observed, except on certain occasions when the catch was small and all fish were purchased. As a result, these data cannot be grouped with the length frequency data for analysis and both data sets are treated separately.

The maturity stages recorded for females were based on the appearance of the ovaries, and covered a scale from 1 to 5. The scale was initially established from literature reviews and macro and microscopic examination of ovaries:

1 Gonad small, thin and thread like: impossible to determine the sex.

2 Gonad small with only a few reddish veins developing on it. Gonad is hard when touched, and sometimes transparent.

3 Damaged gonad for which the precise stage cannot be determined (mostly applied to length frequency specimens)

3- The beginning of the maturing process: the ovaries are bigger, but eggs are not visible with the naked eye. The gonad is jelly like to the touch and more development of blood vessels has occurred.

3+ Matured gonad. Eggs are visible to the naked eye.

4 Gonads much larger and darker in colour, with eggs being translucent. Some eggs may be free from the internal structure of the ovary. Spawning begins.

5 Spent : the fish have spawned and the gonads are empty and purplish in colour

Neither fecundity nor the trophic relations of *P. filamentosus* were assessed. Data in the literature indicated that *P. filamentosus* is a continual spawner (Grimes, 1987). At any one time there will be several more or less distinct groups of developing ova in the ovaries, and it is difficult to distinguish between small developing ova and primary oocytes on the basis of size alone. Furthermore, when a sample is taken from the ovaries it may be the case that the fish has already partially spawned.

S T O C K

A S S E S S M E N T

S T U D I E S

As a result there have been fecundity estimates for lutjanids which vary by several orders of magnitude. Owing to these difficulties and the fact that this information is of low priority in the defined objectives, egg counts were not performed. Similarly, identification of gut contents can be time consuming and difficult and being of low priority this exercise was not conducted.

DATA ANALYSIS

Data was entered onto Foxplus/Dbase III databases according to species and data type (length frequency or biometry). After verification the data was analysed by means of a Dbase III programme written by the author which determined length frequency distributions, maturity and depth fished. Data sorted into length frequency distributions by sex was entered into ELEFAN and LFSA files for appropriate analyses. Certain other analyses were performed using the procedures in the MICROSTAT library of statistical analyses. Data was manipulated using LOTUS 123, and graphics generated were printed via HARVARD GRAPHICS or LOTUS.

4. CHARACTERISTICS OF THE KEY SPECIES

Members of both the Lutjanidae and Serranidae tend to be long lived, slow growing, and have relatively low rates of natural mortality. They generally have limited productive capacity, and are vulnerable to overfishing. They are large predators at the top of the food chain acclaimed for their flavour. They fetch a high price on world markets, and are a particularly important contribution to exports of fresh and frozen fish from Seychelles.

The snapper family (Lutjanidae) includes 17 genera and 103 species distributed throughout the world in tropical and sub-tropical areas. They are largely confined to continental shelves and slopes and to corresponding depths around islands. Adults are usually associated with the sea bottom, and feed on fish and crustaceans (Anderson, 1987).

The genus *Pristipomoides* (Bleeker, 1852) includes 11 species distributed across the Western Atlantic and Indo Pacific. The key study species *P. filamentosus* occurs throughout the whole of the Indo Pacific region. The genus *Lutjanus* (Bloch, 1790) is the largest of the Lutjanidae and includes 65 species of which 39 occur in the Indo Pacific region. They are primarily inhabitants of shallow coral reefs but some species may be found in deeper waters. Key species *L. sebae* is distributed from East Africa to New Caledonia and East Australia (Allen, 1987). The genus *Aprion* (Valenciennes, 1830) is monospecific. *A. virescens* is widely distributed throughout the Indo Pacific.

The sub family Epinephelinae of the family Serranidae consists of 11 genera distributed throughout the Indo Pacific region. These fish are moderate to large size, mostly living in shallow waters in tropical and sub tropical areas. All the species are carniverous and are at or near the top of the food chain. The genus *Epinepheius* includes 63 described species from the Indo Pacific region. The key species *E. chlorostigma* occurs from the Red Sea and East Africa to the Western Pacific (Randall, 1987).

Lutjanids are gonochoristic, whilst the Serranidae are protogynous. Sex ratios for the former may be unequal and skewed in favour of one sex or the other at larger sizes. This probably arises from differential growth rates and mortality between the sexes. For serranids there are generally more females than males, and in Seychelles the ratio was shown to be 2.4:1 females to males for the protogynous hermaphrodite *E. chlorostigma* (Moussac, 1986). Sexual maturation occurs at a slightly smaller size for male Lutjanidae than females, and for island fish populations at about 51% of the maximum length. The Lutjanidae are highly fecund and island populations tend to be batch spawners and reproduce all year round with pulses corresponding to local environmental changes (Grimes, 1987). The Serranidae usually only spawn for about half of the year (Shapiro, 1987).

For both families, small, spherical, pelagic eggs are spawned which hatch in about 24 - 45 hours. Large specimens have been observed in the pelagic larval stage (up to 55mm for some *Pristipomoides* spp.) and it has not been clearly established at what size they settle out of the plankton. However, size appears to be more important than age in determining competency for settlement (Leiss, 1987). Juveniles are believed to inhabit shallow mangrove and sea grass areas but this may vary between species. Adults inhabit a range of depths. Of the key species *P. filamentosus* is regarded as a deep water species (> 100m \1).

Lutjanidae and Serranidae have a varied diet dominated by fish, crabs, shrimp, and other benthic crustaceans. Most species take their prey at, or very near the bottom. The Lutjanidae employ a strategy of widespread foraging, whilst serranidae tend to be more sedentary and feed by ambush. The great diversity in their diets allows resilience to changes in the trophic environment. It also means that reductions of one predator species due to fishing pressure may have a positive effect on other populations of carnivorous fish (Parrish, 1987).

Available data relating to the key species is presented in Table 4.1.

\1 In Seychelles the range is 70 - 110 m

TABLE 4.1. A SUMMARY OF AVAILABLE INFORMATION RELATING TO THE KEY STUDY SPECIES.

DETAILS		P.FILAMENTOSUS	R	L. SEBAE	R	A. VIRESCENS	R	E.CHLOROSTIGMA	R
POPULATION STRUCTURE									
MAXIMUM LENGTH	M	FL 77.6 cm	1	FL 86.0 cm	1	FL 93.3 cm	1		
	F	FL 77.6 cm	1	FL 78.2 cm	1	FL 97.5 cm	1		
	TOT	FL 79.8 cm	1	FL 86.0 cm	1	FL 101.0 cm	1	TL 65.4 cm	1
MAXIMUM LENGTH	M	TL 89.0 cm	2	TL 91.0 cm	2	TL 106.0 cm	2	TL 51.0 cm	2
	F	TL 84.0 cm	2	TL 89.0 cm	2	TL 112.0 cm	2	TL 51.0 cm	2
	TOT			SL 106.6 cm	2			TL 73.0 cm	2
MAXIMUM LENGTH	TOT	SL 94.7 cm	3	SL 66.5 cm	4	3	5	TL 65.0 cm	6
				FL 73.5	7				
MAXIMUM AGE		18 YEARS	8	11 YEARS				41 YEARS	9
DIFF. FREQ. DIST M/F		NO	1	YES	1	YES	1		
		NO	2	YES	2	NO	2		
SEX RATIO F : M		1:1.17 LF DATA	1	1 : 0.83	1	1 : 1.80	1		
		1:1.07 BS DATA	1			1 : 1.05	5		
		1 : 0.76	10	1 : 0.66	2			1 : 0.417	11
		1 : 1.4	12	1 : 1.5	2			1 : 0.417	13
		1 : 1.02	14	1 : 1.04	15				
REPRODUCTIVE BIOLOGY									
MIN SIZE AT MATURITY		FL 33.2 cm	1	FL 34.6 cm	1	FL 48.7 cm	1	TL 28.0 cm	13
		FL 45.6 cm	3	SL 49.0 cm	4	SL 46.5 cm	4	TL 31.0 cm	11
		FL 42.5 cm	16			FL 42.9 cm	5		
MIN SIZE AT SPAWNING		FL 38.1 cm	1	FL 51.2 cm	1	FL 56.6 cm	1		
		FL 52.0 cm	16	TL 62.0 cm	2	TL 72.0 cm	2		
SPAWNING PERIOD		OCT - APR WITH PEAKS FEB - AP AND NOV - DEC	1	ALL YEAR BUT PEAK OCT - NOV AND MAR - MAY	1	ALL YEAR BUT PEAK SEP - NOV AND MAR - APR	1		
		ALL YEAR, PEAK MAY - SEP	14	MAR	15	OCT - FEB	4	NOV - APR PEAK NOV AND APR	6
		AUG - OCT	3	NOV - MAR	4	JAN, OCT	17	MAY - JUL PEAK JUN	13
		MAR	10	OCT, JAN - FEB	17	DEC - MAR	2		
		JUN - DEC PEAK AUG	16	FEB - APR, AND SEP - OCT	18	JAN - MAY	2		
				DEC - JAN, APR	2	JAN - FEB AND JUN - JUL	19		
						MAY - OCT PEAK JUN	5		

TABLE 4.1 Continued.

DETAILS	P.FILAMENTOSUS	R	L. SEBAE	R	A. VIRESCENS	R	E.CHLOROSTIGMA	R
RELATIVE GROWTH								
LENGTH/WEIGHT REL. q	0.00005353	1	0.0000157	2	0.0000162	2	0.00000612	2
(kg / cm) b	2.7004	1	3.02	2	2.905	2	3.245	2
q	0.000012	2	0.0000198 (#)	18	0.000013	2	0.000011	2
b	2.96	2	3 (# GUTTED)	18	2.93	2	3.05	2
q							0.00001104	9
b							3.02156	9
							0.0000149	13
							2.94	13
SEXUAL DIMORPHISM	NO							
GROWTH								
K - MALES	0.30	1	0.380	1	0.29	1		
K - FEMALES	0.275	1	0.270	1	0.14	1		
K - TOTAL	0.420	1	0.307	1	0.26	1	0.175	1
(non seasonal model)								
Loo - MALES	FL 85.5 cm	1	FL 95.12 cm	1	FL 95.0 cm	1		
Loo - FEMALES	FL 77.6 cm	1	FL 90.00 cm	1	FL 108.0 cm	1		
Loo - TOTAL	FL 74.25 cm	1	FL 84.00 cm	1	FL 104.0 cm	1	TL 64.45 cm	1
K - TOTAL	0.146	14	0.157	4	0.31	20	0.1785	6
Loo - TOTAL	FL 78.0 cm	14	FL 85.1 cm	4	FL 65.6 cm	20	TL 68.4 cm	6
K - TOTAL	0.220	21	0.230	18	0.348	19	0.195	9
Loo - TOTAL			FL 96.0 cm	18	FL 78.0 cm	19	TL 64.83 cm	9
Loo - TOTAL			FL 98.0 cm	22				
K - TOTAL	0.290	23	0.220	22				
MORTALITY								
							39-44TL >39TL	
M	0.534	1			0.496	1	0.438	1
F	0.277 - 0.294	1			0.956 - 1.106	1	1.878 0.514	1
Z	0.811	1			1.602	1	1.440 0.076	1
M	0.250	14	0.480	18	0.490	19		
	0.550	21						
	0.530	23						
Z			0.73 - 0.78	18			0.2-0.3 2.1-2.	6
			0.69	22			0.046	9
PRODUCTION								
MSY (T) / SQ.KM	0.62 - 0.75	1			0.046 - 0.074	1	0.013 - 0.023	1

TABLE 4.1 Continued.

DETAILS	P.FILAMENTOSUS	R	L. SEBAE	R	A. VIRESCENS	R	E.CHLOROSTIGMA	R
TROPHIC RELATIONS								
Feeding depth	DEEP (> 10CM)	24	SHALLOW -10CM	24	VARIED BUT USUA -LLY SHA -LLOW	24	MIXED DEPTHS	24
Feeding time	DAYTIME	23	ANYTIME	24	ANYTIME	24	ANYTIME	24
DEPTH RANGE (M)								
Range occupied	80-320 TO 250	23 25	TO 100 100-220 TO 80	14 23 25	20-220 TO 120	23 25	80-320 TO 250	23 25
Usual depth caught	<120 70-112	23 26	20-50 35-75	14 26	TO-35	26	50-70	26

REFERENCES AND GEOGRAPHICAL LOCATION FOR THE DATA PRESENTED IN TABLE 4.1

REFERENCE	LOCATION
1 Mees, this report	**Seychelles**
2 Moussac (1988)	**Seychelles**
3 Kikkawa (1984), in q	Hawaiian Islands
4 Talbot (1960), in q	East Africa
5 Everson et. al. (1989)	Hawaiian Islands
6 Sanders *et. al* (1988)	**Seychelles**
7 Druzhinin and Filatova (1981)	Gulf of Aden
8 Ralston (1981)	Hawaiian Islands
9 Mathews and Samuel (1987)	Kuwait
10 Min *et. al.* (1977), in q	Andaman/S. China Sea
11 Moussac (1986)	**Seychelles**
12 Kami (1973), in q	Guam
13 Ghorab et.al. (1986)	Red Sea
14 Ralston (1981), in q	Hawaiian Islands
15 Druzhinin and Filatova (1980), in q	Gulf of Aden
16 Kikkawa (1984)	Hawaiian Islands
17 Nzioka (1977), in q	East Africa
18 Lablache and Carrara (1988)	**Seychelles**
19 Van der Knapp et. al. (1988)	Maldives
20 Loubens (1980), in q	New Caledonia
21 Ralston and Williams (1983), in q	Hawaiian Islands
22 Bach (1991)	**Seychelles**
23 Brouard and Grandperrin (1984)	Vanuatu
24 Parrish (1987), in q	---
25 Intes and Bach (1989)	**Seychelles**
26 Agathine (Pers Comm)	**Seychelles**
q Ralston and Polovina (1987)	(Key reference)

5. POPULATION STRUCTURE

5.1. *PRISTIPOMOIDES FILAMENTOSUS*

Between November 1989 and January 1991 (15 months) a total of 7,241 *P. filamentosus* were measured in length frequency studies (LFS) and 1,189 in biometric studies (BS). A summary of the data is given in Tables 5.1 and 5.2.

TABLE 5.1. A SUMMARY OF DATA COLLECTED DURING LENGTH (cm) FREQUENCY STUDIES FOR *PRISTIPOMOIDES FILAMENTOSUS*.

YEAR MONTH	SAMPLE SIZE					SEX	ALL FISH		MEAN FORK LENGTH		
	N.	% M	% F	% J	% U	RATIO	MIN FL	MAX FL	MALES	FEMALES	ALL FISH
1989 NOV	670	27.9%	19.4%	0.3%	52.4%	1.44	32.00	76.60	52.50	50.12	53.63
1989 DEC	395	42.0%	29.4%	0.0%	28.6%	1.43	28.30	76.10	49.98	49.29	50.76
1990 JAN	452	21.0%	13.9%	0.0%	65.0%	1.51	29.50	77.20	51.85	53.15	50.66
1990 FEB	335	24.8%	27.2%	1.5%	46.6%	0.91	30.10	74.40	48.13	49.74	51.21
1990 MAR	727	24.5%	22.7%	0.0%	52.8%	1.08	28.40	76.60	49.44	50.16	51.13
1990 APR	1008	24.8%	18.8%	0.0%	56.4%	1.32	29.10	77.60	51.64	47.39	52.92
1990 MAY	551	31.0%	29.0%	0.0%	39.9%	1.07	31.20	79.50	50.55	49.62	51.51
1990 JUN	253	36.0%	29.2%	0.0%	34.8%	1.23	31.50	75.70	43.72	44.01	45.32
1990 JUL	305	33.8%	39.7%	0.0%	26.6%	0.85	31.60	71.80	46.67	46.28	45.94
1990 AUG	58	53.4%	31.0%	0.0%	15.5%	1.72	25.60	69.50	45.42	45.05	45.13
1990 SEP	465	43.4%	39.1%	1.1%	16.3%	1.11	26.00	75.00	50.85	49.99	50.91
1990 OCT	821	40.3%	34.1%	0.0%	25.6%	1.18	28.10	77.60	51.22	50.35	51.23
1990 NOV	531	39.2%	37.3%	0.0%	23.5%	1.05	30.30	72.80	54.02	52.72	53.46
1990 DEC	489	38.9%	34.6%	0.0%	26.6%	1.12	29.20	79.80	55.40	51.99	54.47
TOTAL	7241	32.4%	27.7%	0.2%	39.7%	1.17	25.6	79.8	50.81	49.64	51.35

TABLE 5.2. SUMMARY OF DATA COLLECTED DURING BIOMETRIC STUDIES FOR *PRISTIPOMOIDES FILAMENTOSUS* (cm)

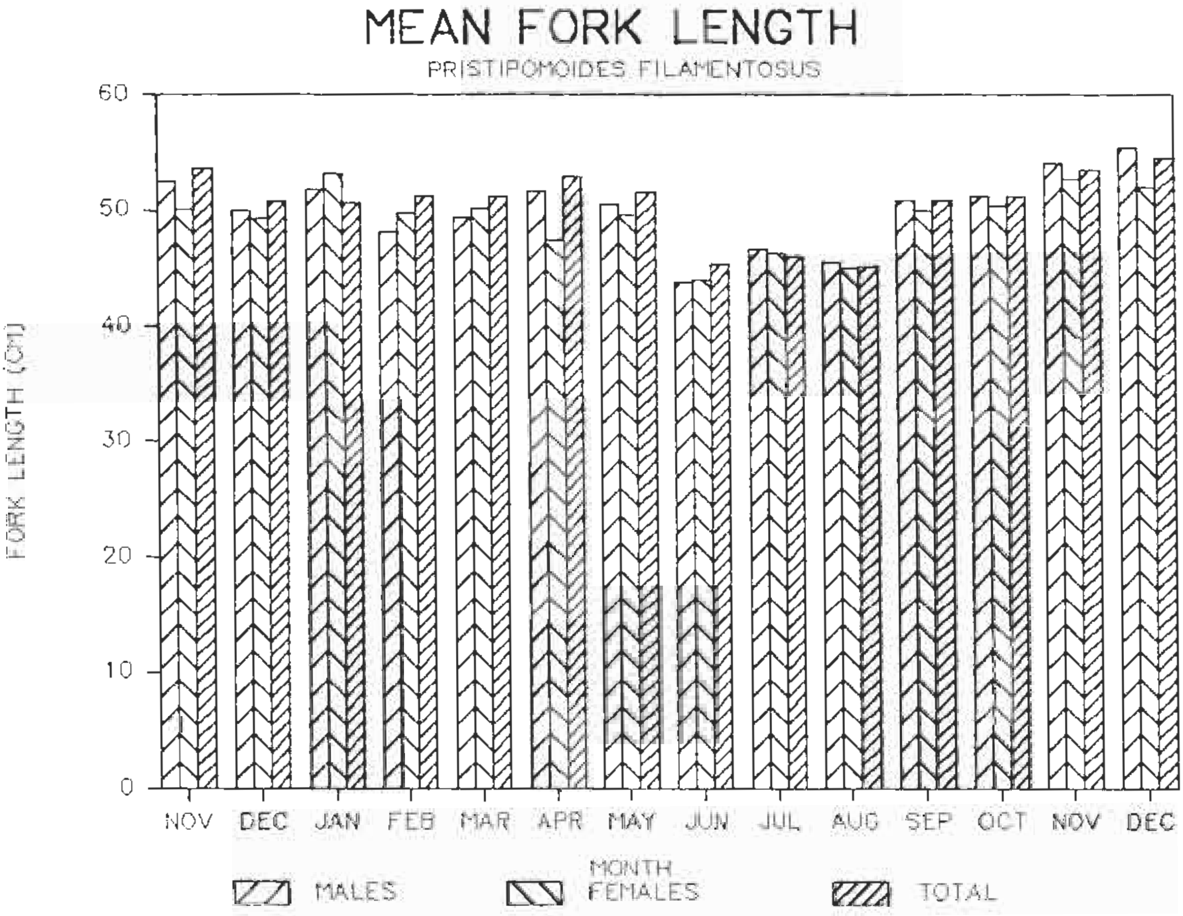
YEAR MONTH	SAMPLE SIZE					SEX	ALL FISH		MEAN FORK LENGTH		
	N.	% M	% F	% J	% U	RATIO	MIN FL	MAX FL	MALES	FEMALES	ALL FISH
1989 NOV	0										
1989 DEC	21	9.5%	90.5%	0.0%	0.0%	0.11	40.30	56.90	56.30	47.55	48.39
1990 JAN	95	46.3%	53.7%	0.0%	0.0%	0.86	30.10	69.60	50.25	46.10	48.02
1990 FEB	262	51.5%	48.5%	0.0%	0.0%	1.06	35.10	72.90	53.48	53.08	53.29
1990 MAR	175	51.4%	48.6%	0.0%	0.0%	1.06	33.40	72.50	55.80	54.35	55.10
1990 APR	122	52.5%	47.5%	0.0%	0.0%	1.10	38.10	73.60	58.00	51.76	55.04
1990 MAY	38	47.4%	52.6%	0.0%	0.0%	0.90	32.90	68.40	51.63	52.49	52.08
1990 JUN	3	66.7%	33.3%	0.0%	0.0%	2.00	58.40	63.50	59.70	63.50	60.97
1990 JUL	45	55.6%	44.4%	0.0%	0.0%	1.25	43.10	69.30	51.58	52.45	51.97
1990 AUG	0										
1990 SEP	45	46.7%	48.9%	4.4%	0.0%	0.95	31.00	66.70	45.48	45.12	44.84
1990 OCT	190	52.6%	45.3%	2.1%	0.0%	1.16	32.00	69.00	50.34	48.73	49.65
1990 NOV	40	47.5%	52.5%	0.0%	0.0%	0.90	39.20	72.60	47.83	54.94	51.56
1990 DEC	174	54.0%	45.4%	0.6%	0.0%	1.19	30.50	73.10	56.67	56.51	56.45
TOTAL ALL	1189	51.5%	47.9%	0.6%	0.0%	1.07	30.1	73.6	53.48	52.07	52.75

Most of the following discussion relates to data collected in length frequency studies since the population structure observed for fish from the biometric studies may be biased (see 3 above). References to 'Length' relate to fork length unless otherwise stated, except for *E. chlorostigma* where the total length was measured.

The largest fish observed measured 79.8cm (sex undetermined), and the smallest fish was 25.6cm (male). By sex : males, FL_{max}=77.6cm FL_{min}=25.6cm; females, FL_{max}=77.6cm, FL_{min}=29.2cm.

The mean length was 52.75 +/- 9.79cm for all fish observed and by sex : males, FL_{mean}=50.81 +/- 9.97cm; females, FL_{mean}=49.64 +/- 9.48. The mean length was significantly different between males and females (t=3.9519, df=4354, P<0.001). Slight variation also occurred on a monthly basis, the mean size of individuals caught being smaller between June and August (Fig 5.1).

FIGURE 5.1. THE MEAN FORK LENGTH OF *P. FILAMENTOSUS* PER MONTH



The structure of the sample population for the entire 15 months is shown in Fig. 5.2, and that for males and females in Fig. 5.3. The Bhatacharya method was used from the MPA routine of ELEFAN in order to define the modes, simply for purposes of comparison between the sexes. The results appear in table 5.3.

FIG. 5.2. *P. FILAMENTOSUS* SAMPLE POPULATION STRUCTURE - ALL DATA NOVEMBER 1989 - JANUARY 1991

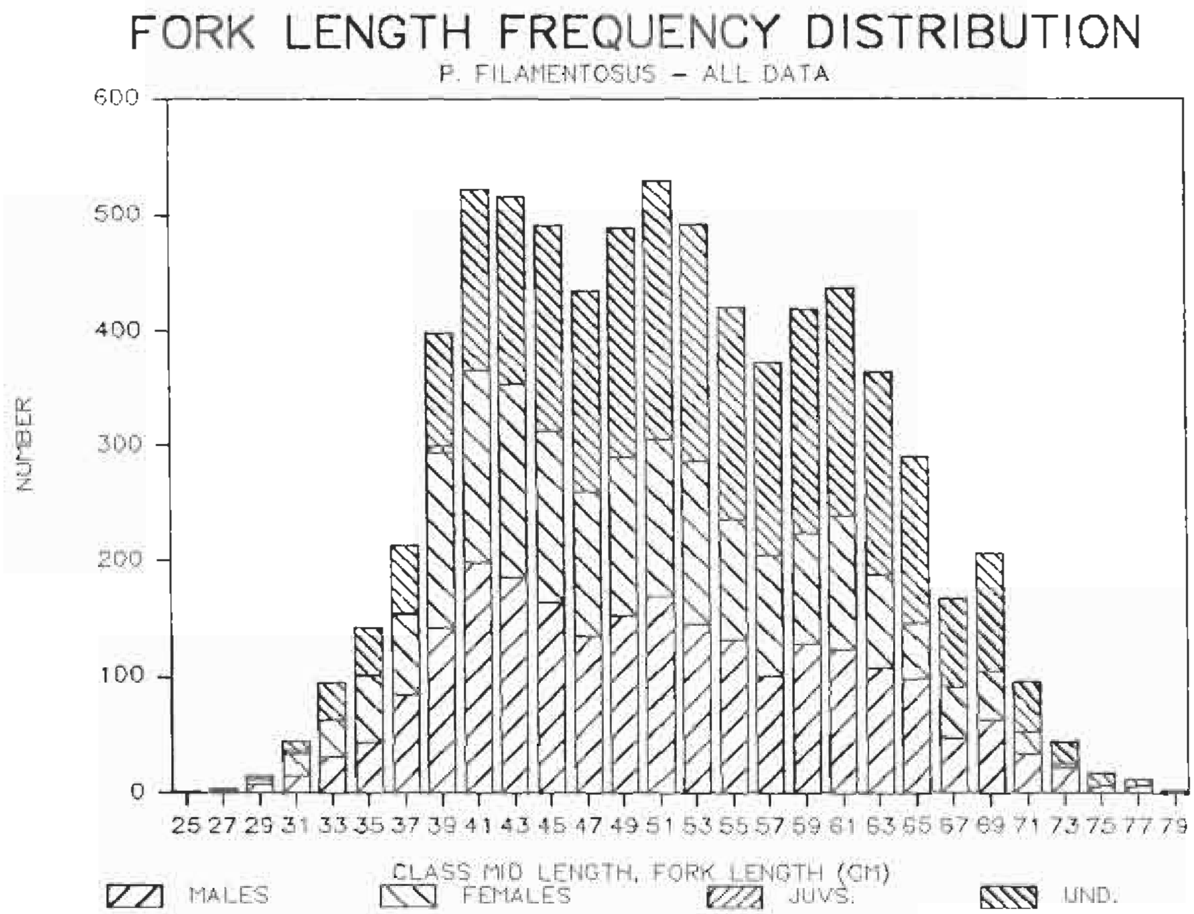


TABLE 5.3. THE MODES OBSERVED IN FORK LENGTH (CM) DATA FOR *P. FILAMENTOSUS* - POOLED DATA FROM NOV 89-JAN 91.

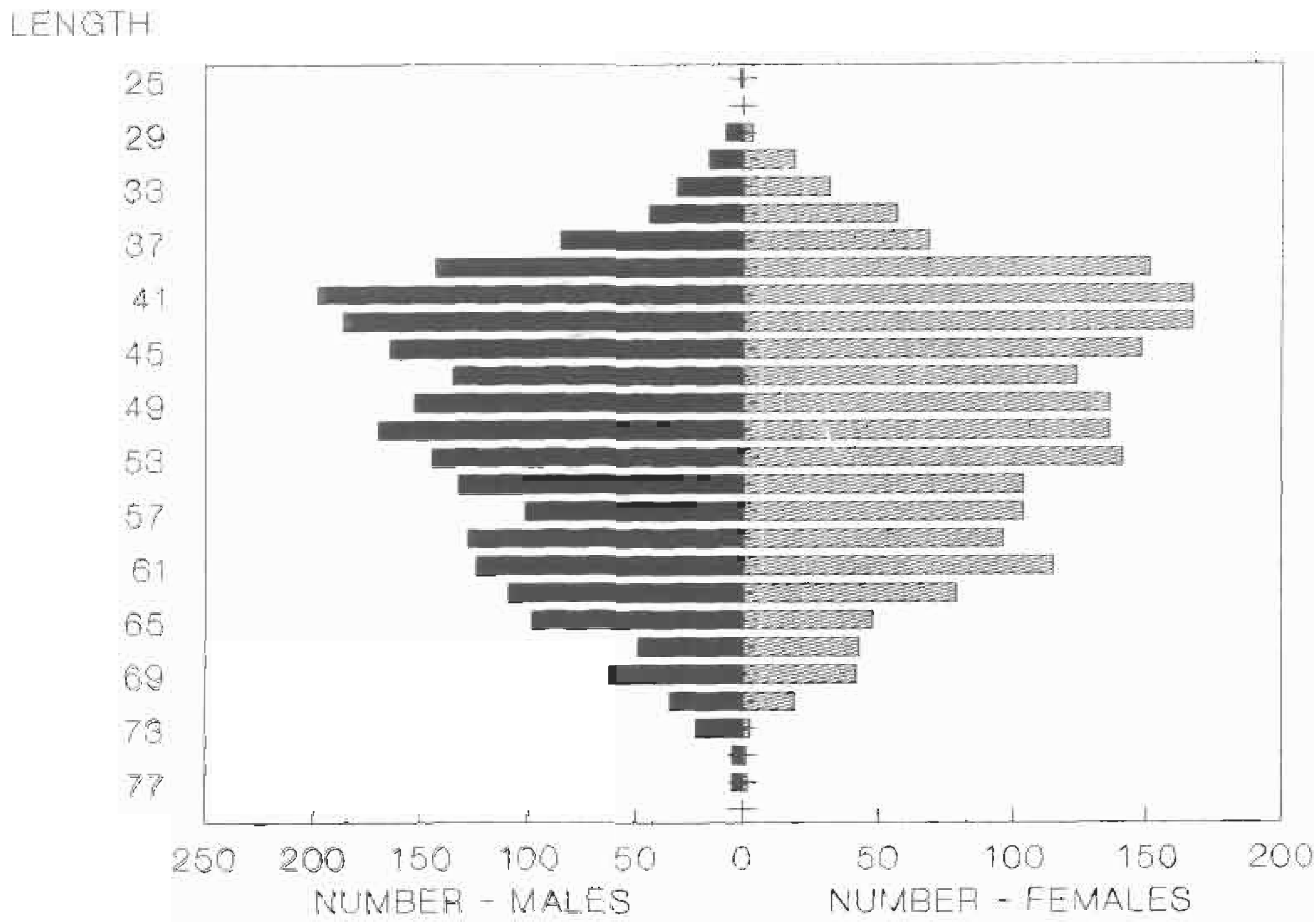
MODE	MALE	FEMALE	UNDETERMINED	TOTAL
1	42.1	42.3	42.8	41.8
2	51.9	52.3	52.2	51.7
3	61.1	60.8	62.1	61.3
4	69.8	69.2	-	69.3

Differences between the modes observed for males and females were negligible. The range of lengths observed were also similar, both facts clearly illustrated in Fig. 5.3. However, slightly more small females than males were caught which accounts for the very slight difference in mean length observed: 50% of males were in the size class 50<52cm or below, whilst 50% of females were in the size class 48<50cm or less. Overall there would appear to be no appreciable difference between male and female *P. filamentosus* with respect to length frequency.

39.7% of fish from the length frequency studies were of undetermined sex. The proportion was greater in November 1989 than December 1990 (Table 5.1) and this probably reflects

FIGURE 5.3

FORK LENGTH (CM) FREQUENCY DISTRIBUTION
P. FILAMENTOSUS ALL DATA BY SEX FOR 1990



learning on the part of the Technicians. With LFS there will always be some fish for which the sex cannot be determined, whilst this is not the case for the Biometric studies (Table 5.2). Juveniles were observed in November 1989 (0.3%), February (1.5%) and September 1990 (1.1%) for LFS and in the biometric study sample in September (4.4%), October (2.1%) and December 1990 (0.6%).

More males (2,349) than females (2,007) were recorded in LFS producing a sex ratio (M/F) of 1.17 which differs significantly from unity (ie. equal numbers of each sex, chi^2=26.69, df=1, P<0.001). Biometric studies examined 612 males and 570 females giving a sex ratio of 1.07, which does not differ significantly from unity (chi^2=1.42, df=1, P=0.23). Since sex is not distinguishable before evisceration one would not expect bias in the BS sample with respect to sex.

Examining the sex ratio with time it may be seen from Fig. 5.4 that for the LFS sample the ratio falls below unity in February and July (ie. more females these months), but otherwise is greater than unity. For the BS sample there were significant numbers of females caught (90.5% of the sample) in December 1989, and the sex ratio was also less than unity in January, May September and November.

FIG. 5.4. *P. FILAMENTOSUS* - SEX RATIO (M/F) WITH TIME

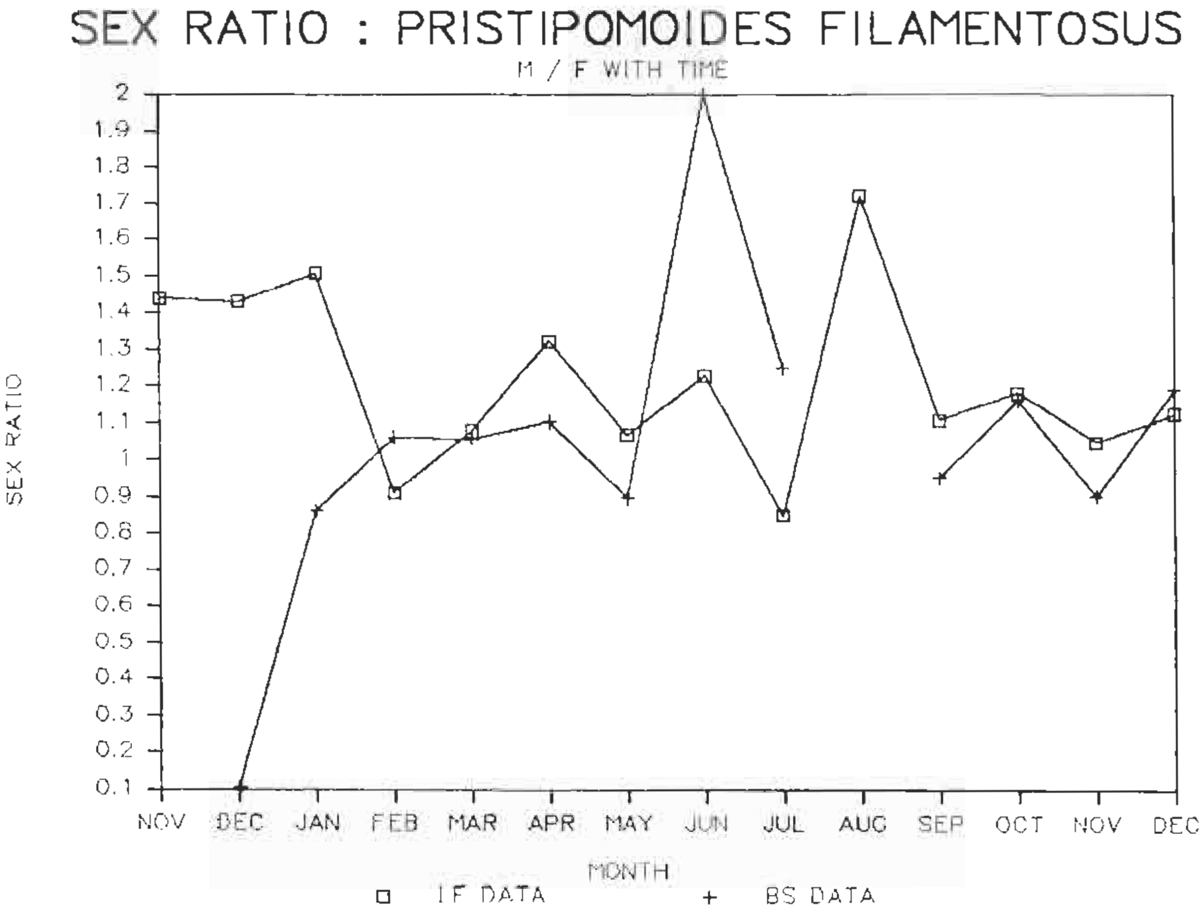
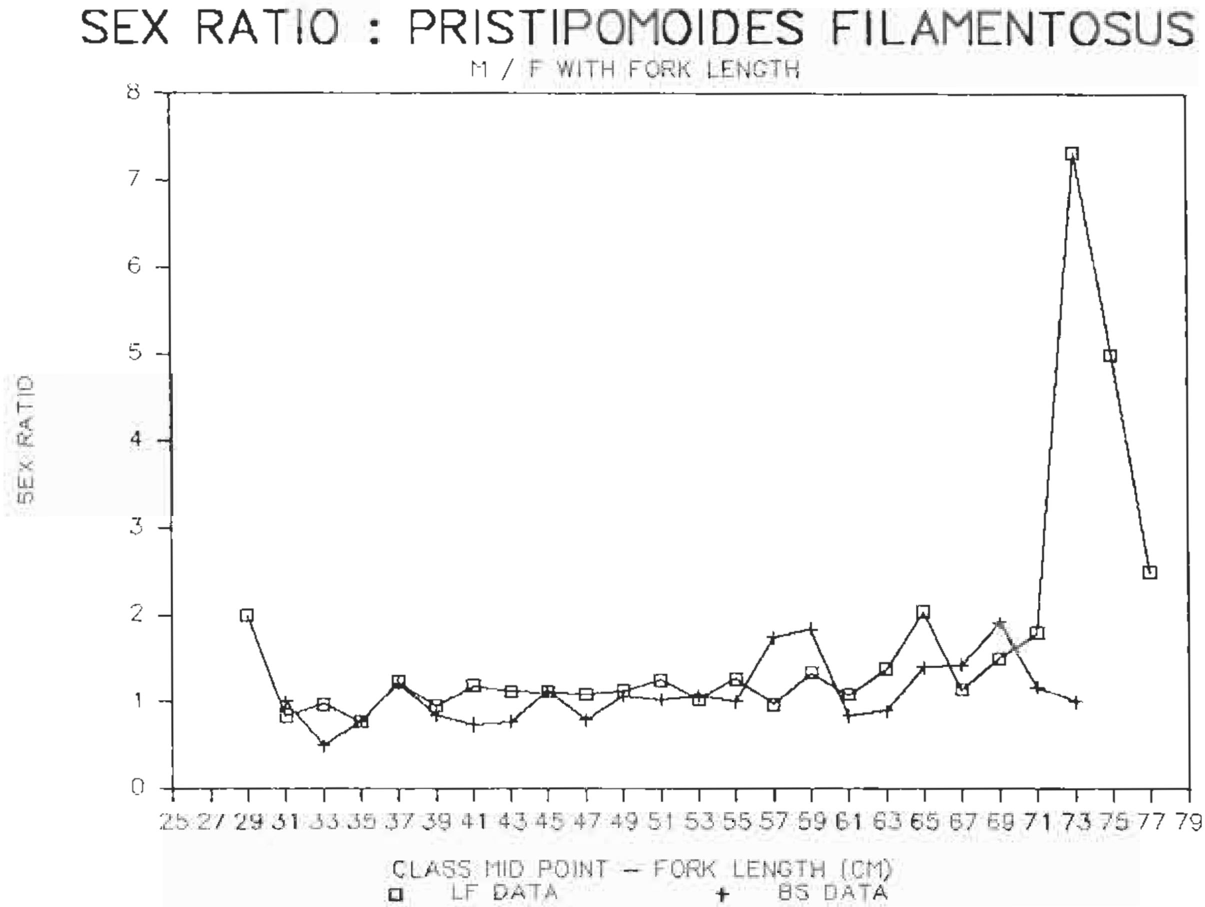


Figure 5.5 indicates that the sex ratio remains close to unity with increasing fork length, and only differs significantly at

the extreme of the size range observed. For the LFS sample more males than females were recorded at sizes greater than 72 cm. For the BS sample the tendency was towards increasing sex ratio with length but this trend was not statistically significant.

FIG. 5.5 *P. FILAMENTOSUS* - SEX RATIO AT FORK LENGTH



DEPTH RANGE AND POPULATION STRUCTURE

The sample data relates to commercial catches and so accurate details relating to the fishing depth are not available. By interviewing the skipper of the boat from which the fish were sampled the depth range is ascertained, in metres for boats equipped with echo sounders, or in arms-lengths for those without (1\). The range 'From' and 'To' is recorded and the mean of these values has been used in all calculations involving depth. Thus it could occur that all fish of a particular species were caught at the minimum of the range fished, and this detail will not be apparent from the following results. Furthermore, data relating to depth was only collected from September 1990 onwards so sample sizes are small, and a single large catch at a particular depth could bias the results. Nevertheless, the following information is of value bearing in mind these limitations, and will benefit from further analysis as more data is collected.

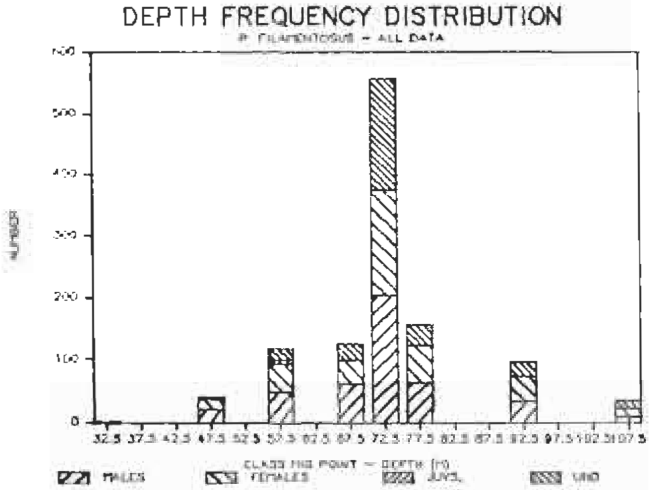
Table 5.4. summarises the data relating to the depth at which *P. filamentosus* were caught whilst Figs. 5.6. and 5.7. indicate the number caught at each depth for LFS and BS respectively.

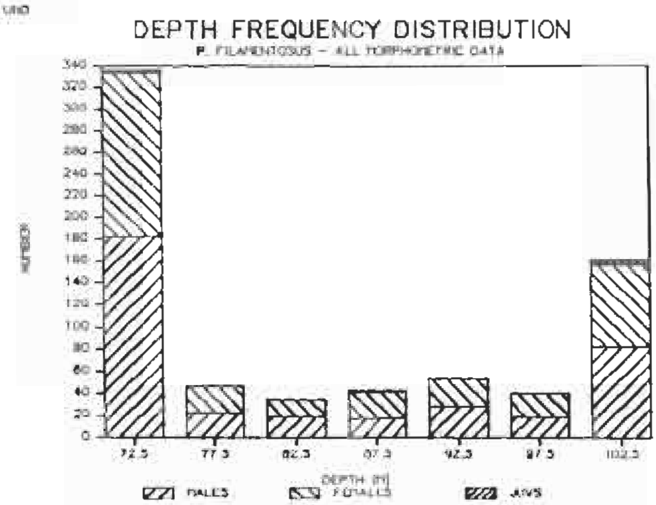
1\ 1 Brass (Arms length) = 1.83m

TABLE 5.4. A SUMMARY OF FISHING DEPTH (METRES) DATA RELATING TO *P. FILAMENTOSUS*

DETAILS	BIOMETRIC STUDY SAMPLE M	F	J	U	T	LENGTH FREQUENCY STUDY SAMPLE M	F	J	U	T
NUMBER	369.00	333.00	7.00	0.00	709.00	440.00	384.00	5.00	299.00	1128.00
MINIMUM	73.00	73.00	73.00	0.00	73.00	47.50	47.50	57.50	33.00	33.00
MAXIMUM	102.50	102.50	100.50	0.00	102.50	105.00	105.00	57.50	105.00	105.00
MEAN	83.51	84.03	90.64	0.00	83.82	71.29	72.56	57.50	73.54	72.26
ABS.MIN	51.00	51.00	51.00	0.00	51.00	15.00	15.00	25.00	15.00	15.00
ABS.MAX	150.00	150.00	150.00	0.00	150.00	137.00	137.00	90.00	137.00	137.00

FIGS. 5.6. AND 5.7. NUMBER OF *P. FILAMENTOSUS* CAUGHT AT EACH DEPTH FOR LENGTH FREQUENCY AND BIOMETRIC STUDY SAMPLES.





The total depth range fished by boats catching *P. filamentosus* extended from an absolute minimum of 15m to a maximum of 150m, whilst mid range values were from 33m to 105m. The range covered for fish sampled for the BS was not as great as that for LFS, and these fish were generally from a greater depth. The mean depth for all fish caught in LFS was 72.26m and for BS it was 83.82m. There were no apparent sexual differences in relation to depth range.

From both Figs. 5.6. and 5.7. it is apparent that most *P. filamentosus* are caught in the depth class 70m to 75m. Whilst the depth ranges over which males and females are caught are similar the numbers of each sex in the catch are apparently different at different depths. Fig. 5.8. indicates that more females than males were caught at greater depths for the LFS sample. However, this was not the case for the BS sample. Similar numbers of males and females were caught at each depth and no trend was apparent. Regression analysis, however, reveals that for the LFS sample the trend is not significant (F=4.013, P=0.1015, df=5), although treatment of the data greater than 60m depth does produce a significant trend (F=11.798, P=0.0414, df=3).

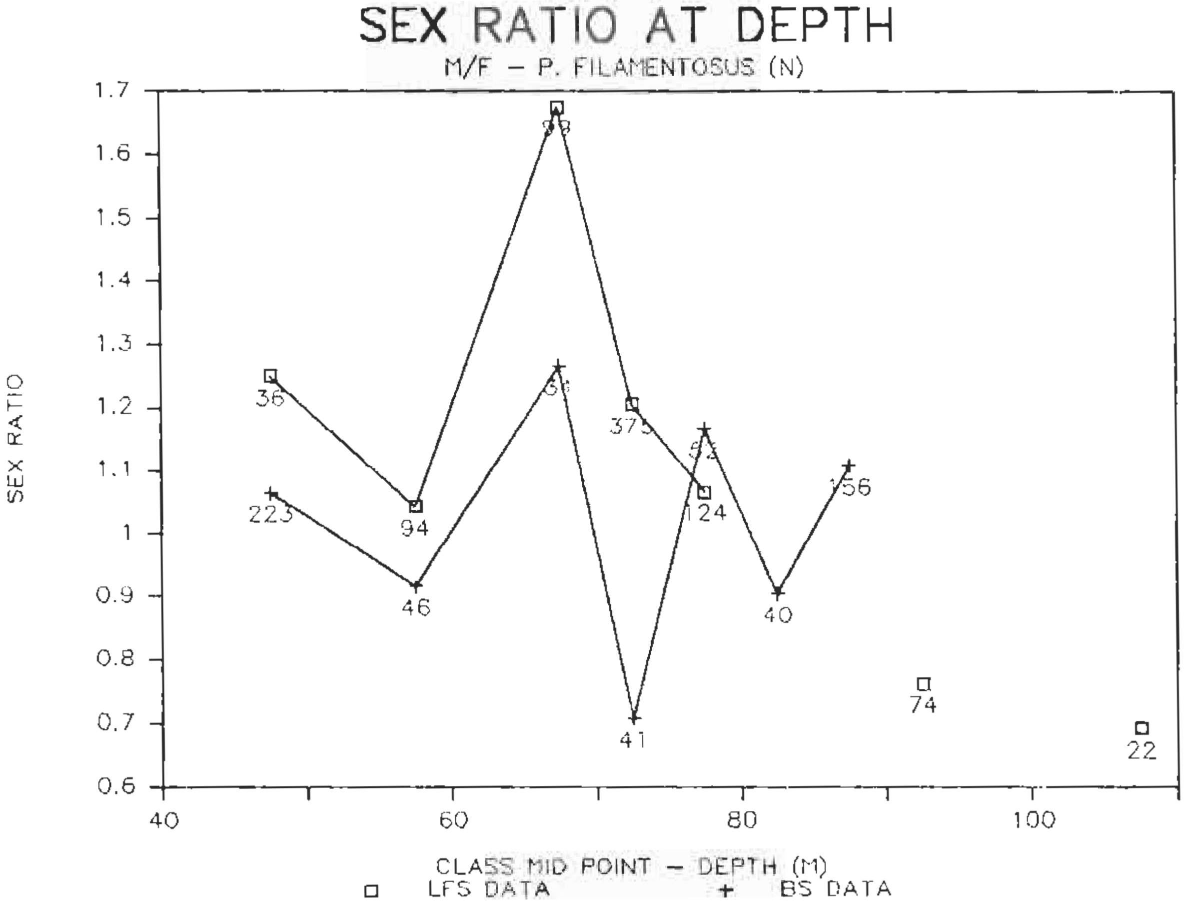
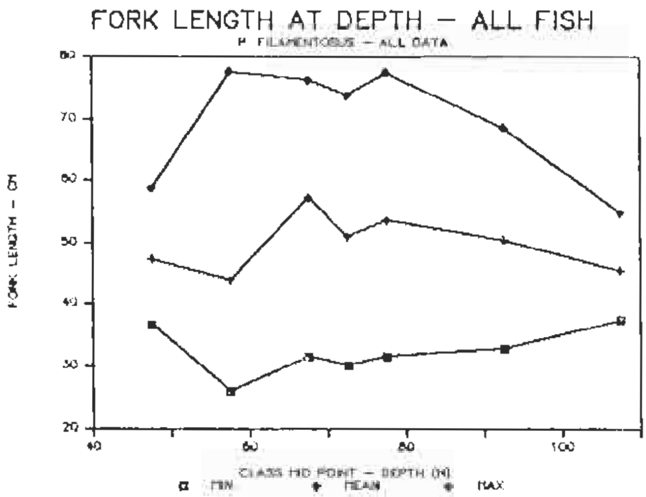


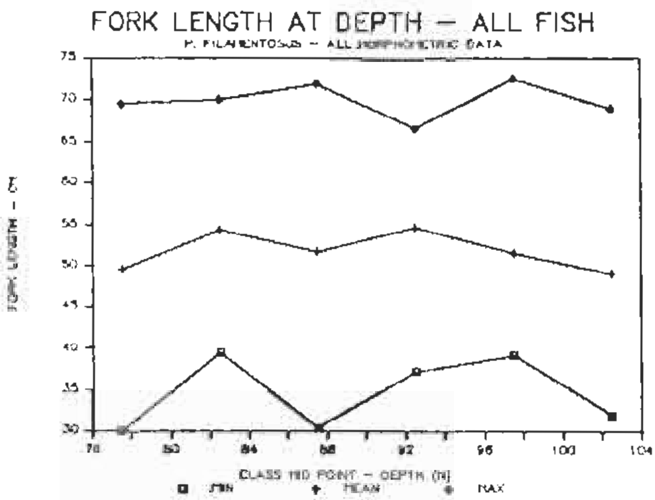
Table 5.5 indicates the mean length at depth observed for each sex, and for the total sample. No sexual differences were apparent, and the mean length remained similar at all depths, if anything, decreasing at the greatest depths, though no statistically significant trend was observed. For males the length at each depth was slightly greater than that for females as reported for the whole sample (above, males, FL_{mean}=50.81 cm; females, FL_{mean}=49.64 cm). This was true for both the LFS and BS samples. The mean, minimum and maximum lengths at each depth are indicated in Figures 5.9. and 5.10. for the LFS and BS samples respectively. Similarly to the mean values, the minimum and maximum lengths observed show no significant trend with depth though there is a tendency for the minimum length observed to increase with increasing depth.

TABLE 5.5. *P. FILAMENTOSUS* - MEAN FORK LENGTH AT DEPTH.

DEPTH CLASS	M	F	J	U	T
LFS SAMPLE					
45 50	50.11	43.69		47.25	47.26
55 60	45.45	43.71	30.44	43.74	43.86
65 69	58.88	55.66		55.97	57.31
70 74	51.01	51.39		50.43	50.94
75 79	54.63	52.91		52.79	53.58
90 95	49.05	50.14		52.74	50.40
105 110	46.18	43.52		46.98	45.45
BS SAMPLE					
70 74	54.98	53.73	34.95		54.20
75 79	50.60	48.56			49.53
80 84	56.36	51.71			54.31
85 89	52.28	52.26	30.50		51.75
90 94	55.21	54.03			54.66
95 100	47.83	54.94			51.56
100 105	49.37	48.64	51.92		49.10

FIGS. 5.9. AND 5.10 : *P. FILAMENTOSUS* - FORK LENGTH AT DEPTH (M)





FISHING LOCATION AND POPULATION STRUCTURE

Data pertaining to fishing location is only available for BS data. Precise locations are generally not provided by the commercial fishermen so the broad areas of North, South, East and West of the Mahe Plateau, and the Amirantes Plateau have been selected for analysis. Table 5.6 summarises this data.

TABLE 5.6. A SUMMARY OF FORK LENGTH DATA FOR *P. FILAMENTOSUS* BY FISHING GROUNDS

FISHING	SAMPLE SIZE		SEX	MALES		FEMALES		MEAN FL		STD. DEV.	
GROUNDS	MALES	FEMALES	RATIO	MIN FL	MAX FL	MIN FL	MAX FL	MALES	FEMALES	MALES	FEMALES
SOUTH	407	354	1.15	32.9	73.6	33.9	73.1	55.25	53.60	8.21	8.38
NORTH	179	185	0.97	31.0	69.6	30.1	72.6	49.38	48.58	9.42	9.34
EAST	25	24	1.04	34.7	70.7	33.4	72.5	54.21	57.06	10.17	10.38
AMIRANTES	1	7	0.14	46.9	46.9	44.0	60.3	46.90	51.09		6.87

64.4% of the sample derived from the South of the Mahe Plateau, 31.0% from the North, and 4.1% from the East. 0.5% was from the Amirantes. The sample from the Amirantes was too small and is not discussed further, although the skewed sex ratio is of interest. The sex ratios observed for fish caught in the South and East of the Mahe Plateau were similar to that reported above for the whole BS sample, with slightly more males than females, whilst in the North more females were caught. However, none of the ratios differed significantly from unity (South, Chi^2=3.55, P=0.059, df=1; North, Chi^2=0.69, P=0.793, df=1; East, Chi^2=0.00, P=1.00, df=1).

The minimum and maximum fork lengths observed were similar for both males and females from the South and East, but were smaller for fish caught in the North of the Plateau. Comparison of the mean lengths for each sex by location is indicated in Table 5.7.

TABLE 5.7. COMPARISON OF MEAN FORK LENGTH OF *P. FILAMENTOSUS* BY SEX AND FISHING LOCATION.

SEX	LOCATION	COMPARISON	t	df	P	SIGNIFICANT?
-	SOUTH	M vs F	2.812	759	0.003	YES
-	NORTH	M vs F	0.812	362	0.209	NO
-	EAST	M vs F	-0.970	47	0.169	NO
M	-	S vs N	7.619	584	<0.001	YES *
F	-	S vs N	6.291	537	<0.001	YES *
M	-	S vs E	0.607	430	0.272	NO
F	-	S vs E	-1.948	376	0.026	YES
M	-	N vs E	-2.379	202	0.009	YES
F	-	N vs E	-4.120	207	<0.001	YES *

* Highly significant

No significant differences were observed between the mean lengths of males and females from each of the North and East of the Plateau, whilst males from the South were significantly larger than females from the same area. Comparing the different locations, the mean fork lengths of both males and females from the South were significantly greater than those from the North, but compared to the population from the East, the males showed no significant difference. The sample from the North was significantly different from that from the East for both males and females. Thus, with respect to the population structure it would appear that the samples from the South and East are similar, and significantly different from that in the North.

It should be noted that with respect to the differences by location reported above, insufficient data was available to allow complete stratification by location, depth fished and by month. It is thus possible that these other factors may partly explain the differences (see Table 5.8.).

TABLE 5.8. TO INDICATE THE TIME AND DEPTH AT WHICH DATA FOR EACH LOCATION WAS SAMPLED.

FISHING LOCATION	MONTH J	F	M	A	M	J	J	A	S	O	N	D	MEAN DEPTH
SOUTH	*	*	*	*	*	*	*					*	75.9m
NORTH	*								*	*	*	*	92.4m
EAST			*										73.0m
AMIRANTES										*			85.0m

5.2. *APRION VIRESCENS*

6,442 *A. virescens* were measured between November 1989 and December 1990 in length frequency studies (Table 5.9.)

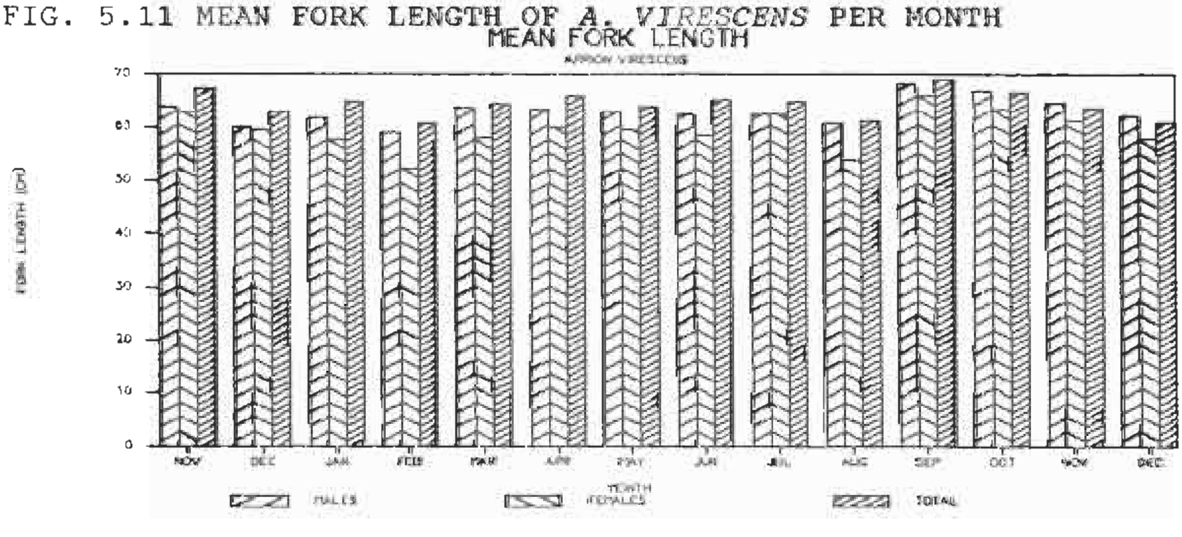
TABLE 5.9. A SUMMARY OF DATA COLLECTED DURING LENGTH (cm) FREQUENCY STUDIES FOR *A. VIRESCENS*

MONTH	SAMPLE SIZE N.	% M	% F	% J	% U	SEX RATIO	ALL FISH MIN FL	ALL FISH MAX FL	MEAN FORK LENGTH MALES	MEAN FORK LENGTH FEMALES	MEAN FORK LENGTH ALL FISH
NOV	414	33.1%	14.7%	0.0%	52.2%	2.25	28.50	90.70	63.92	62.97	67.20
DEC	218	31.7%	22.0%	0.0%	46.3%	1.44	29.50	99.30	60.00	59.57	62.86
JAN	532	25.2%	17.1%	0.0%	57.7%	1.47	25.20	101.00	61.72	57.94	64.94
FEB	560	24.8%	17.1%	0.0%	58.0%	1.45	30.60	93.30	59.12	52.40	60.75
MAR	967	32.5%	15.5%	0.0%	52.0%	2.09	28.90	92.90	63.61	58.21	64.46
APR	620	34.5%	13.2%	0.0%	52.3%	2.61	28.50	91.90	63.49	60.11	65.90
MAY	308	30.2%	19.2%	0.0%	50.6%	1.58	34.50	95.90	62.95	59.48	63.82
JUN	53	35.8%	28.3%	0.0%	35.8%	1.27	37.10	88.20	62.43	58.59	65.11
JUL	274	38.7%	20.1%	0.0%	41.2%	1.93	31.60	96.70	62.50	62.50	64.96
AUG	84	32.1%	22.6%	0.0%	45.2%	1.42	37.60	80.60	60.78	53.86	61.32
SEP	276	33.7%	12.0%	0.0%	54.3%	2.82	41.00	87.80	68.30	66.07	68.90
OCT	762	41.3%	20.1%	0.0%	38.6%	2.06	29.50	92.50	66.68	63.30	66.67
NOV	886	42.9%	29.1%	0.0%	28.0%	1.47	32.90	91.70	64.73	61.33	63.66
DEC	488	45.9%	28.3%	0.0%	25.6%	1.62	28.10	85.20	62.17	58.03	60.89
ALL	6442	35.1%	19.5%	0.0%	45.3%	1.80	25.20	101.00	63.66	59.78	64.46

For the total sample FL_{max}=101.0 cm; FL_{min}=25.2 cm, the sex being undetermined in each case. By sex : males, FL_{max}=93.3 cm; FL_{min}=28.5 cm; females, FL_{max}=97.5 cm; FL_{min}=28.1 cm.

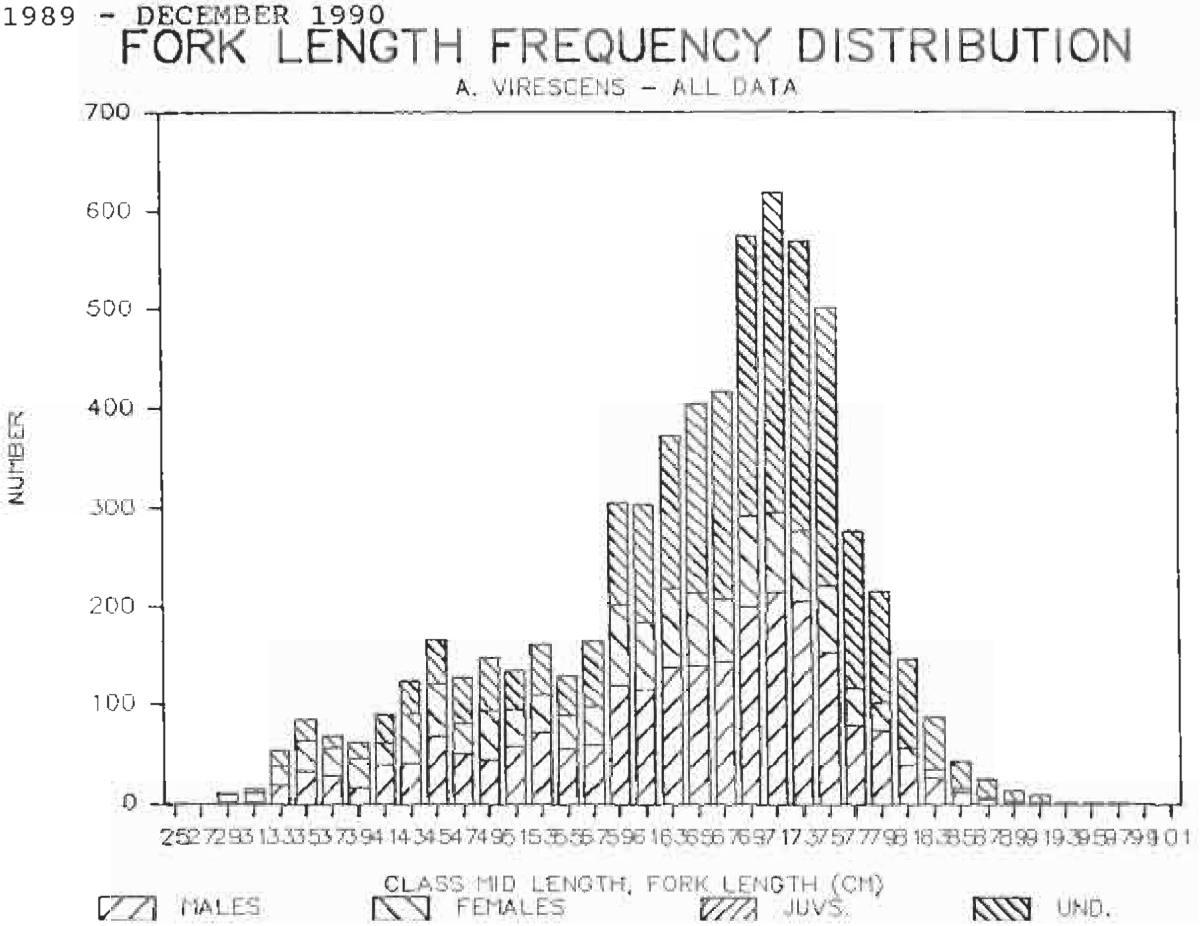
The mean fork length was 64.46 +/- 12.03 cm overall, and by sex : males, FL_{mean}=63.66 +/- 11.81 cm; females, FL_{mean}=59.78 +/- 13.24 cm; undetermined, FL_{mean}=67.10 +/- 10.89 cm. There was a highly significant difference between the mean lengths of males and females (t=8.9426, df=3520, P<0.001). The variation in mean length per month is shown in Figure 5.11.

FIG. 5.11 MEAN FORK LENGTH OF *A. VIRESCENS* PER MONTH



The structure of the entire sample population is indicated in Fig 5.12, and that for males and females in Fig 5.13.

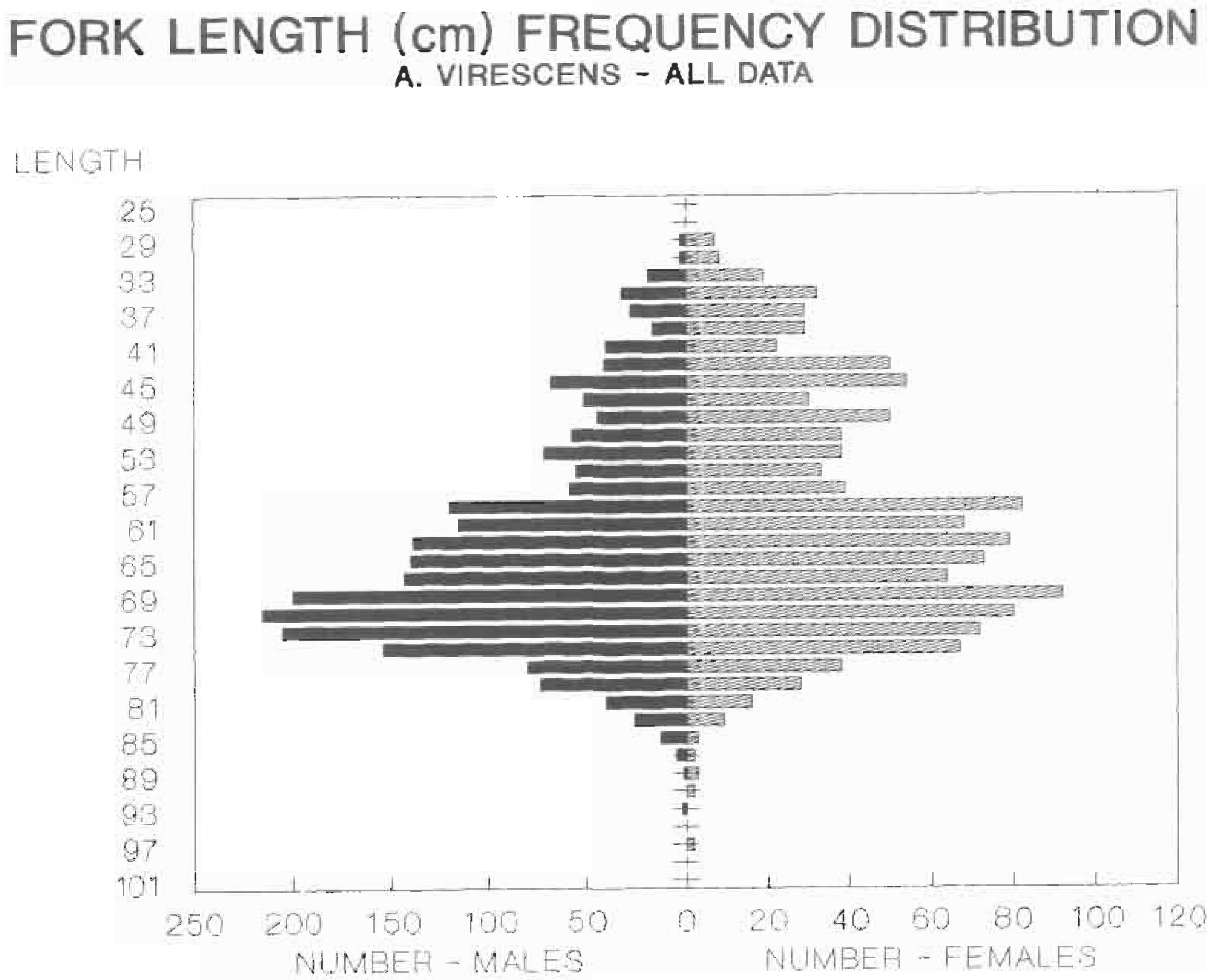
FIG 5.12. *A. VIRESCENS* SAMPLE POPULATION STRUCTURE - NOVEMBER 1989 - DECEMBER 1990



It was not possible to satisfactorily resolve the modes of this data using MPA of ELEFAN. The major mode occurs at a relatively large size probably indicating gear selectivity, smaller specimens either being less aggressive or less able to take the hooks. The major mode was tentatively calculated as 72.9 cm for the whole sample, 71.0 cm for males and 69.9 cm for females. The first two modes separated out also seemed to indicate a smaller size for females than males (male, 36.1 cm, 45.3 cm; female, 35.7 cm, 44.5 cm), but this is not obvious from Fig. 5.13, although it is apparent that a greater proportion of smaller females were caught than males.

45.3% of all fish sampled were of undetermined sex. Juveniles were not recorded at all (Table 5.9). The sex ratio was significantly biased in favour of males (males, 2264; females, 1258, sex ratio 1.80, Chi^2=286.78, df=1, P<0.001), and in no month were more females than males caught (see Fig. 5.14). During the inter monsoon periods of March/April and September/October more than twice as many males as females were caught. A highly significant trend is observed with increasing fork length. Regression analysis of the data up to class 86<88cm indicates that with increasing fork length the sex ratio increases (F=99.29, df=29, P<0.001). More females than males were caught at small sizes whilst the reverse is true for the large fish (Fig 5.15).

FIGURE 5.13:



FORK LENGTH (cm) FREQUENCY DISTRIBUTION
A. VIRESCENS - ALL DATA
LENGTH
25
29
33
37
41
45
49
53
57
61
65
69
73
77
81
85
89
93
97
101
250 200 150 100 50 0 20 40 60 80 100 120
NUMBER - MALES
NUMBER - FEMALES

FIG 5.14. *A. VIRESCENS* - SEX RATIO (M/F) WITH TIME, 1989-1990

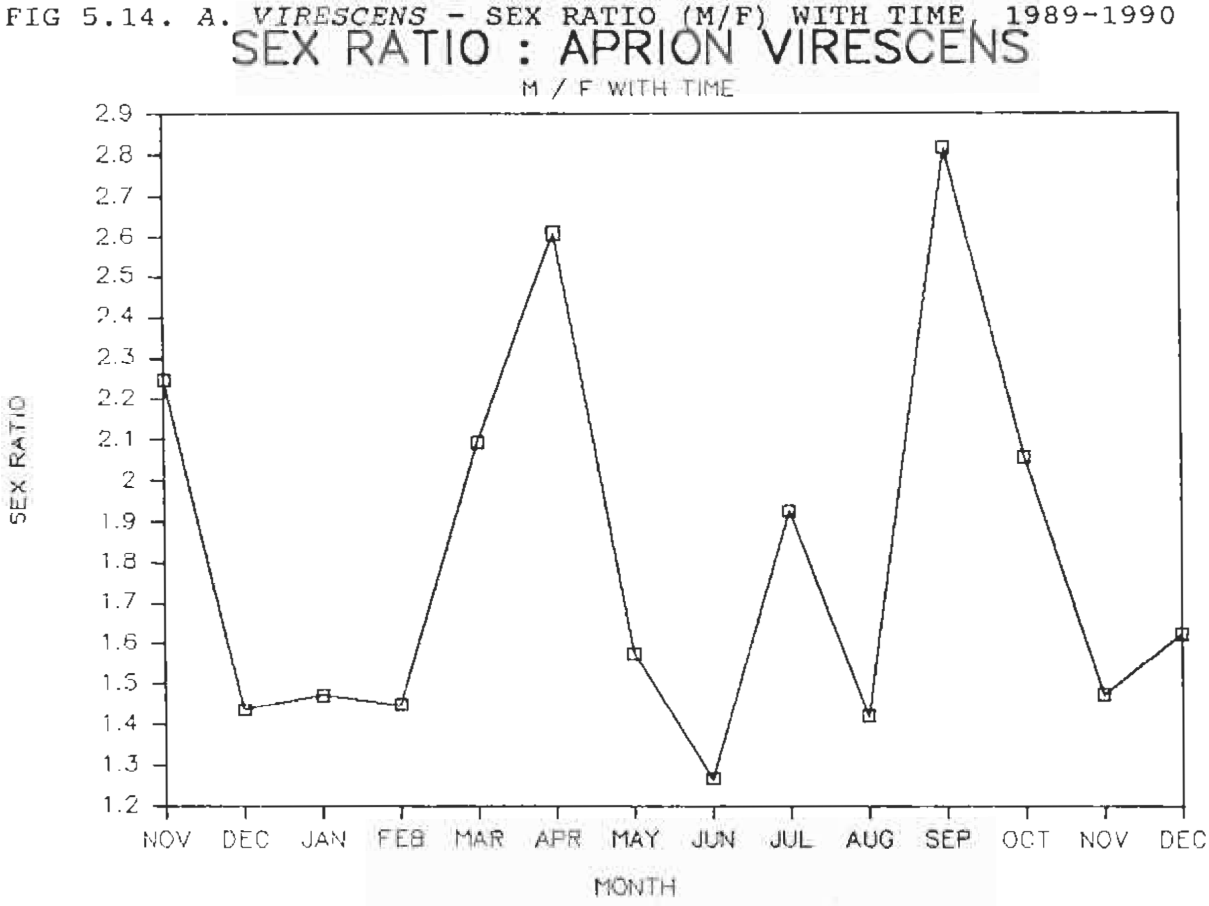
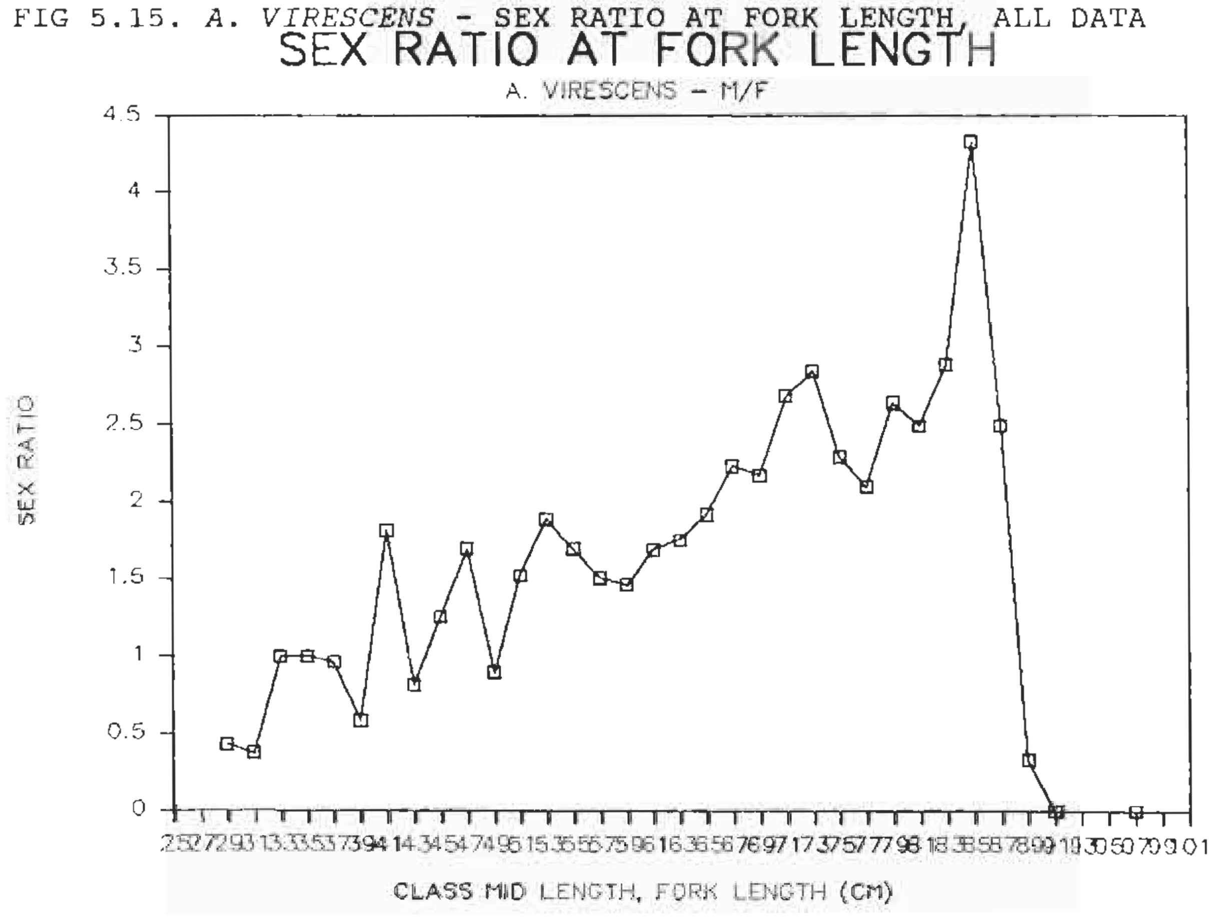


FIG 5.15. *A. VIRESCENS* - SEX RATIO AT FORK LENGTH, ALL DATA



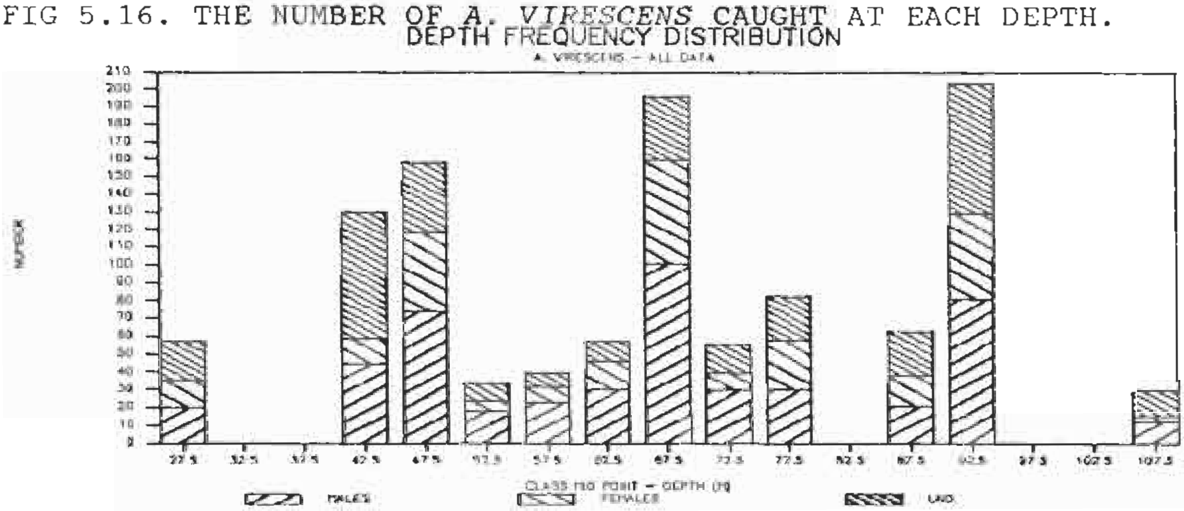
DEPTH RANGE AND POPULATION STRUCTURE

Table 5.10. summarises the data relating to depth for *A. virescens* and Fig 5.16. indicates the numbers caught at each depth.

TABLE 5.10. A SUMMARY OF FISHING DEPTH (METRES) DATA RELATING TO *A. VIRESCENS*.

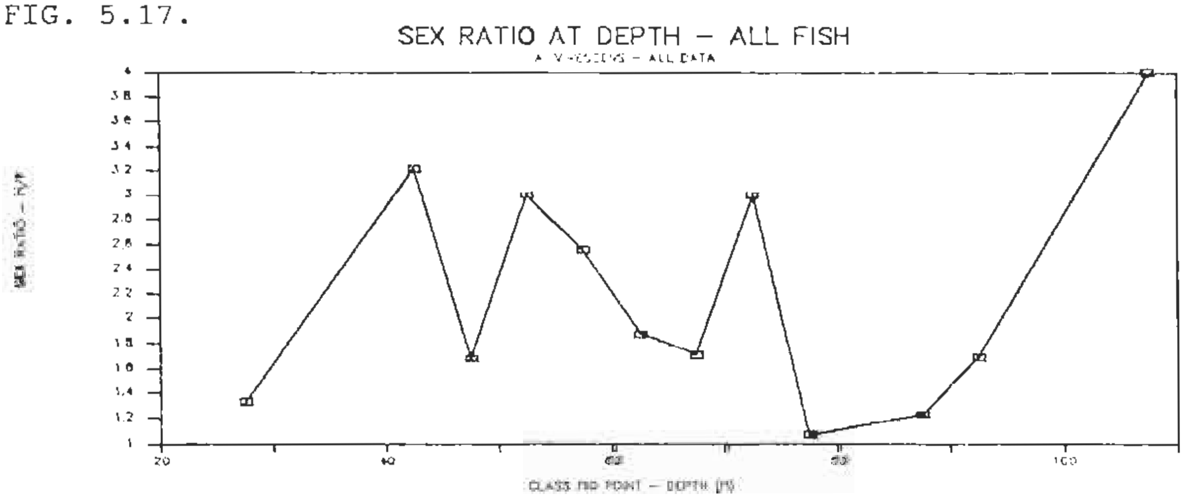
DETAILS	M	F	U	T
NUMBER	485.00	269.00	352.00	1107.00
MINIMUM	29.50	29.50	29.50	29.50
MAXIMUM	105.00	105.00	105.00	105.00
MEAN	65.18	66.32	65.10	65.43
ABS.MIN	15.00	15.00	15.00	15.00
ABS.MAX	137.00	137.00	137.00	137.00

FIG 5.16. THE NUMBER OF *A. VIRESCENS* CAUGHT AT EACH DEPTH.



A. virescens were caught over a total depth range from an absolute minimum of 15m to a maximum of 137m. Mid range values were between 29.5m and 105m. The mean depth was 65.43m and both males and females were caught over the entire range. No significant trend was observed with increasing depth in relation to sex ratio, but at the greatest depths more males than females were caught (Fig. 5.17.)

FIG. 5.17.

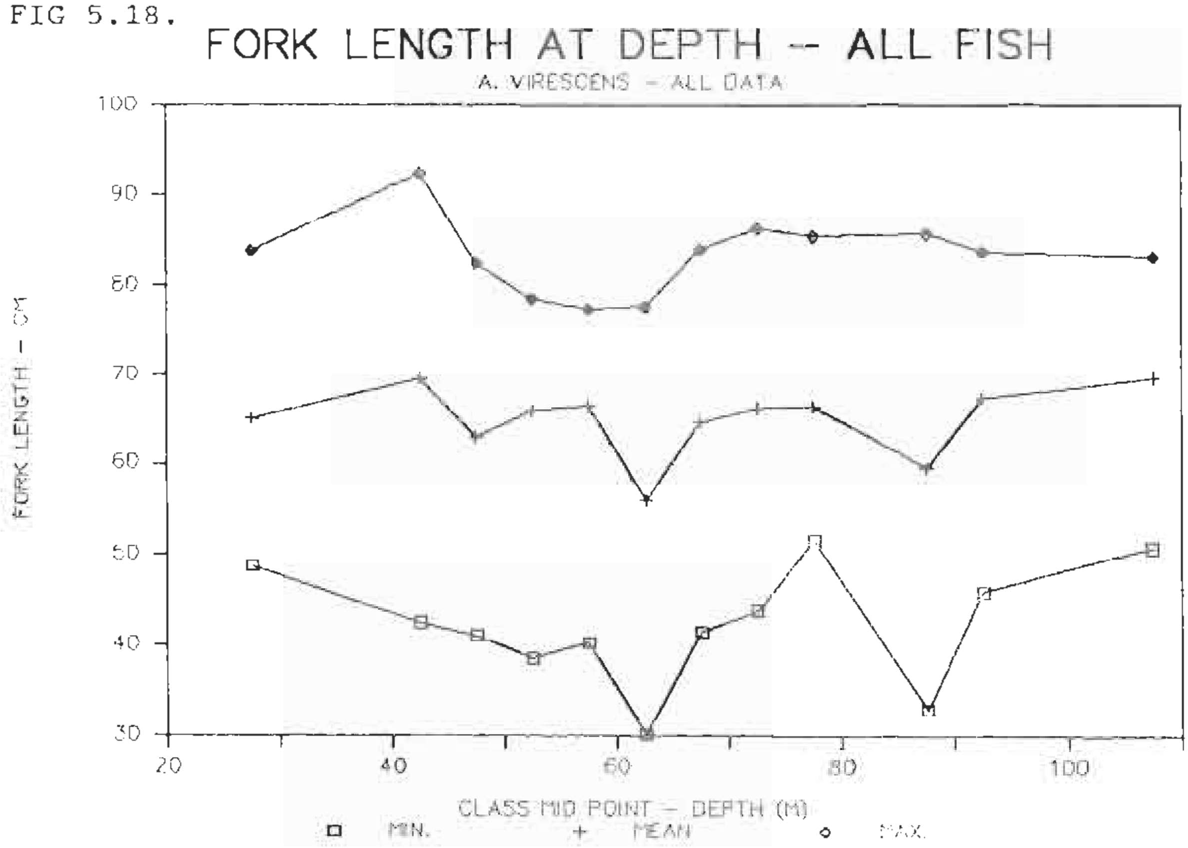


The mean length of fish caught remained similar at each depth range examined and this was true for the whole sample and by sex (Table 5.11., Fig 5.18.). However, at each depth class the mean length of females was less than that of the males. The maximum and minimum lengths observed at each depth for the total sample are indicated in Fig 5.18.

TABLE 5.11. *A. VIRESCENS* - MEAN FORK LENGTH AT DEPTH BY SEX

DEPTH CLASS	M	F	U	T
25< 30m	64.22	62.25	67.91	65.13
40< 45	69.50	68.58	69.94	69.64
45< 50	62.45	61.61	65.67	63.03
50< 55	66.21	67.82	64.38	65.96
55< 60	67.05	64.99	66.44	66.46
60< 65	56.61	53.37	58.27	56.02
65< 70	65.95	62.43	64.32	64.63
70< 75	67.21	61.04	67.67	66.24
75< 80	66.76	64.65	67.68	66.33
85< 90	58.97	57.68	61.39	59.58
90< 95	69.44	64.28	67.10	67.37
105<110	69.33	69.30	70.14	69.72

FIG 5.18.



5.3. *LUTJANUS SEBAE.*

A summary of the length frequency study measurements of *L. sebae* appears in Table 5.12. A total of 5,571 specimens were measured in the 14 month period between November 1989 and December 1990.

TABLE 5.12. A SUMMARY OF DATA COLLECTED DURING LENGTH (cm) FREQUENCY STUDIES FOR *L. SEBAE*.

MONTH	SAMPLE SIZE					SEX	ALL FISH		MEAN FORK LENGTH		
	N.	% M	% F	% J	% U	RATIO	MIN FL	MAX FL	MALES	FEMALES	ALL FISH
NOV	727	38.1%	29.3%	0.6%	31.9%	1.30	21.40	84.50	63.46	57.17	60.80
DEC	156	27.6%	50.0%	1.9%	20.5%	0.55	20.30	83.30	61.86	51.59	55.85
JAN	253	20.2%	35.2%	9.5%	35.2%	0.57	18.40	77.40	54.49	42.06	44.44
FEB	531	29.9%	36.9%	1.5%	31.6%	0.81	21.90	81.50	56.58	50.78	52.64
MAR	947	23.9%	32.1%	5.1%	39.0%	0.74	20.00	84.40	57.24	48.60	51.66
APR	573	30.2%	35.8%	1.7%	32.3%	0.84	20.80	82.90	55.29	48.73	52.58
MAY	216	24.1%	34.3%	7.9%	33.8%	0.70	21.50	82.30	61.41	50.24	53.99
JUN	26	57.7%	11.5%	0.0%	30.8%	5.00	41.10	71.80	60.27	48.97	57.99
JUL	281	23.8%	38.8%	4.6%	32.7%	0.61	19.60	83.80	56.61	47.86	49.97
AUG	147	21.1%	36.1%	0.0%	42.2%	0.58	31.50	78.00	57.93	49.78	53.19
SEP	314	22.3%	38.5%	0.0%	39.2%	0.58	23.20	82.50	65.18	49.84	57.11
OCT	732	29.6%	36.2%	0.0%	34.0%	0.82	21.00	86.00	61.18	51.42	55.55
NOV	360	35.8%	37.5%	0.0%	26.7%	0.96	25.40	83.50	62.06	55.81	58.13
DEC	308	38.0%	35.1%	0.0%	26.9%	1.08	25.10	81.20	49.58	45.45	47.33
ALL	5571	29.2%	35.0%	2.3%	33.4%	0.83	18.4	86.00	58.93	50.41	53.90

For the total sample FL_{max}=86.0 cm (male) and FL_{min}=18.4 cm (juvenile). By sex : males, FL_{max}=86.0 cm, FL_{min}=21.7 cm; females, FL_{max}=78.2 cm, FL_{min}=19.5 cm; juveniles, FL_{max}=42.2 cm, FL_{min}=18.4 cm).

The mean lengths observed were: total, FL_{mean}=53.9 +/- 14.9 cm; males, FL_{mean}=58.9 +/- 14.7 cm; females, FL_{mean}=50.4 +/- 13.09 cm ; juveniles, FL_{mean}=26.6 +/- 4.5 cm. The mean length of females was highly significantly smaller than that of the males (t=18.27, df=3579, $P<0.001$). The monthly variation in mean fork length is illustrated in Fig. 5.19.

FIGURE 5.19. THE MEAN FORK LENGTH OF *L. SEBAE* PER MONTH

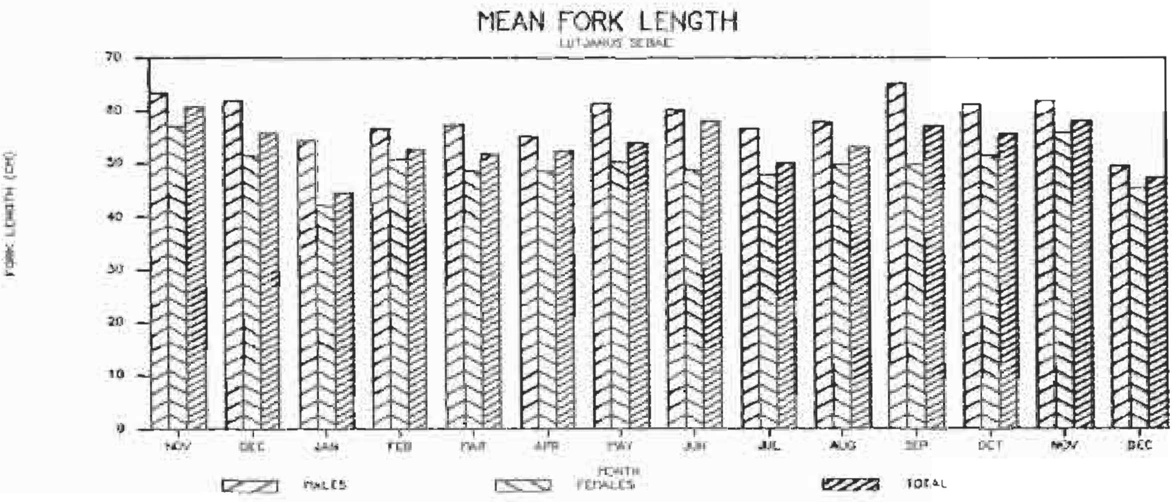
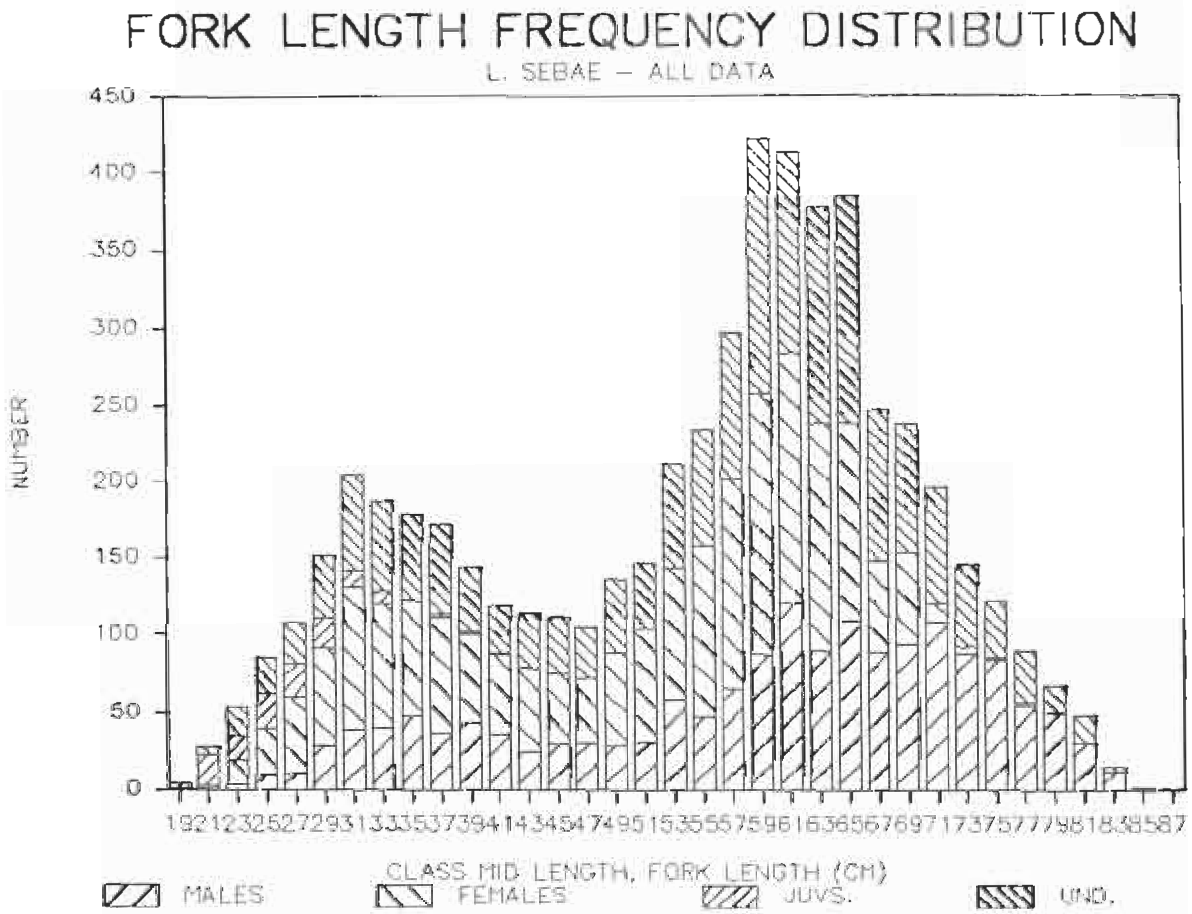


Figure 5.20 indicates the sample population structure for all data collected throughout the 14 month period, and that for males and females appears in Fig 5.21. Only two modes are clearly visible, at 34.2 cm and 62.7 cm for the whole sample. Comparing the sexes, similarly only two modes are apparent, but they are smaller for females than males, and the whole population structure for females is skewed towards the smaller sizes with no individuals recorded at the largest fork lengths. The modes were 36.4 cm and 64.9 cm for males, and 30.6 cm and 59.3 cm for females. Juveniles exhibited a single mode at 26.1 cm.

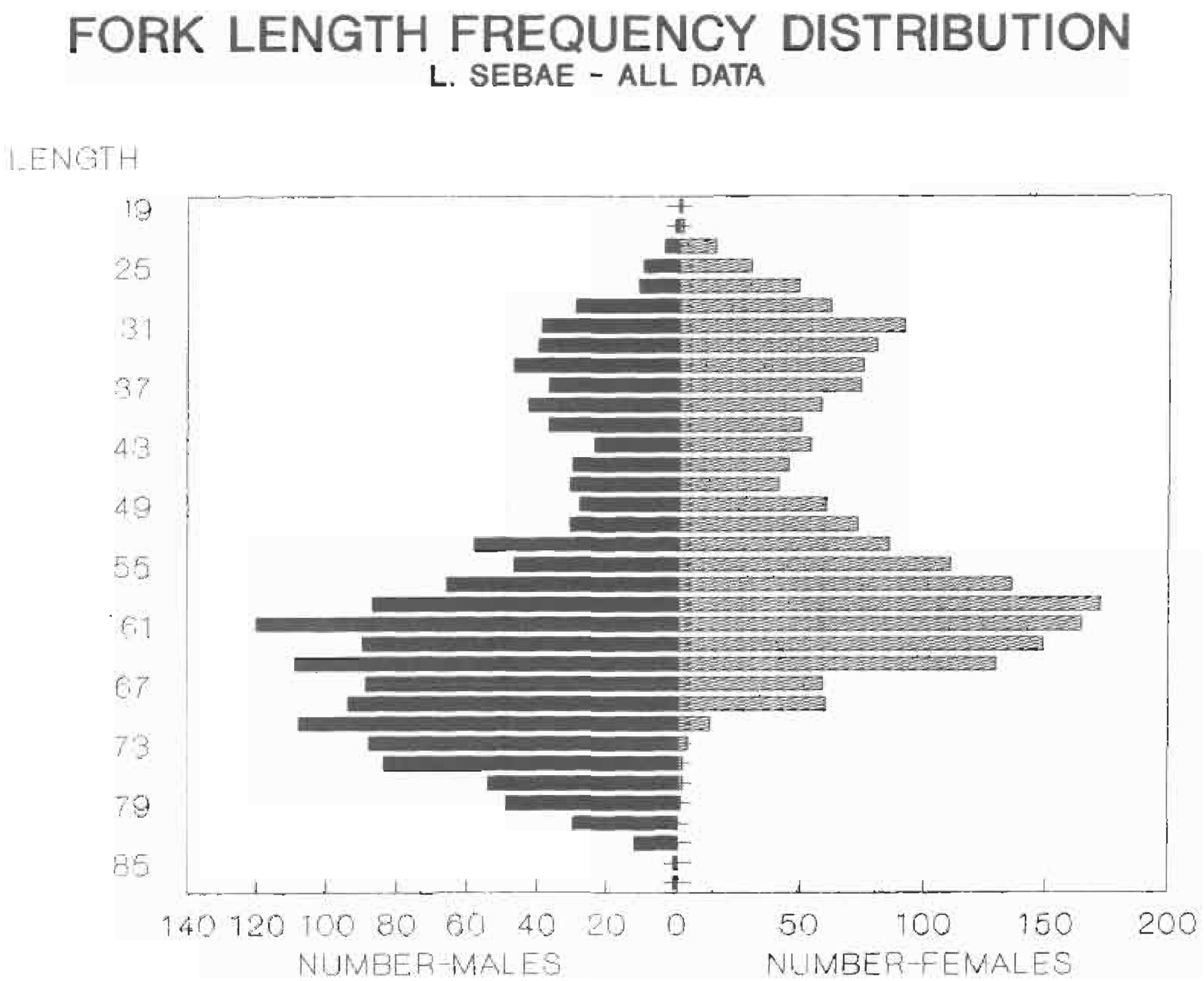
FIG. 5.20. *L. SEBAE* SAMPLE POPULATION STRUCTURE, NOV 89 - DEC 90



33.4% of the sample was of undetermined sex. Juveniles comprised 2.3% of the sample and were recorded from November to May and in July. The greatest numbers were recorded in January and May.

The sex ratio was biased in favour of females (males, 1629; females, 1952; sex ratio M/F, 0.83). The overall sex ratio was significantly below unity (Chi^2=28.95, df=1, P<0.001), and only rose above it in November 1989 (1.3), June 1990 (5.0) and December 1990 (1.08, see Fig 5.22.). In the case of June the sample size was small. Figure 5.23 indicates the sex ratio at fork length, and as also apparent from Fig 5.21 at large sizes the ratio is heavily biased in favour of males. At the largest fork lengths only males were recorded. Fig 5.24 reproduces that part of the graph up to fork length 68-70 cm. Regression analysis reveals that the increase in sex ratio with increase in size is statistically significant for the whole length range (F=16.17,

FIGURE 5.21:



FORK LENGTH FREQUENCY DISTRIBUTION
L. SEBAE - ALL DATA
LENGTH
19
25
31
37
43
49
55
61
67
73
79
85
140 120 100 80 60 40 20 0
50 100 150 200
NUMBER-MALES
NUMBER-FEMALES

df=30, P<0.001, r^2=0.60), and for that part up to class 68-70 cm (F=16.05, df=24, P<0.001, r^2=0.64).

FIG. 5.22.

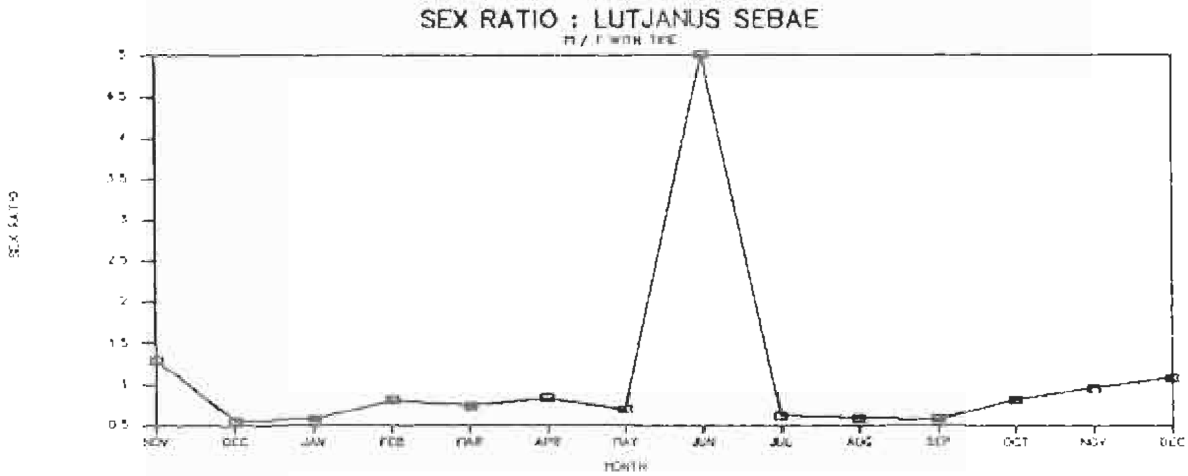


FIG. 5.23.

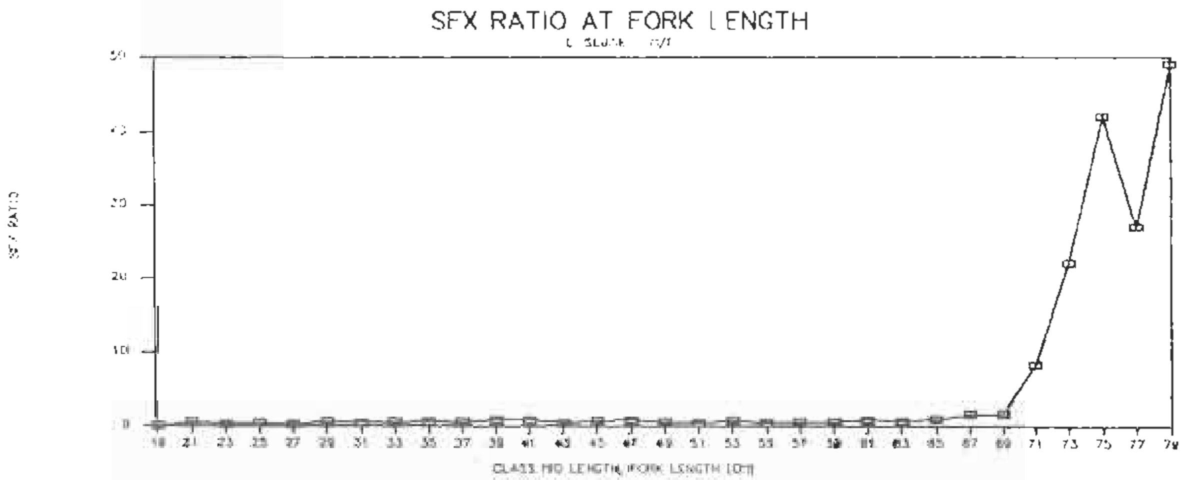
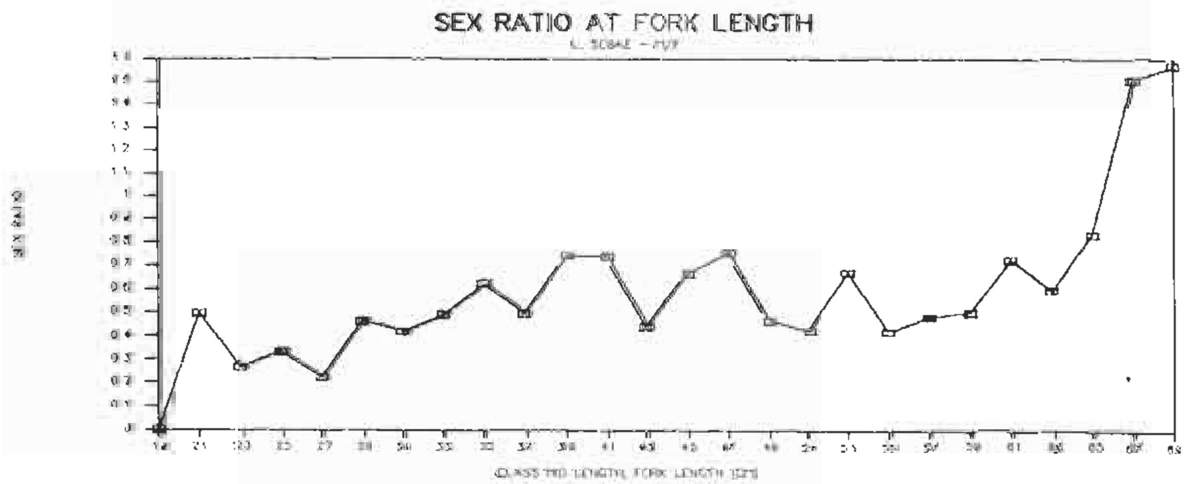


FIG. 5.24.



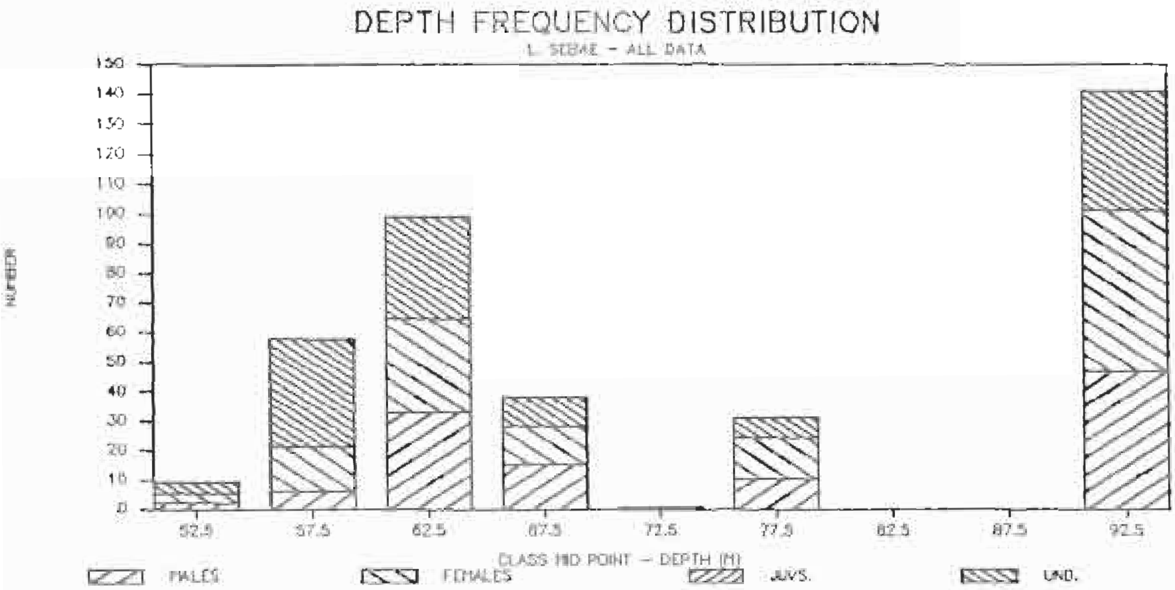
DEPTH RANGE AND POPULATION STRUCTURE

Table 5.13 summarises the data relating to depth at which *L. sebae* were caught and Fig. 5.25 indicates the number caught at each depth class.

TABLE 5.13. A SUMMARY OF FISHING DEPTH (m) DATA RELATING TO *L. SEBAE*

DETAILS	M	F	J	U	T
NUMBER	113.00	131.00	0.00	133.00	377.00
MINIMUM	53.00	53.00	0.00	53.00	53.00
MAXIMUM	91.50	91.50	0.00	91.50	91.50
MEAN	76.27	75.81	0.00	70.71	74.15
ABS.MIN	25.00	25.00	0.00	25.00	25.00
ABS.MAX	110.00	110.00	0.00	110.00	110.00

FIG. 5.25.



The depth range fished by boats catching *L. sebae* extended from an absolute minimum of 25 m to a maximum of 110 m, the mid range fishing depths varying between 53 - 91 m. The mean depth was 74.2m. The largest number of fish were recorded from the depth class 90-95m, but it is apparent from Fig. 5.25 that the majority of fish were caught below 70m. With increasing depth there is a slight tendency towards increasing sex ratio (Fig. 5.26) though this is not significant. Similarly, there is no significant difference in fork length at depth for either sex or the whole sample (see Fig. 5.26). Table 5.14 indicates, however, that at each depth class the mean length of females is less than that of males.

FIG. 5.26.

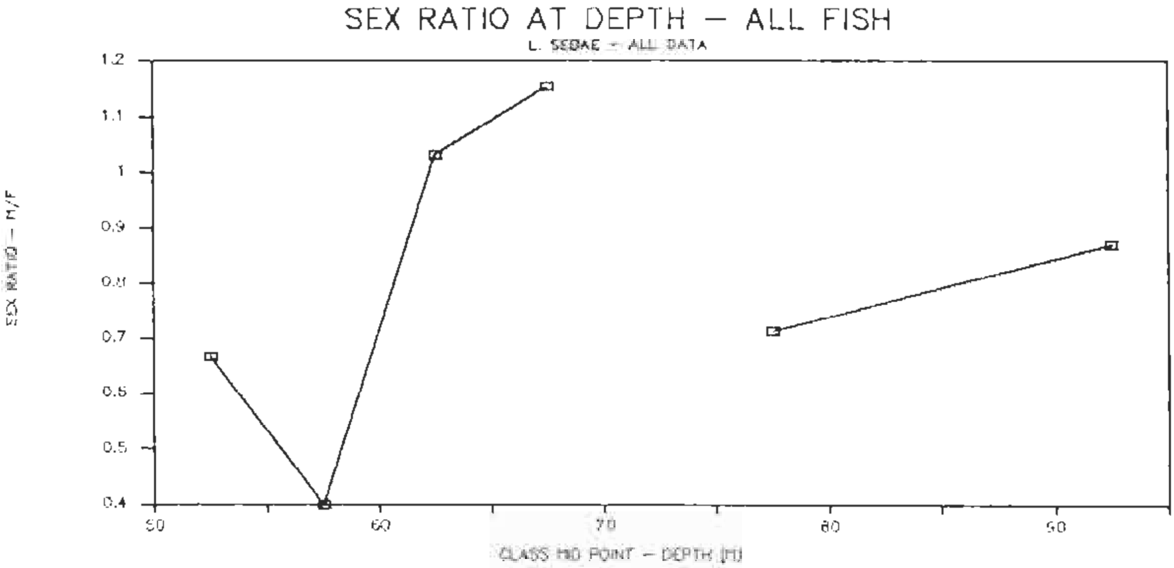
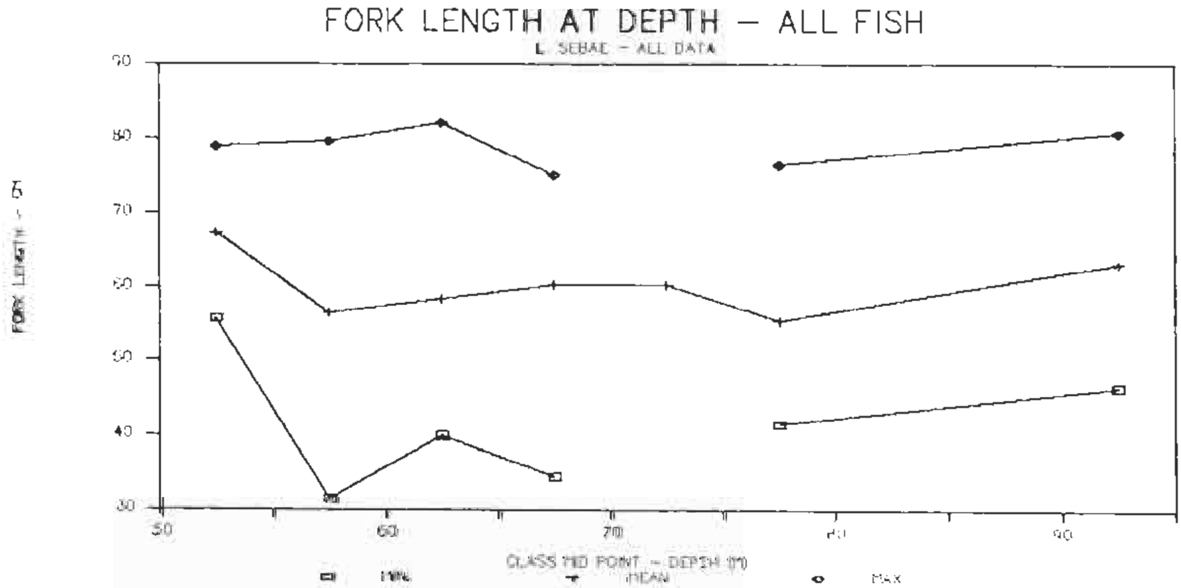


TABLE 5.14. *L. SEBAE* - MEAN FORK LENGTH AT DEPTH

DETAILS	M	F	J	U	T
50< 55	74.50	64.57	0	65.82	67.33
55< 60	60.33	55.13	0	56.49	56.54
60< 65	59.84	53.13	0	61.82	58.35
65< 70	60.76	61.30	0	58.33	60.31
70< 75			0	60.20	60.20
75< 80	57.77	52.44	0	58.10	55.44
90< 95	67.55	59.83	0	62.37	63.12

FIG. 5.27.



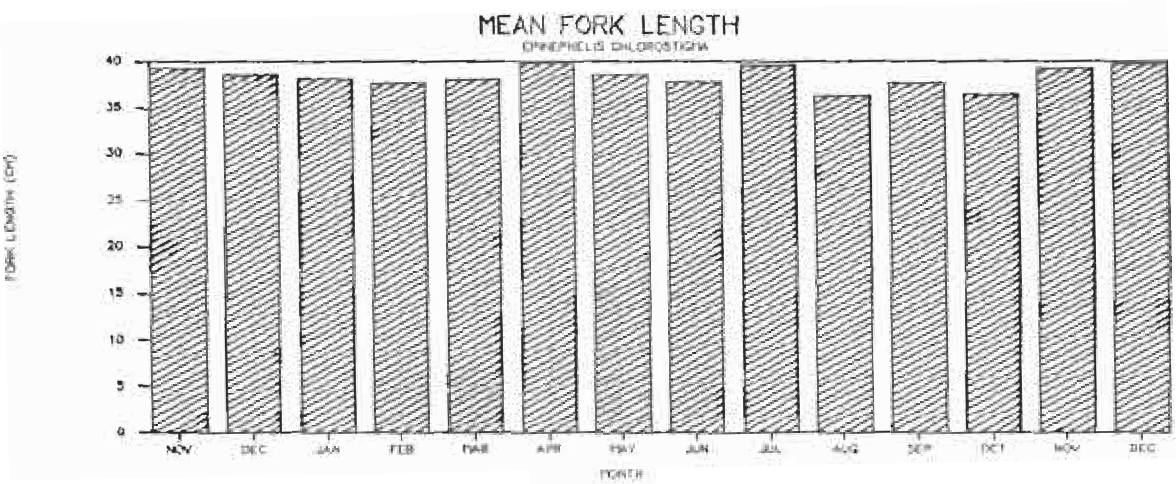
5.4. *EPINEPHELIS CHLOROSTIGMA.*

A total of 6,478 *E. chlorostigma* were measured between November 1989 and December 1990. The details are presented in Table 5.15. No analysis by sex is given. The species is a protogynous haermaphrodite and so sex was not recorded. The variation in mean length with time is illustrated in Figure 5.28, whilst the minimum maximum and mean lengths observed overall are reported in the Table.

TABLE 5.15. A SUMMARY OF DATA COLLECTED IN LENGTH (cm) FREQUENCY STUDIES FOR *EPINEPHELIS CHLOROSTIGMA*

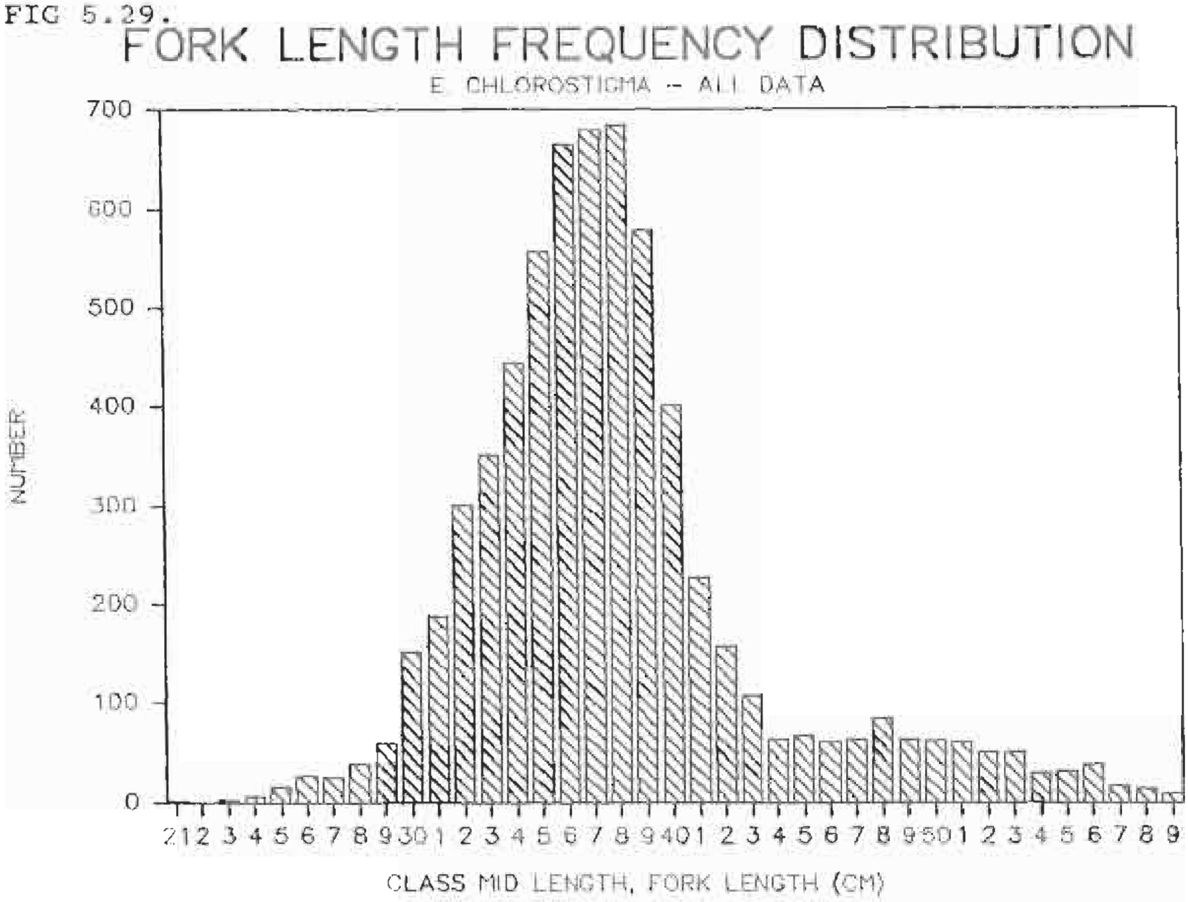
MONTH	N.	TL_{min}	TL_{max}	TL_{mean}
NOV	588	25.00	60.10	39.34
DEC	325	26.50	64.60	38.56
JAN	582	25.10	64.70	38.20
FEB	610	24.80	59.80	37.69
MAR	910	24.80	56.70	37.99
APR	612	25.70	65.40	39.86
MAY	327	25.80	62.50	38.60
JUN	153	24.00	50.40	37.73
JUL	337	23.80	60.80	39.55
AUG	206	24.80	55.20	36.24
SEP	471	21.30	63.70	37.58
OCT	708	25.20	63.20	36.42
NOV	351	23.40	64.30	39.19
DEC	297	23.10	59.80	39.73
TOTAL	6478	21.30	65.40	38.30

FIG. 5.28.



The structure of the total sample population is shown in Figure 5.29. A single mode at 37.0cm is apparent with few large fish being caught.

FIG 5.29.



DEPTH RANGE AND POPULATION STRUCTURE

Data relating to depth was available for 415 fish. The absolute range over which they were caught extended from 25m to 110m, with mid range values (see 5.1) of : min., 40m; max., 91.5m; mean, 65.8m. Figure 5.30 indicates the number caught at depth, and Fig 5.31 indicates the mean total length at depth.

FIG. 5.30.

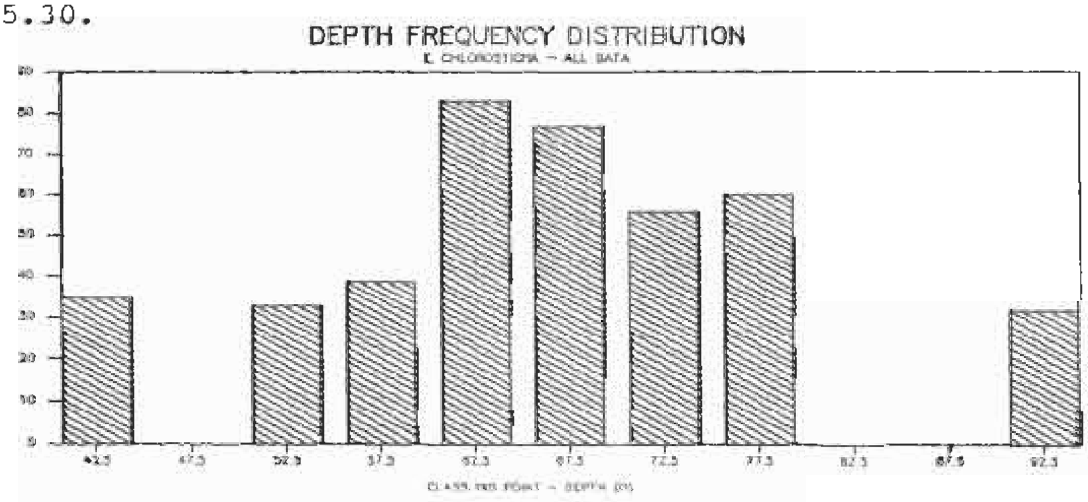
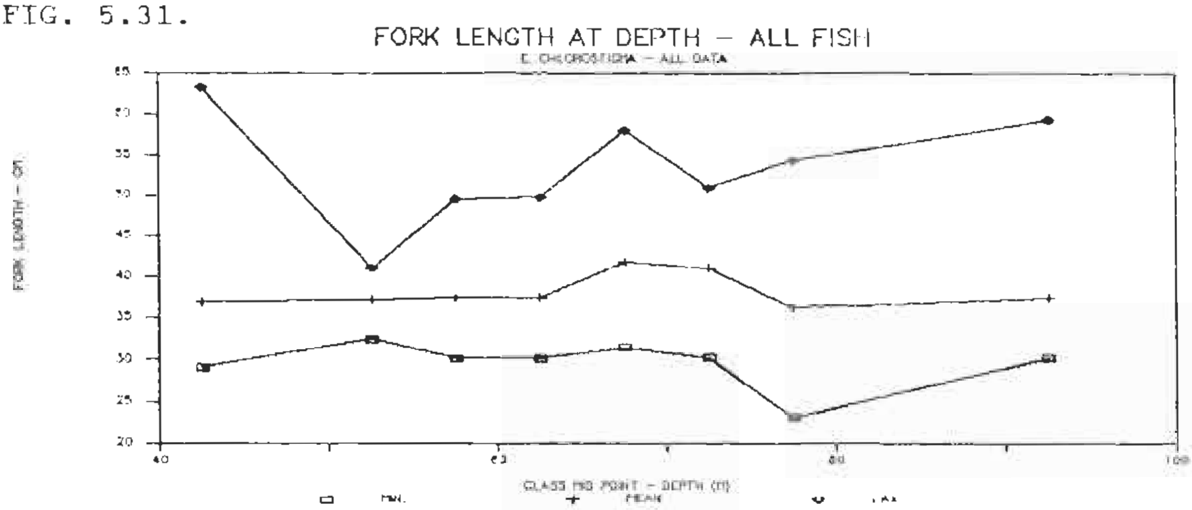


FIG. 5.31.



Most fish were caught between 50m and 80m with the greatest number in the depth range 60-65m. There was no significant change in the mean total length with increasing depth, but a tendency was apparent for the maximum size of fish caught to increase with depth (possibly because the greater depths are less heavily fished).

6. REPRODUCTIVE BIOLOGY

6.1. *PRISTIPOMOIDES FILAMENTOSUS*

SIZE AT SEXUAL MATURITY

The gonads of female fish from both the Length Frequency (LFS) and Biometric Studies (BS) were staged as described in (3). For the BS the gonads of both males and females were also weighed. Stage 3+ and above relate to mature fish. The mean fork length at each maturity stage, and the minimum lengths observed for mature fish are indicated in Tables 6.1 and 6.2 for LFS and BS respectively.

TABLE 6.1. MEAN FORK LENGTH AT MATURITY STAGE , AND THE MINIMUM SIZE OBSERVED FOR MATURE FISH / MONTH (LFS)

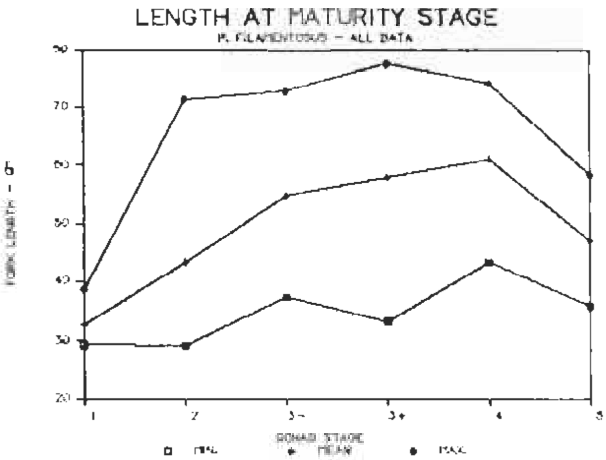
MONTH	MATURITY STAGE							MINIMUM FL / STAGE(cm)		
	1	2	3	3-	3+	4	5	3+	4	5
11		45.55	53.50	57.60	57.53	64.30		47.30	55.90	
12		45.07	55.07	55.26	54.41			45.20		
1		47.67	59.01	56.26	54.49			40.70		
2		42.64	59.16	56.36	60.50			54.50		
3		43.27	58.00	55.15	60.92	62.07		50.30	54.00	
4	32.64	42.53	50.80	48.85	55.95	65.49		33.20	55.90	
5	33.92	43.41	46.85	56.17	54.52	59.59		38.00	43.30	
6		42.28	48.04	53.13						
7		41.56	48.60	55.78	56.72	59.60	35.80	47.10	59.60	35.80
8		39.51		59.46						
9		42.85	60.30	53.82	55.16	58.75		40.10	58.50	
10	29.40	43.37	55.46	53.08	59.34	58.94		45.10	48.90	
11		44.23	48.92	56.59	59.96	63.45		41.10	51.30	
12		43.06	50.10	54.98	59.56	59.82	58.20	45.20	48.20	58.20
TOTAL	32.73	43.36	54.58	54.77	57.90	61.03	47.00	33.20	43.30	35.80

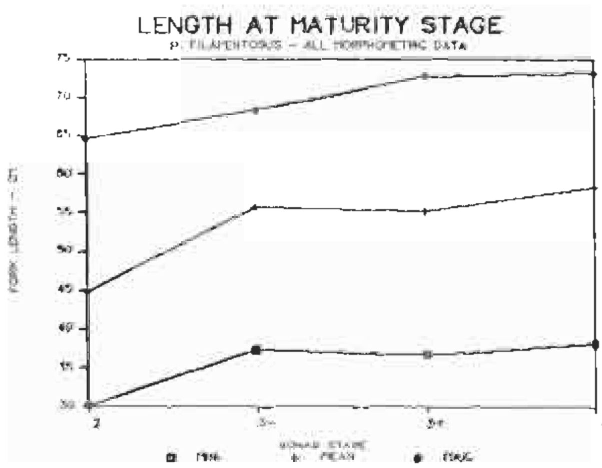
TABLE 6.2. MEAN FORK LENGTH AT MATURITY STAGE , AND THE MINIMUM SIZE OBSERVED FOR MATURE FISH / MONTH (BS)

MONTH	MATURITY STAGE							MINIMUM FL / STAGE (cm)		
	1	2	3	3-	3+	4	5	3+	4	5
11										
12					47.57	47.55		46.30	40.30	
1		41.99		54.40	54.85	65.13		49.00	64.90	
2		44.06	45.40	52.83	55.28	58.24		41.70	46.60	
3		42.50			56.54	58.33		40.30	46.70	
4		43.97		47.40	52.66	53.78		38.70	38.10	
5		45.63		56.99	57.40	68.40		54.00	68.40	
6						63.50			63.50	
7		49.71		55.70	50.57	61.17		46.60	54.10	
9		41.39		41.20	47.60	56.60		47.60	46.20	
10		44.25	46.60	37.30	53.68	57.78		36.60	41.70	
11		45.77		58.70	57.78	62.84		46.90	57.10	
12		51.34		59.81	58.30	61.34		43.40	47.80	
TOTAL		44.81	46.00	55.70	55.18	58.25		36.60	38.10	

The smallest fish observed with a matured gonad measured 33.2cm (LFS), and the smallest spawning fish measured 38.10cm (BS). A positive correlation existed between fork length and maturity stage, with larger fish having a greater stage of development (\1). This is also indicated in Figures 6.1A and 6.1B for LFS and BS respectively, which show the mean, maximum and minimum fork lengths recorded for each stage.

FIGS. 6.1A (LFS) AND 6.1B (BS).



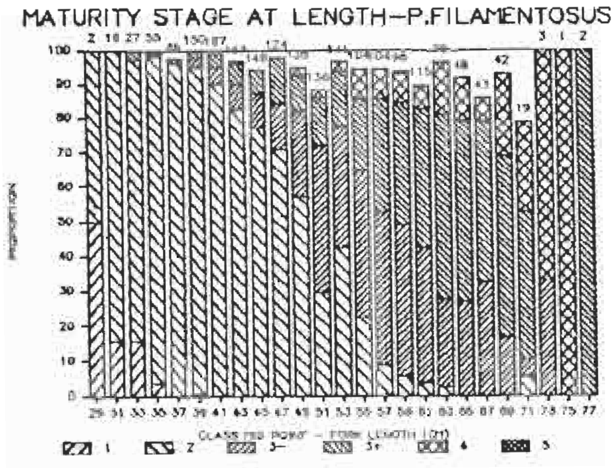


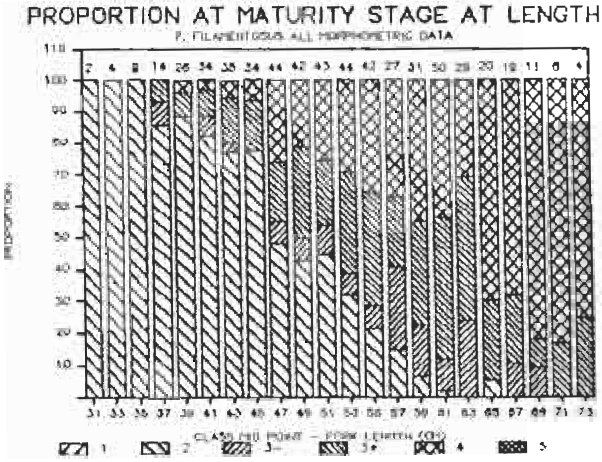
Figures 6.2A and 6.2B (LFS and BS respectively) indicate the proportion of the fish at each fork length with gonads at each stage of development. It is evident that whilst the smallest recorded fish with a mature gonad was 33.2cm the proportion of mature and spawning fish is small at this length, and increases with increasing fork length, until at the larger sizes there are no immature fish.

The fork length at which 50 % of all female P. filamentosus were mature (stage 3+ or above) was 59-61 cm for the LFS data and 51 - 53 cm for BS data.

\1) Maturity Stage=0.0857xFL-2.0332 ($r=0.61$; $F=349.98$, $df=567$, $P<0.001$)

FIGS. 6.2A (LFS) AND 6.2B (BS)





For the BS sample the Gonado-somatic index (GSI) was calculated thus:

GSI = Gonad weight in grammes/Fish weight in Kilogrammes

The gonad weight increases at a relatively faster rate than the total body weight of the fish and this is related to the development of the gonads (production of ova or sperm). The GSI is thus an index of the relative growth of the gonads independent of body weight. At the point of sexual maturity an increase in the GSI will occur, whilst before maturity the gonads may be expected to grow at the same rate as the total body weight and the GSI would be constant. A positive correlation was found to exist between fork length and GSI for both male and female *P. filamentosus* (\2), further indicating the relationship between size and sexual maturity (see Figs. 6.3, 6.4). The advantage of the GSI is that it is an empirical value and not subjective like the maturity stage which is open to the interpretation of the Technician making the recording. Used together an accurate picture of the size at sexual maturity and the stage of sexual development may be obtained.

\2) Males : GSI=0.3683xFL-11.9485 ($r=0.42$, $F=127.92$, df=610, $P<0.001$)
Females : GSI=0.4962xFL-16.4604 ($r=0.53$, $F=222.98$, df=568, $P<0.001$)

FIG. 6.3.

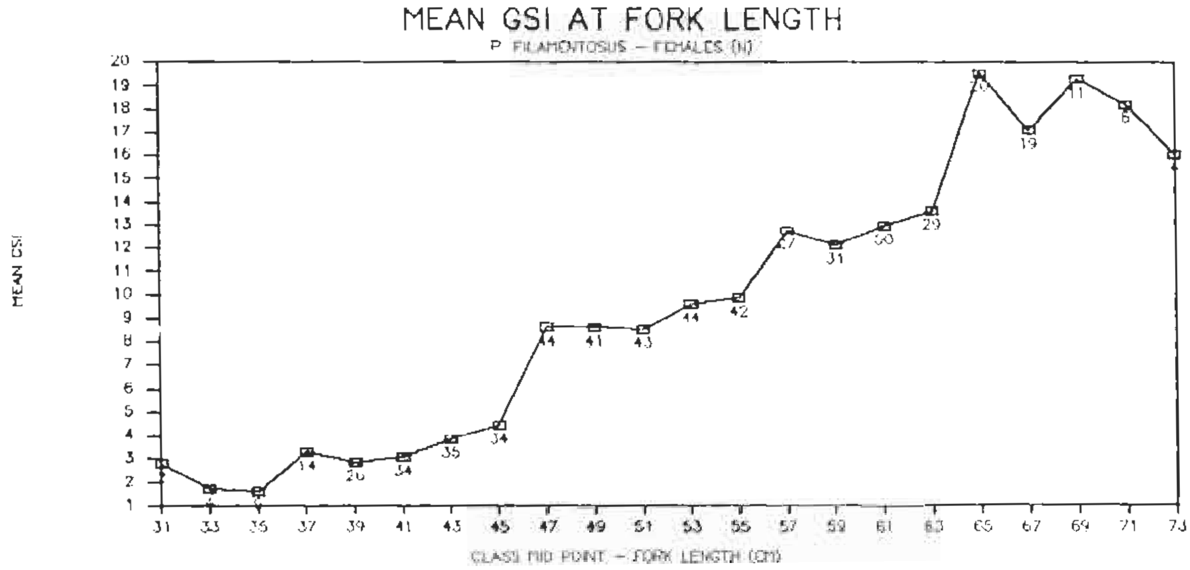
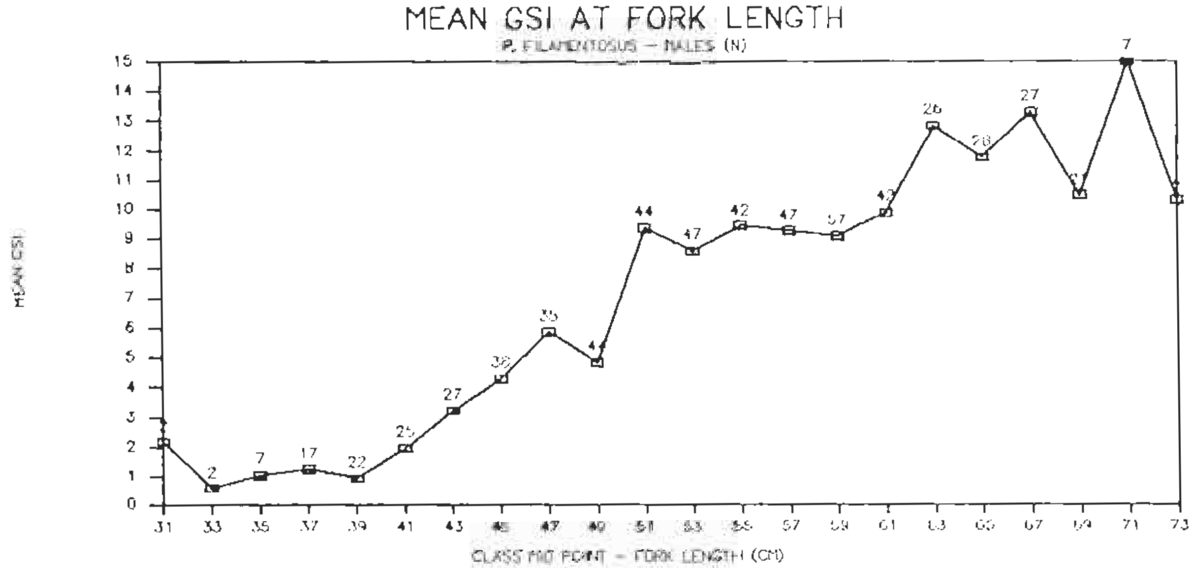


FIG. 6.4.



The correlation between size and sexual maturity has been established. Figures 6.5 and 6.6 indicate the mean gonad weight at each 2cm size class, and the percentage change in gonad weight between size classes. The greatest increase in gonad weight may be expected at maturity. For males this occurs in the 40-42cm size class and for females in the 36-38cm size class. These size classes also correspond to the size at which the GSI first increases. For both males and females a second strong size class is apparent at 50-52cm and 46-48cm respectively. This is apparent both from increases in the GSI and the percentage change in gonad weight. The GSI continues to increase after maturity for two reasons :

i) Larger fish have relatively larger gonads in relation to body weight (greater production of gametes)

ii) As seen from Fig. 6.2 a greater proportion of the population enters the reproductive phase so the mean GSI of the sample will continue to increase until all fish reach maturity

The second reproductive peak may thus represent a greater proportion of fish entering the reproductive phase, and Figure 6.2 indicates that a greater proportion of females begin spawning (stage 4) at this size. It may be the case that only a few individuals from one recruitment year spawn at age 'x', whilst the following year (x+1) a greater proportion reach maturity. The length interval between ages 'x' and 'x+1' `corresponds to approximately 10cm, and is similar to the growth observed over 12 months in Section 7.2. (growth) supporting this argument.

FIG. 6.5.

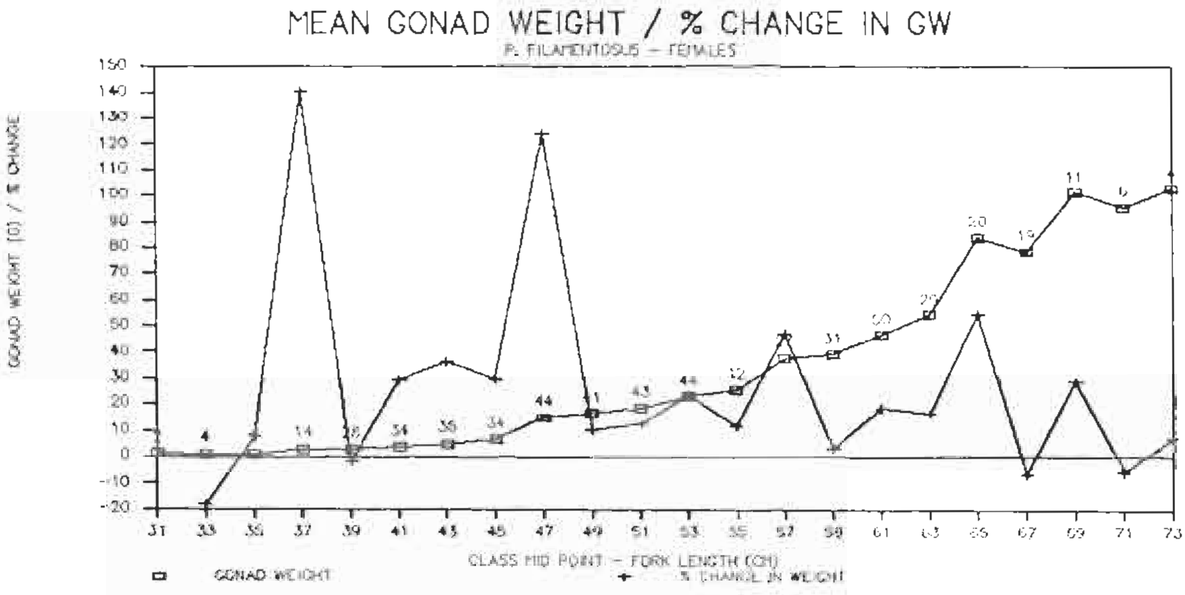
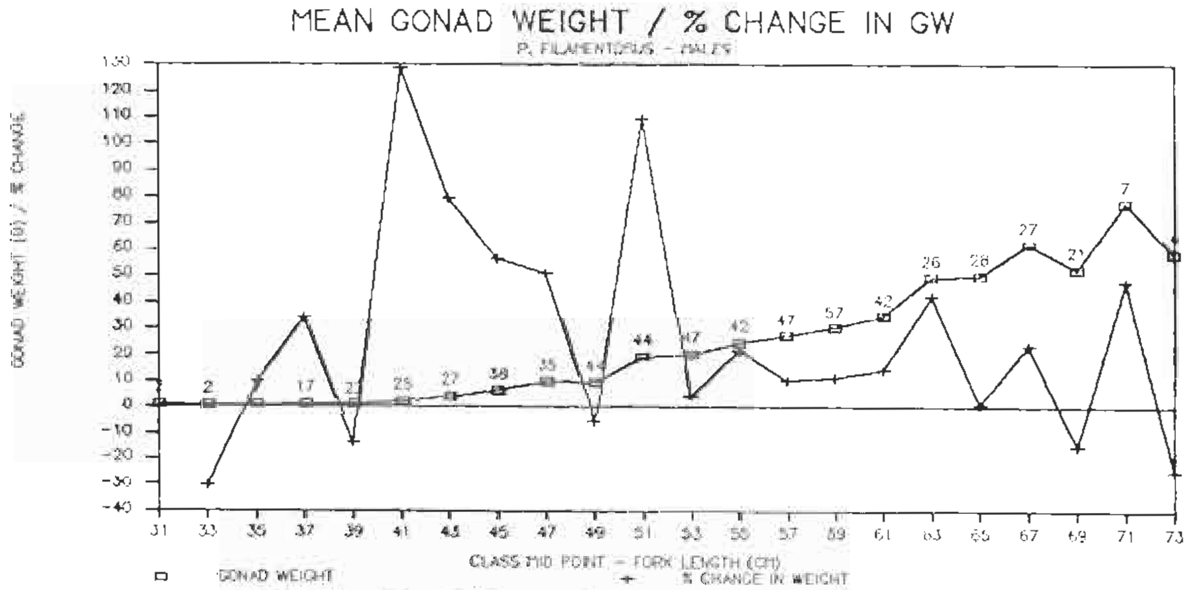


FIG. 6.6.



In summary, female *P. filamentosus* mature in the size class 36-38cm. The smallest specimen with a mature gonad measured 33.2 cm but was probably a precocious fish, and the smallest spawning female observed measured 38.1 cm. Males first mature in the size class 40-42 cm. Maturity is positively correlated with fish size, and a greater proportion of fish are sexually active at larger sizes.

SEASONALITY OF SPAWNING

Tables 6.3 and 6.4 indicate the proportion of the fish sampled each month at each stage of maturity, and Figures 6.7A and B indicate the proportion of mature female *P. filamentosus* each month in the LFS and BS samples, respectively.

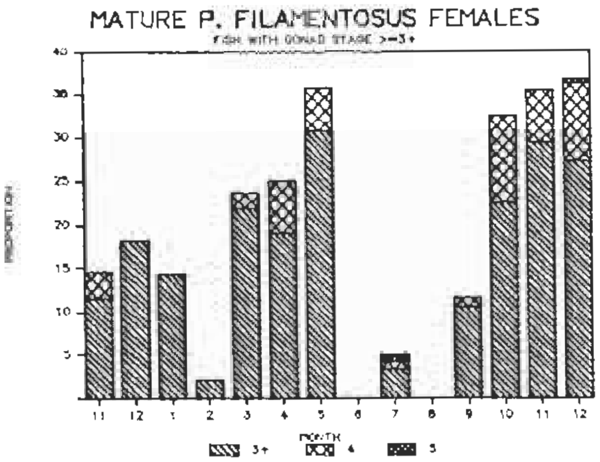
TABLE 6.3. PROPORTION OF FEMALES AT EACH MATURITY STAGE EACH MONTH (LFS)

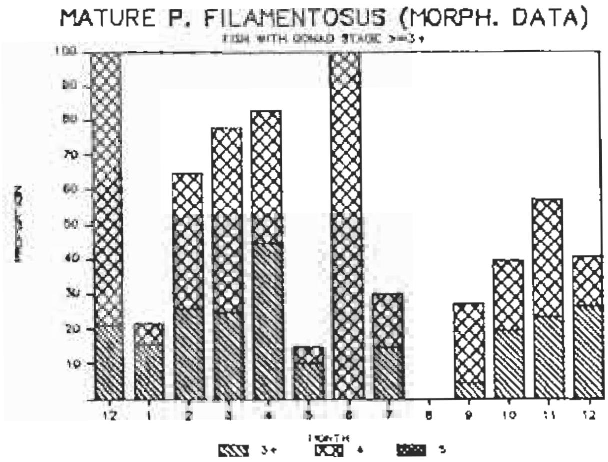
MONTH	N.	MATURITY STAGE						
		1	2	3	3-	3+	4	5
11	130		58.5	15.4	11.5	11.5	3.1	
12	116		56.9	10.3	14.7	18.1		
1	63		42.9	30.2	12.7	14.3		
2	91		51.6	13.2	33.0	2.2		
3	165		53.9	1.2	21.2	21.8	1.8	
4	189	2.6	54.5	4.8	13.2	19.0	5.8	
5	160	3.8	41.3	1.3	18.1	30.6	5.0	
6	74		78.4	12.2	9.5			
7	121		65.3	1.7	28.1	3.3	0.8	0.8
8	18		72.2		27.8			
9	182		37.4	1.1	50.0	10.4	1.1	
10	280	0.7	47.5	2.5	16.8	22.5	10.0	
11	198		41.4	2.0	21.2	29.3	6.1	
12	169		39.1	0.6	23.7	27.2	8.9	0.6
TOTAL	2007	0.6	50.7	5.0	21.5	17.8	4.2	0.1

TABLE 6.4. PROPORTION OF FEMALES AT EACH MATURITY STAGE (BS)

MONTH		MATURITY STAGE						
		1	2	3	3-	3+	4	5
12	19					21.1	78.9	
1	51		72.5		5.9	15.7	5.9	
2	127		27.6	0.8	7.1	26.0	38.6	
3	85		22.4			24.7	52.9	
4	58		12.1		5.2	44.8	37.9	
5	20		45.0		40.0	10.0	5.0	
6	1						100.0	
7	20		55.0		15.0	15.0	15.0	
8								
9	22		68.2		4.5	4.5	22.7	
10	86		58.1	1.2	1.2	19.8	19.8	
11	21		38.1		4.8	23.8	33.3	
12	79		36.7		22.8	26.6	13.9	
TOTAL	570		38.6	0.4	8.2	24.0	28.8	

FIGS. 6.7.A, 6.7.B



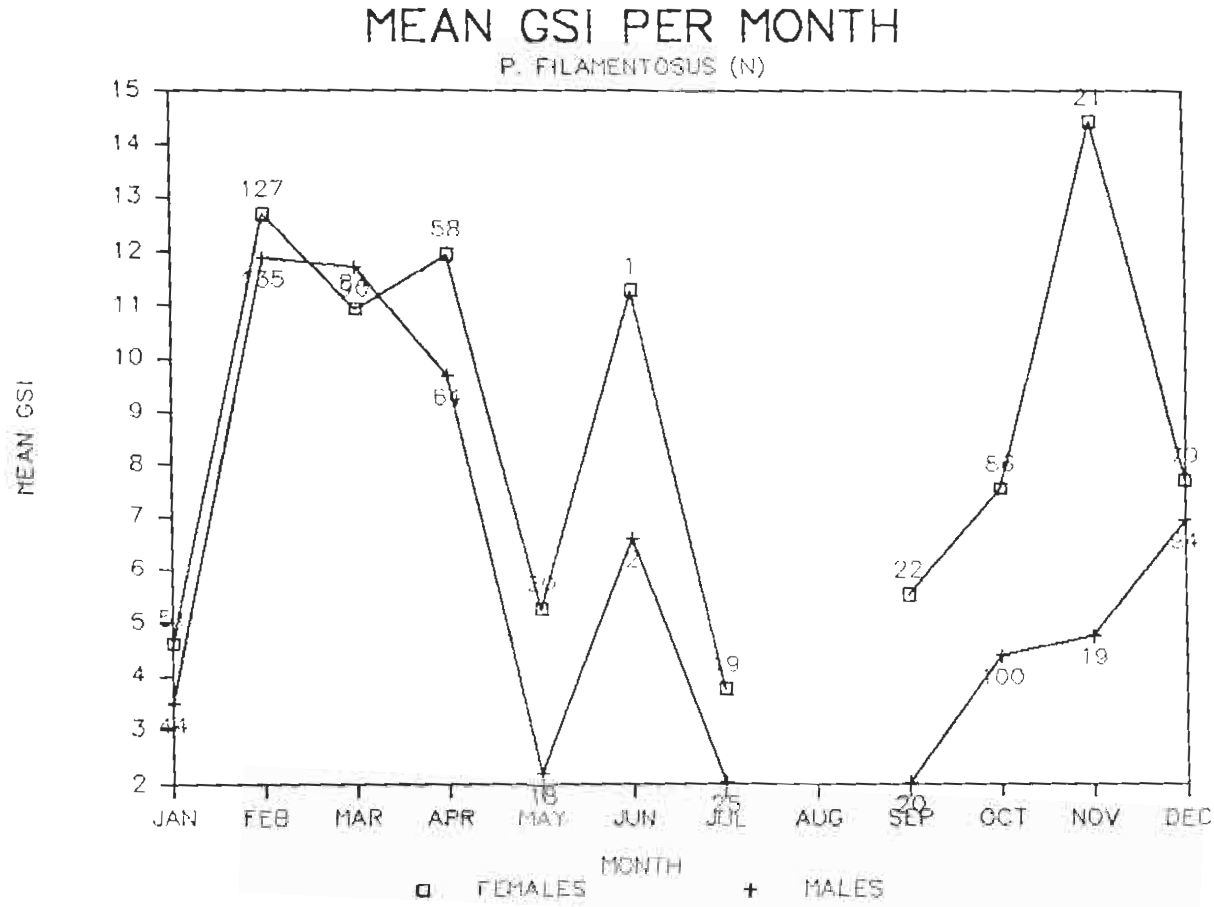


It would appear that there are mature fish and spawning fish throughout the whole year. However, the two sets of data also imply either a protracted spawning period from September to May, or two spawning periods, from February to April/May and from October to December, with a decrease in sexual activity in January and from June to August (for the BS the June sample size was one fish which happened to be spawning \1).

Figure 6.8. indicates the mean GSI recorded for both males and females in BS each month. This data suggests that gonadal development (ie production of gametes within the gonads leading to an increase in the weight of gonadal tissue) begins around October, but reaches a peak during the period February to April, and declines again from May to September. The development of ovaries and testes coincide, although there is a discrepancy in November when a peak was observed for females. Little emphasis has been placed on the result for June when only 2 males and 1 female were sampled. This analysis will be refined by the addition of a second year of data.

\1) It is also apparent that a greater proportion of mature fish are observed in BS than LFS suggesting that possibly LFS underestimate the number of mature fish since their gonads have been completely removed. 72.8% of the LFS sample were immature (stage <= 3-) cf. 46.8% of the BS sample.

FIG. 6.8.



In summary, *P. filamentosus* has a protracted spawning season extending from October to April, with a major spawning period between February and April and a lesser one in November/December. During these months a greater proportion of fish may be expected to be spawning, although throughout the whole year a certain number of spawning fish may be caught.

6.2. *APRION VIRESCENS*

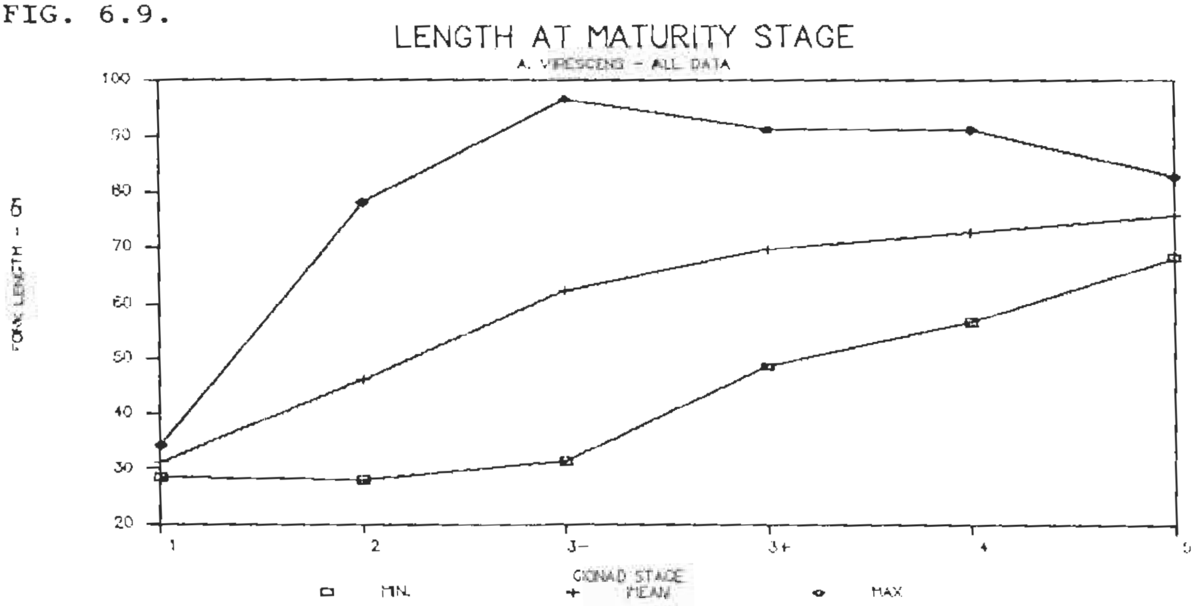
SIZE AT SEXUAL MATURITY

A summary of the data relating to size at maturity stage for *A. virescens* appears in Table 6.5. for LFS, and the minimum, maximum and mean lengths observed for each stage are indicated in Figure 6.9.

TABLE 6.5. MEAN FORK LENGTH AT EACH MATURITY STAGE, AND THE MINIMUM SIZE OBSERVED FOR MATURE FISH EACH MONTH

MONTH	MATURITY STAGE							MINIMUM FL / STAGE		
	1	2	3	3-	3+	4	5	3+	4	5
11		45.52	69.65	71.22	72.22	75.37	78.20	53.70	65.10	76.00
12	29.50	52.41	69.05	68.15	66.30	68.24		65.00	59.60	
1	30.35	46.65	64.93	68.62	70.63	72.95	70.50	48.70	69.20	70.50
2	34.15	41.87	60.89	60.36	69.00	66.55		51.60	56.60	
3		40.44	64.32	60.43	70.60	75.86		60.90	67.40	
4		44.57	57.34	59.60	73.57	73.09	68.30	58.30	63.50	68.30
5		49.82		62.19	70.48			64.80		
6		40.92	75.05	60.95	72.28			64.50		
7		52.13	61.50	63.28	72.38	87.40		58.40	87.40	
8		45.69	58.80	57.48	74.85			74.20		
9		42.27		65.45	71.87	77.00	77.10	61.40	77.00	77.10
10	29.50	49.16	77.67	64.59	69.83	74.90		54.30	66.00	
11		50.84	62.50	60.20	67.73	69.39		51.70	61.40	
12		45.31	63.13	62.92	69.29	69.47		58.60	61.20	
TOTAL	31.33	46.33	65.31	62.50	69.90	72.87	75.86	48.70	56.60	68.30

FIG. 6.9.

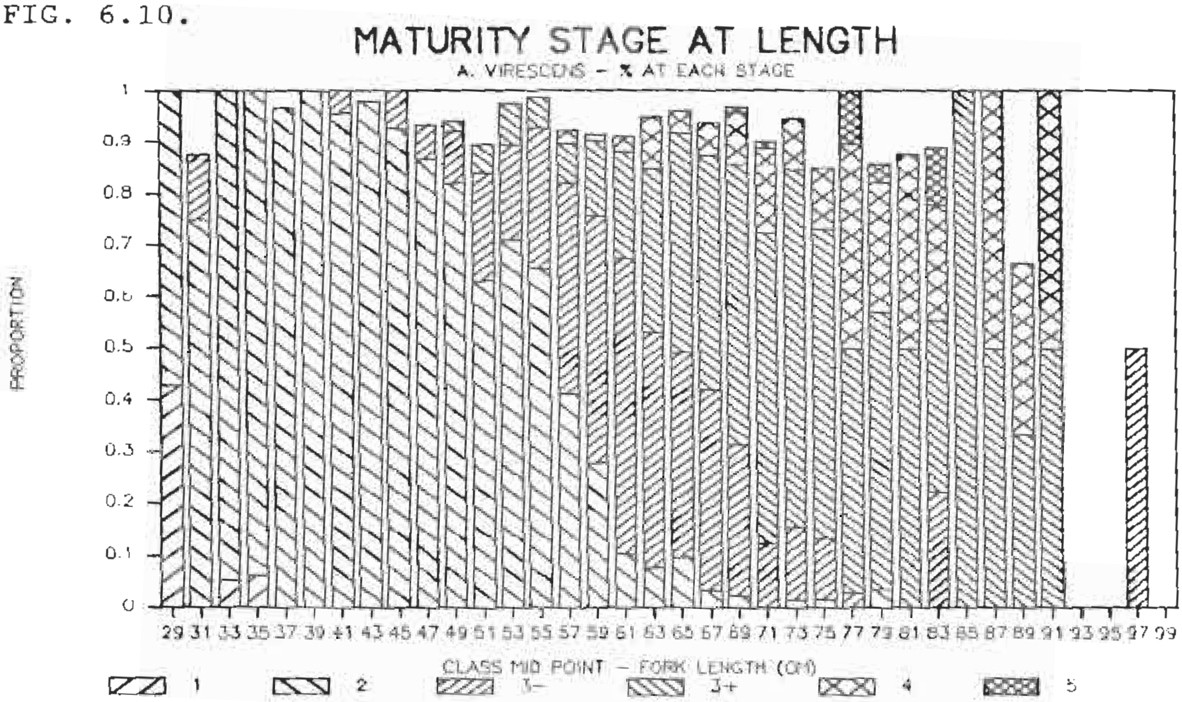


The minimum size at which a mature gonad was observed was 48.7 cm FL, and for spawning fish was 56.6cm. Maturity stage was positively correlated to fork length (1). A greater proportion

1) Maturity Stage = 0.0601xFL-1.4762 ($r=0.7836$, $F=1880$, $df=1183$, $P<0.001$)

of fish had mature gonads at greater fork lengths. This is illustrated in Figure 6.10. 57.9% of all fish sampled were immature (maturity stage 3- or less). The length at which 50 % of fish were mature (stage 3+ or greater) was 62 - 64 cm.

FIG. 6.10.



SEASONALITY OF SPAWNING

Table 6.6 indicates the proportion of fish sampled each month at each stage of gonadal development, whilst Figure 6.11 indicates the proportion of mature fish sampled each month during the study period.

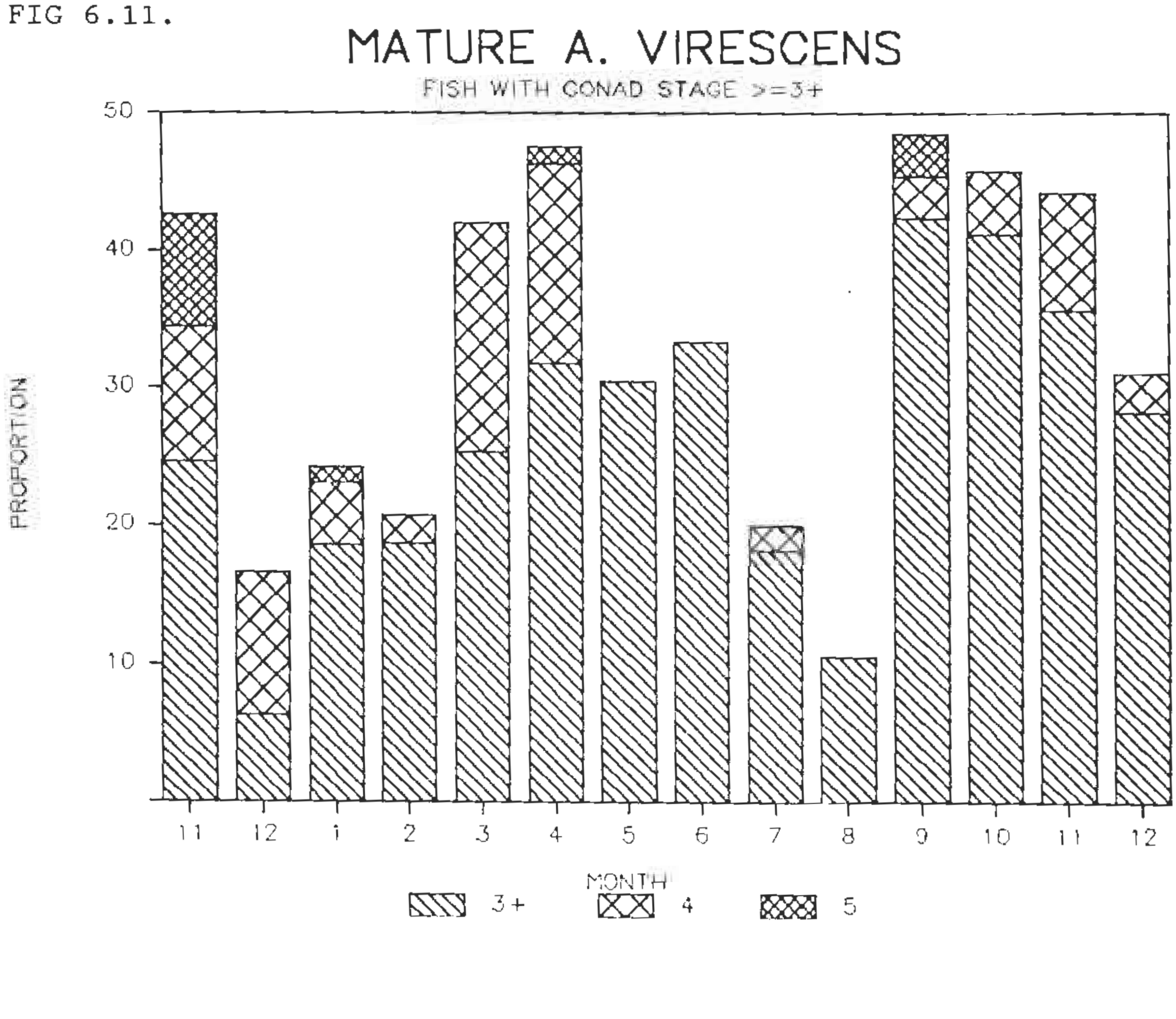
Female *A. virescens* with mature gonads were observed throughout the entire year, but spawning fish were mainly seen between September and April (apart from a small number observed in July). This suggests a protracted spawning period, and the data also indicates peak spawning times within this period, of September to November, and March and April.

To perform this regression, MS 2,3-,3+,4,5 were converted to 1,2,3,4,5 respectively. Stage 3 (undetermined) was not used.

TABLE 6.6. PROPORTION OF FEMALES AT EACH MATURITY STAGE PER MONTH

MONTH	N.	MATURITY STAGE						
		1	2	3	3-	3+	4	5
11	61		36.1	13.1	8.2	24.6	9.8	8.2
12	48	2.1	50.0	22.9	8.3	6.3	10.4	
1	91	2.2	45.1	14.3	14.3	18.7	4.4	1.1
2	96	2.1	50.0	14.6	12.5	18.8	2.1	
3	150		38.0	6.0	14.0	25.3	16.7	
4	82		39.0	6.1	7.3	31.7	14.6	1.2
5	59		42.4		26.3	30.5		
6	15		40.0	13.3	13.3	33.3		
7	55		25.5	1.8	52.7	18.2	1.8	
8	19		47.4	10.5	31.6	10.5		
9	33		12.1		38.1	42.4	3.0	3.0
10	153	0.7	26.1	2.6	24.8	41.2	4.6	
11	258		25.2	0.8	29.8	35.7	8.5	
12	138		39.1	2.2	27.5	28.3	2.9	
TOTAL	1258	0.5	35.1	5.9	22.3	28.6	7.1	0.6

FIG 6.11.



6.3. *LUTJANUS SEBAE.*

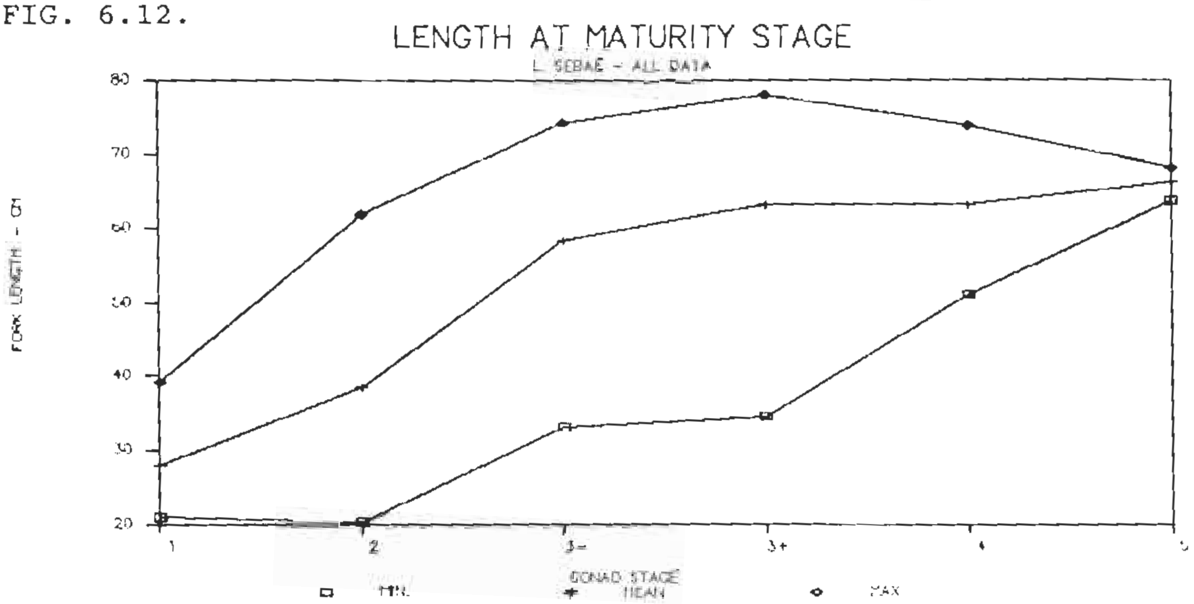
SIZE AT SEXUAL MATURITY

Table 6.7 summarises the data relating to size at maturity stage for *Lutjanus sebae*, and Figure 6.12 indicates the minimum, maximum and mean size of fish observed at each maturity stage throughout the study period.

TABLE 6.7. MEAN FORK LENGTH AT EACH MATURITY STAGE, AND THE MINIMUM SIZE OBSERVED FOR MATURE FISH EACH MONTH

MONTH	MATURITY STAGE							MINIMUM FL / STAGE		
	1	2	3	3-	3+	4	5	3+	4	5
11		44.17	57.80	58.34	61.55	63.18	66.43	51.4	51.2	63.8
12		35.35	60.21	56.62	62.17	62.37		54.5	57.4	
1		31.84	57.21	56.58	61.45	61.70		55.0	59.5	
2		35.71	59.38	58.56	61.07	61.80		50.5	58.1	
3		36.47	56.20	58.74	61.58	64.24		34.6	59.1	
4		36.66	52.30	58.14	64.25	65.90		52.4	64.4	
5		36.12		58.51	61.89	66.27		54.4	63.5	
6		41.10		52.90						
7		39.59	37.00	58.15	64.40	66.60		61.3	66.6	
8		39.91		56.03	67.60			65.4		
9	31.27	38.88		58.27	64.58			57.8		
10	26.13	41.04		59.29	64.44	62.06		53.4	51.2	
11		47.79		59.57	65.61			57.3		
12	28.90	38.39		57.76	65.35			51.2		
TOTAL	27.98	38.50	58.13	58.33	63.17	63.17	66.43	34.6	51.2	63.8

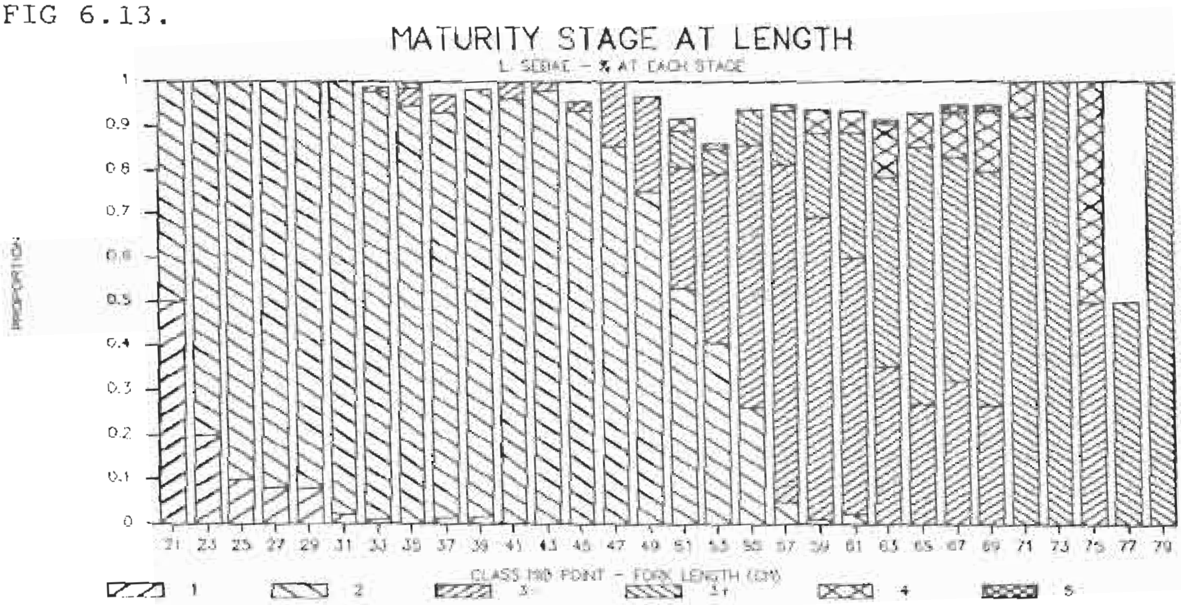
FIG. 6.12.



The minimum size at which a matured gonad was recorded was 34.6cm (March), and the smallest spawning fish was 51.2cm fork length. The former may have been a misidentification, since this value is considerably less than observed during any other month. A positive correlation existed between fork length and maturity stage (\1).

Figure 6.13 indicates the proportion of fish at each maturity stage by length of fish. It is apparent that a large proportion of females caught were immature (74.5% were at stage 3- or less and 44.3% had undeveloped gonads, stage 1 or 2: \2). The proportion of mature fish increases with increasing fork length, but only 3.4% of the entire sample were spawning. The length at which 50 % of the sampled population were mature (stage 3+ or greater) was 61 - 63 cm.

FIG 6.13.



SEASONALITY OF SPAWNING

Table 6.8. indicates the proportion of fish at each stage of development per month during the study period, the proportion of mature fish being illustrated in Fig 6.14. Mature fish were recorded throughout the year, but a greater proportion were evident during October / November and March to May. Spawning fish were observed between October and May and in July.

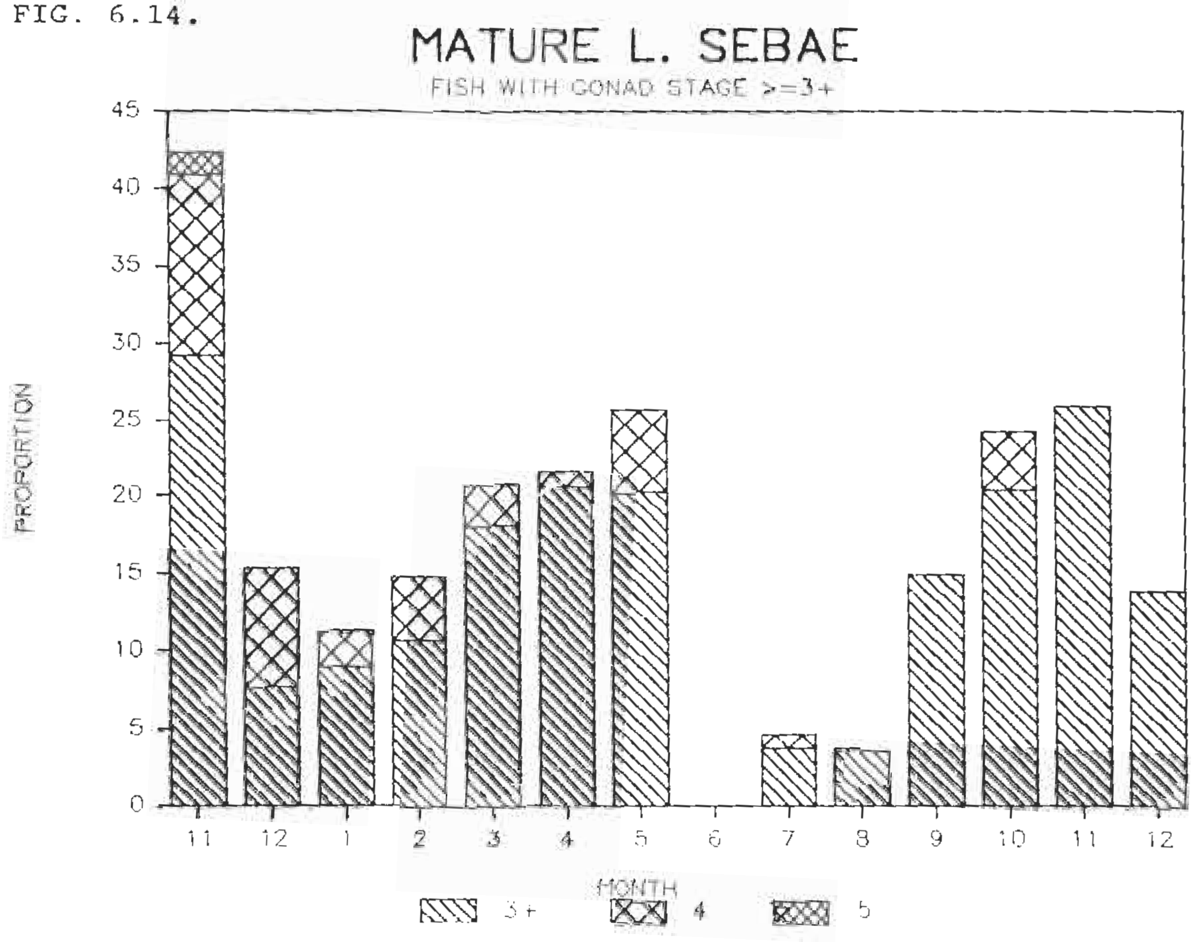
\1) Maturity Stage = 0.0510xFL-0.7616 (r=0.7726, F=843.86, df=1860, P<0.001)

\2) It is not clear whether this is a result of interpretation of LFS data or whether it reflects the true situation (see data for *P. filamentosus* for comparison).

TABLE 6.8. PROPORTION OF FEMALES AT EACH MATURITY STAGE PER MONTH

MONTH	N.	MATURITY STAGE 1	2	3	3-	3+	4	5
11	212	0.0	19.8	17.9	19.8	29.2	11.8	1.4
12	78	0.0	30.8	17.9	35.9	7.7	7.7	0.0
1	88	0.0	60.2	11.4	17.0	9.1	2.3	0.0
2	196	0.0	36.2	11.2	37.8	10.7	4.1	0.0
3	304	0.0	48.4	1.3	29.6	18.1	2.6	0.0
4	204	0.0	49.5	0.5	28.4	20.6	1.0	0.0
5	74	0.0	41.9	0.0	26.3	20.3	5.4	0.0
6	3	0.0	33.3	0.0	66.7	0.0	0.0	0.0
7	108	0.0	55.6	0.9	38.9	3.7	0.9	0.0
8	53	0.0	41.5	0.0	54.7	3.8	0.0	0.0
9	120	5.8	40.8	0.0	38.1	15.0	0.0	0.0
10	264	4.9	40.5	0.0	30.3	20.5	3.8	0.0
11	135	0.0	45.2	0.0	28.9	25.9	0.0	0.0
12	108	0.9	67.6	0.0	17.6	13.9	0.0	0.0
TOTAL	1947	1.1	43.2	4.6	30.2	17.3	3.4	0.2

FIG. 6.14.



7. GROWTH AND MORTALITY

7.1. RELATIVE GROWTH

Relative growth refers to the fact that an increase in size of certain dimensions of an animal (fish) may occur at different rates to others. In general, growth may be explained by the equation:

$$Y = a.X^b \quad (1)$$

which is the form of a curvilinear relationship. 'a' and 'b' are constants where 'b' (sometimes written as alpha) indicates the relative growth rate, or level of allometry. Positive allometry occurs when 'b' is greater than 1 and isometric growth occurs when 'b' is equal to 1, that is, the body dimensions grow at an equal rate throughout time. In general, the dimensions of a fish will display isometric growth unless they relate to a secondary sexual characteristic such as the large claws of male lobsters. A classical example of positive allometry is the length weight relationship where the weight of a fish increases in proportion to the length cubed (weight is approximately equal to volume so approximately length $(cm)^3$).

The above equation may be linearised for ease of analysis by a logarithmic transformation:

$$LOG.Y = LOG.a + b.LOG.X \quad (2)$$

where 'b', the level of allometry, is the slope of a linear regression line. When isometric growth occurs a linear regression may be applied directly to the two dimensions concerned without performing the logarithmic transformation.

In this section, the relative growth of different dimensions of *P. filamentosus* are presented in relation to the reference dimension of Fork Length, expressed in centimetres. Relative growth may be used to examine whether sexual dimorphism occurs and to examine whether differences occur between samples of the same species of fish taken from different locations. This would indicate whether the populations were discrete or homogeneous. The specific case of the length weight relationship is also used in fisheries biology to help convert sampled length frequency data into weight at length, necessary for production analyses.

Fish used in morphometric studies were chosen to encompass the entire size range observed. The fishing location was recorded, but due to the relatively vague answers given by fishermen it was only possible to differentiate locations according to direction from Mahe, specific banks or locations seldom being reported. For the purpose of this study the locations were grouped to give 5 fishing areas : South (1), North (2), East (3), West (4), of the Mahe Plateau, and the Amirantes (5).

To compare the results of regression analyses by sex and location the slopes of the regressions were compared using the t-test:

$$t = (b_1 - b_2)/((df_1SE_1{}^2 + df_2SE_2{}^2)/(df_1 + df_2))^{-2}$$

The degrees of freedom for t are:

$$df = 1/((U^2/N_1{}^{-2})+((1-U^2)/N_2{}^{-2}))$$

where,

$$U = (SE_{biggest})^2/(SE_1{}^2 + SE_2{}^2)$$

b_1 and b_2 area the slopes of the regression lines

SE_1 and SE_2 are the standard errors of b_1 and b_2

df_1 and df_2 are the degrees of freedom for the two lines

N_1 and N_2 are the number of data sampled

LENGTH WEIGHT RELATIONSHIP

Equation (1) is usually written:

$$W = q.L^b \quad (3)$$

to express the length (L) weight (W) relationship. After logarithmic transformation and analysis by linear regression the slope provides an estimate of 'b', whilst 'q' is the antilog of the intercept 'a'.

Log. transformed data for *P. filamentosus* was analysed and the length weight relationships given in Table 7.1.1 were derived. A comparison of these data by sex and location appears in Table 7.1.4. and 7.1.5 respectively.

TABLE 7.1.1. LENGTH (cm) WEIGHT (Kg) RELATIONSHIPS FOR *P. FILAMENTOSUS* BY SEX AND SAMPLING LOCATION.

POPn.	VARIABLE (Y)	REF. (X)	EQUATION	S.E.b	r2	F	P	N
ALL	WEIGHT	F.L.	LOG.Y = 2.7004 x LOG.X - 4.2714	0.0167	0.9568	26125.8	<0.001	1182
MALES	WEIGHT	F.L.	LOG.Y = 2.7097 x LOG.X - 4.2887	0.0213	0.9637	16172.1	<0.001	612
FEMALES	WEIGHT	F.L.	LOG.Y = 2.6931 x LOG.X - 4.2578	0.0261	0.9493	10645.8	<0.001	570
AREA 1	WEIGHT	F.L.	LOG.Y = 2.8008 x LOG.X - 4.4496	0.0152	0.9782	34033.6	<0.001	761
AREA 2	WEIGHT	F.L.	LOG.Y = 2.5939 x LOG.X - 4.0808	0.0406	0.9186	4086.7	<0.001	364
AREA 3	WEIGHT	F.L.	LOG.Y = 2.8332 x LOG.X - 4.5108	0.0582	0.9805	2368.1	<0.001	49
AREA 5	WEIGHT	F.L.	LOG.Y = 2.6166 x LOG.X - 4.1444	0.2345	0.9540	124.5	<0.001	8

All regressions were highly significant. There was no significant difference between the length weight relationships of males and females (Table 7.1.4) indicating that it is valid to use the results from the complete sample in further analyses and that males and females need not be treated separately. The growth equation for all fish from all locations was:

$$W(Kg) = 0.00005353 \times FL(cm)^{2.7004}$$

The parameters q = 0.00005353 and b = 2.7004 are used in Section 7.3. for determining weight at length.

The eviscerated length weight relationship is given in Table 7.1.2. for reference purposes. Also given is the relationship between eviscerated weight and whole weight, and eviscerated fork length and whole fork length in order that these parameters may be derived should only an eviscerated sample of fish be available. Weights are expressed in Kg and lengths in cm in these equations.

TABLE 7.1.2. RELATIONSHIPS FOR EVISCERATED FISH

POPn.	VARIABLE (Y)	REF. (X)	EQUATION	S.E.b	r2	F	P	N
ALL	EVISC.WT	E.FL	LOG.Y = 2.7016 x LOG.X - 4.3059	0.0192	0.9440	19848.0	<0.001	1180
MALES	EVISC.WT	E.FL	LOG.Y = 2.7148 x LOG.X - 4.3275	0.0204	0.9667	17725.7	<0.001	612
FEMALES	EVISC.WT	E.FL	LOG.Y = 2.6837 x LOG.X - 4.2756	0.0340	0.9164	6217.1	<0.001	569
ALL	EVISC.WT	WT.	LOG.Y = 0.9931 x LOG.X - 0.0294	0.0050	0.9714	40080.8	<0.001	1181
MALES	EVISC.WT	WT.	LOG.Y = 0.9942 x LOG.X - 0.0280	0.0045	0.9879	49733.8	<0.001	612
FEMALES	EVISC.WT	WT.	LOG.Y = 0.9908 x LOG.X - 0.0305	0.0091	0.9547	11953.3	<0.001	569
ALL	EVISC.FL	F.L.	Y = 1.0005 x X - 0.0121	0.0010	0.9987	921987.3	<0.001	1181

RELATIVE GROWTH OF BODY PARTS

The following body parts were measured:

Length of first dorsal spine - LFDS
Diameter of eye - DIA_EYE
Distance of first dorsal spine from mouth - DFDSM
Distance from mouth to pre- operculum - PRE_OPER
Distance from mouth to operculum - OPERCULE
Distance between lateral line and first dorsal spine - DBLLFDS

The relationship between these body parts and the reference dimension of Fork Length was examined by sex and location. Isometric growth was assumed so the regression analyses were performed on the original data. Where the result was of low significance (Low r^2, F, High P) log transformation was attempted to see if a better fit of the data might be obtained indicating positive allometry. The isometric models were found to give the best fit. The results are shown in Table 7.1.3.

TABLE 7.1.3. EQUATIONS FOR THE RELATIVE GROWTH OF DIFFERENT BODY PARTS (cm) WITH RESPECT TO FORK LENGTH (cm)

POPn.	VARIABLE (Y)	REF. (X)	EQUATION	S.E.b	r2	F	P	N
ALL	LFDS	F.L.	Y = 0.0367 x X + 0.5761	0.0024	0.4281	232.8	<0.001	319
ALL	DIA_EYE	F.L.	Y = 0.0325 x X + 1.1331	0.0013	0.6546	602.8	<0.001	319
ALL	DFDSM	F.L.	Y = 0.3088 x X - 0.2108	0.0039	0.9514	6258.7	<0.001	321
ALL	PRE_OPER	F.L.	Y = 0.1713 x X + 0.9911	0.0025	0.9354	4601.2	<0.001	319
ALL	OPERCULE	F.L.	Y = 0.0802 x X + 0.3961	0.0023	0.7954	1240.3	<0.001	320
ALL	DBLLFDS	F.L.	Y = 0.1216 x X - 0.1439	0.0033	0.8094	1358.5	<0.001	321

TABLE 7.1.3 Continued.

POPn.	VARIABLE (Y)	REF. (X)	EQUATION	S.E.b	r2	F	P	N
MALE	LFDS	F.L.	Y = 0.0405 x X + 0.3797	0.0046	0.4495	78.4	<0.001	98
FEMALE	LFDS	F.L.	Y = 0.0350 x X + 0.7023	0.0044	0.3862	64.2	<0.001	104
MALE	DIA EYE	F.L.	Y = 0.0309 x X + 1.1802	0.0022	0.6650	196.6	<0.001	101
FEMALE	DIA EYE	F.L.	Y = 0.0302 x X + 1.1440	0.0030	0.5269	114.7	<0.001	105
MALE	DFDSM	F.L.	Y = 0.3073 x X - 0.0780	0.0048	0.9760	4027.9	<0.001	101
FEMALE	DFDSM	F.L.	Y = 0.3079 x X - 0.1926	0.0113	0.8781	749	<0.001	106
MALE	PRE OPER	F.L.	Y = 0.1656 x X + 1.3001	0.0038	0.9499	1877.7	<0.001	101
FEMALE	PRE OPER	F.L.	Y = 0.1703 x X + 1.1523	0.0061	0.8822	779.1	<0.001	106
MALE	OPERCULE	F.L.	Y = 0.0776 x X + 0.5644	0.0030	0.8729	680	<0.001	101
FEMALE	OPERCULE	F.L.	Y = 0.0820 x X + 0.3749	0.0032	0.8656	669.9	<0.001	106
MALE	DBLLFDS	F.L.	Y = 0.1248 x X - 0.2806	0.0051	0.8577	596.5	<0.001	101
FEMALE	DBLLFDS	F.L.	Y = 0.1204 x X - 0.0479	0.0056	0.8137	454.4	<0.001	106
AREA 1	LFDS	F.L.	Y = 0.0378 x X + 0.5448	0.0031	0.4197	144	<0.001	201
AREA 1	DIA_EYE	F.L.	Y = 0.0312 x X + 1.1712	0.0018	0.5895	293	<0.001	206
AREA 1	DFDSM	F.L.	Y = 0.3081 x X - 0.1638	0.006	0.9275	2624.4	<0.001	207
AREA 1	PRE_OPER	F.L.	Y = 0.1672 x X + 1.2656	0.0036	0.9147	2199.5	<0.001	207
AREA 1	OPERCULE	F.L.	Y = 0.0794 x X + 0.4884	0.0022	0.8686	1354.9	<0.001	207
AREA 1	DBLLFDS	F.L.	Y = 0.1227 x X - 0.1673	0.0038	0.8385	1064.4	<0.001	207
AREA 2	LFDS	F.L.	Y = 0.0341 x X + 0.6418	0.0045	0.3818	58.1	<0.001	96
AREA 2	DIA_EYE	F.L.	Y = 0.0378 x X + 0.9563	0.002	0.7861	349.1	<0.001	97
AREA 2	DFDSM	F.L.	Y = 0.3096 x X - 0.2486	0.0047	0.9788	4428.4	<0.001	98
AREA 2	PRE_OPER	F.L.	Y = 0.1735 x X + 0.7784	0.0039	0.9536	1930.2	<0.001	96
AREA 2	OPERCULE	F.L.	Y = 0.0767 x X + 0.4673	0.0058	0.6456	173.1	<0.001	97
AREA 2	DBLLFDS	F.L.	Y = 0.1165 x X - 0.0641	0.0078	0.6991	223.1	<0.001	98
AREA 3	LFDS	F.L.	Y = 0.0287 x X + 1.0477	0.0087	0.4545	10.8	<0.001	15
AREA 3	DIA_EYE	F.L.	Y = 0.0355 x X + 0.8989	0.0036	0.8642	95.4	<0.001	17
AREA 3	DFDSM	F.L.	Y = 0.3085 x X - 0.3235	0.0068	0.9927	2037.8	<0.001	17
AREA 3	PRE_OPER	F.L.	Y = 0.1711 x X + 0.9214	0.0057	0.9834	888.4	<0.001	17
AREA 3	OPERCULE	F.L.	Y = 0.0808 x X + 0.3788	0.0084	0.8617	93.5	<0.001	17
AREA 3	DBLLFDS	F.L.	Y = 0.1234 x X - 0.4201	0.0047	0.9789	694.9	<0.001	17

COMPARISON OF RELATIVE GROWTH OF BODY PARTS BY SEX AND LOCATION

Table 7.1.4. compares male and female *P. filamentosus*. It may be seen that there is no evidence for sexual dimorphism and that the relative growth of all body parts examined was the same for males and females. This was also true for the length weight relationship. One might have expected some difference in this relationship due to the greater weight of gonadal tissue in larger females, but no differences were observed for either whole or eviscerated fish. For analyses by location data for both sexes was thus pooled.

TABLE 7.1.4. A COMPARISON OF THE RELATIVE GROWTH OF BODY PARTS OF MALE AND FEMALE *P. FILAMENTOSUS* BY MEANS OF THE t STATISTIC TO COMPARE THE SLOPE OF REGRESSION (FROM DATA PRESENTED IN TABLES 7.1.1 - 7.1.3)

VARIABLE (Y)	REF. (X)	COMPAR- ISON	t	df	P
WEIGHT	F.L.	M v F	0.6994	1116	>0.1
EVIS.WT	E.FL	M v F	1.1189	990	>0.1
LFDS	F.L.	M v F	1.2227	197	>0.1
DIA EYE	F.L.	M v F	0.4169	183	>0.1
DFDSM	F.L.	M v F	0.0685	134	>0.1
PRE OPER	F.L.	M v F	0.9199	167	>0.1
OPERCULE	F.L.	M v F	1.4175	201	>0.1
DBLLFDS	F.L.	M v F	0.8206	200	>0.1

TABLE 7.1.5. A COMPARISON OF THE RELATIVE GROWTH OF BODY PARTS OF *P. FILAMENTOSUS* FROM DIFFERENT FISHING LOCATIONS

VARIABLE (Y)	REF. (X)	COMPAR- ISON	t	df	P
WEIGHT	F.L.	1 v 2	7.8838	948	<0.001
		1 v 3	1.5903	806	>0.1
		1 v 5	7.1617	764	<0.001
		2 v 3	5.5663	283	<0.001
		2 v 5	0.4524	364	>0.1
		3 v 5	2.2546	51	<0.001
LFDS	F.L.	1 v 2	1.0253	293	>0.1
		1 v 3	2.4620	16	<0.05>0.02
		2 v 3	1.0395	21	>0.1
DIA EYE	F.L.	1 v 2	3.5372	277	<0.001
		1 v 3	2.1758	172	<0.05>0.02
		2 v 3	1.0065	101	>0.1
DFDSM	F.L.	1 v 2	0.2670	296	>0.1
		1 v 3	0.0660	70	>0.1
		2 v 3	0.2185	85	>0.1
PRE OPER	F.L.	1 v 2	1.7041	272	>0.1
		1 v 3	1.0316	126	>0.1
		2 v 3	0.5723	85	>0.1
OPERCULE	F.L.	1 v 2	0.7226	257	>0.1
		1 v 3	0.4586	220	>0.1
		2 v 3	0.6593	85	>0.1
DBLLFDS	F.L.	1 v 2	1.1466	280	>0.1
		1 v 3	0.1810	82	>0.1
		2 v 3	0.9253	97	>0.1

Table 7.1.5 compares the relative growth rates of body parts of *P. filamentosus* from different locations. For the body parts displaying isometric growth significant differences were shown to exist in relation to the length of the first dorsal spine and the diameter of the eye. However, the regressions of these data produced the least good fit (see Table 7.1.3) and so the observation of differences by location for these variables may arise through anomalies of the data. All other isometric variables showed no significant difference by location and within these variables the results were not conclusive.

By contrast, for the positively allometric length weight relationship, a highly significant difference was observed between the South and North, and South and Amirantes, between the North and East, and the East and Amirantes, whilst the North and Amirantes were the same as were the South and East. However, the fact that the other regressions, on balance, showed no location specific differences tends to suggest that this observation does not mean that there are two discrete populations. It is more likely that some other factor explains the difference such as food availability or time of year that each location was sampled (see also 5.1).

To conclude this section : there is no evidence of sexual dimorphism in *P. filamentosus* from Seychelles. The populations from different locations showed no significant differences indicating that they may be treated as a single homogeneous population for stock assessment purposes. However, it should also be stated that the lack of specificity in describing fishing locations may partly explain the apparent homogeneity.

7.2. GROWTH

7.2.1. *PRISTIPOMOIDES FILAMENTOSUS*

Growth parameters were calculated as follows for the example of male *P. filamentosus*. Unless otherwise stated this procedure was used for each sex and species. To implement these analyses routines in the computer aided packages for stock assessment by Sparre (1987, LFSA) and Gayanilo *et. al.* (1988, the compleat ELEFAN) were used as appropriate.

MALES

The Bhattacharya (1967) method was used with each of the monthly length frequencies (Table 7.2.1) in turn in order to determine the mean lengths for each of the normally distributed components in each sample. An example is given in Figure 7.2.1 for the first sample in the series, November 1989. Table 7.2.2. indicates the time series of data, moved laterally relative to each other in order to achieve an arrangement consistent with positive growth between months.

TABLE 7.2.1. *PRISTIPOMOIDES FILAMENTOSUS* MALES, LENGTH FREQUENCY DATA, NOVEMBER 1989 - DECEMBER 1990.

ML	DATE:11	12	1	2	3	4	5	6	7	8	9	10	11	12
25										1				
27										0				
29			1			2				0	2	3		
31		2	0	1	4	1		1	1	1	0	0	3	1
33	3	2	2	1	4	3	3	1	1	1	0	4	2	2
35	1	2	1	3	8	2	3	5	6	1	0	6	3	2
37	4	1	1	5	8	12	10	6	11	2	7	10	3	3
39	12	16	6	7	11	10	3	10	12	3	14	23	3	3
41	9	14	5	8	12	21	11	19	16	5	18	24	10	14
43	7	10	6	8	6	21	21	16	13	6	17	28	13	3
45	20	12	10	3	18	17	21	11	3	1	6	20	8	6
47	10	12	6	6	12	17	14	1	2	1	11	20	11	7
49	6	17	3	5	16	17	10	5	2	1	13	28	16	13
51	15	18	7	6	16	21	9	5	2	1	20	21	17	11
53	18	10	7	6	5	13	11	3	7	1	18	18	14	14
55	15	13	8	10	11	8	6	3	4	0	19	15	9	11
57	10	3	6	3	6	7	6	2	1	0	11	16	15	12
59	12	11	3	3	10	8	8	1	6	1	14	16	12	18
61	14	4	4	3	10	15	3	0	7	1	10	19	22	12
63	11	4	4	3	6	13	9	1	4	0	10	11	11	22
65	6	6	6	0	5	15	8	0	4	1	4	15	15	13
67	4	2	3	1	1	7	4	0	0	1	1	12	4	8
69	4	2	4	1	6	9	4	0	0	2	3	11	9	8
71	0	2	1		2	7	2	1	1		3	7	4	4
73	4	2	1		0	2	3				0	4	4	2
75	2	0			0	1	1				1			0
77		1			1	1	1							1
Sum	187	166	95	83	178	250	171	91	103	31	202	331	208	190

n = 2,286

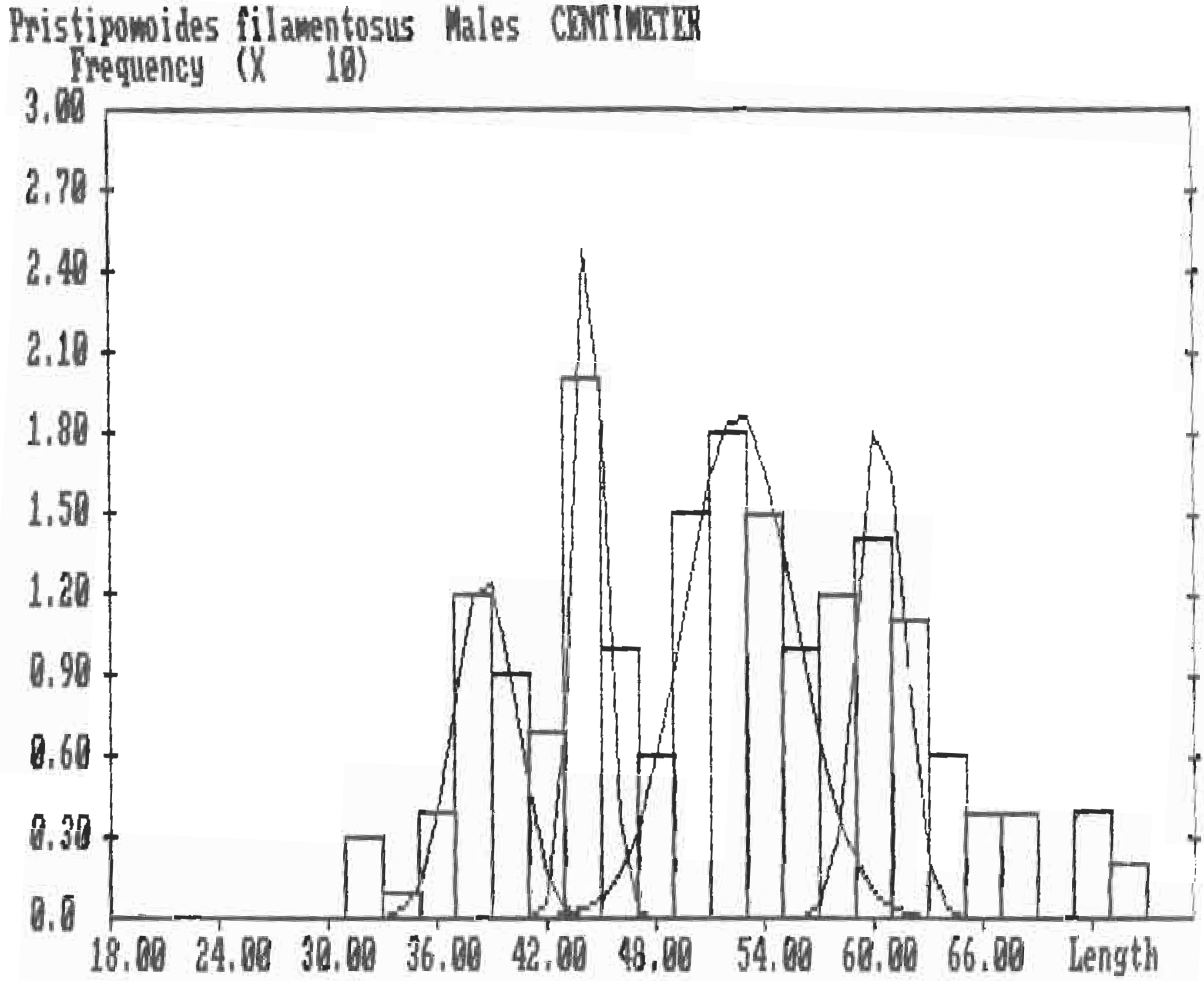


FIGURE 7.2.1: TO SHOW THE MEAN LENGTHS OF THE NORMALLY DISTRIBUTED COMPONENTS OF THE LENGTH FREQUENCY DISTRIBUTION FOR MALE P.FILAMENTOSUS FOR NOVEMBER 1989 - BHATACHARYA METHOD.

TABLE 7.2.2. MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.1

MONTH	MODES IDENTIFIED						N
11		39.6	**45.3**	53.6		61.4	187
12		39.9	49.7				166
1		**39.8**	45.1	54.6		64.8	95
2		**41.8**		54.7			83
3		39.6	**49.7**		60.0		178
4	**33.5**	**42.7**	**50.6**		62.8		250
5	**37.0**	**44.3**	**52.6**	58.1	63.8		171
6	36.3	41.9	51.0				91
7	**39.6**		**54.5**				103
8	**41.4**						31
9	40.9		53.1	61.8			202
10	42.0	**49.5**	53.8				331
11	**42.8**	**51.7**	**61.0**				208
12	41.0	**52.0**	**62.1**				190

The difference between mean lengths corresponds roughly to the difference observed over 6 months of data, indicating that probably two cohorts enter the fishery each year with the age difference between cohorts being about 6 months (\1). However, if correct, the growth over one year is 12-15cm which is quite considerable and equates to 0.033-0.041 cm/day compared with 0.022cm/day in Hawaii estimated for the same species on the basis of daily rings on otoliths (Ralston, 1981).

Modal Progression Analysis was next performed : the progression of the identified means through time was achieved by linking those highlighted in Table 7.2.2. Those means which indicated negative growth were excluded from this analysis. It was only possible to satisfactorily resolve three cohorts. The von Bertalanffy growth parameters (L_{oo}, K) were obtained by the Gulland and Holt (1959) method, and are given in Table 7.2.3.

Next ages were assigned to each of the cohorts used from each sample. This was done iteratively relative to arbitrary birth dates of January 1 and July 1. A modification of the original von Bertalanffy (1934) method as executed through the programme LFSA was then used to estimate t_0 and K for the (forced) value of L_{oo} obtained from the method of Gulland and Holt. The results for the January and July cohorts appear in Table 7.2.3. In fact, the 'Best Choice' of von Bertalanffy parameters for both cohorts produced values of L_{oo} in excess of 120 cm at which point the iteration was not continued. This indicates that the original data set was not sufficiently robust to produce a meaningful result (\2). As a consequence the values reported here should only be regarded as initial estimates to be refined as more data becomes available. As a further check, the method of Stomatopoulos and Caddy (1989) which also uses length at age data to calculate the von Bertalanffy growth parameters, was applied

\1) Chapter 6 indicated that there was a prolonged spawning period with peaks around November and April-May, the latter being stronger.

\2) or that it has been incorrectly interpreted, although the Bhatacharya analysis was repeated several times until the author was satisfied that the modes identified could not be improved upon. Several variations were also attempted in the MPA but that given was considered to be the best fit to the data.

to this data. Again unacceptably high values of L_{oo} were obtained (results not shown).

Next, in order to attempt to refine the estimates of L_{oo} and K the values obtained from the Gulland and Holt analysis were used as initial values in the 'response surface analysis' and 'optimising parameters' routines of ELEFAN I.

Guyanilo *et. al.* (1988) suggest that the procedure described above requires subjective judgement which can lead to large potential errors. They argue that by reformulating the method described above the subjective element has been removed in the analytical package 'ELEFAN I' of the compleat ELEFAN. The method, originally described in Pauly and David (1981), consists of two major steps: restructuring the length frequency data in order to emphasise the peaks and troughs (modes); fitting a growth curve. Pauly and David (1981) defined an objective measure of the goodness of fit of the growth curve to the restructured length frequency data as the ratio of the 'Explained Sum of Peaks' to the 'Available Sum of Peaks': $Rn=10^{ESP/ASP}/10$, that is, the 'score' achieved when the growth curve passes through a peak compared with the potential maximum score for that growth curve. The growth curve with the highest Rn value fits the data best. ELEFAN I also allows the fitting of a seasonalised von Bertalanffy growth curve for which the additional parameters WP (Winter Point) and C (amplitude of oscillations) are required.

Initial estimates of L_{oo} and K are required. L_{max} may be used (or the mean of the 10 largest fish in the sample), or the Wetherall *et. al.* (1987) method may be applied to obtain an initial estimate of L_{oo}. The response surface routine of ELEFAN I must next be used to obtain an estimate of K and refine that of L_{oo}. The values of L_{oo} and K identified are then seeded into the Automatic Search Routine in order to find the optimum parameters. This routine attempts a large number of growth curves and computes Rn for each of them. The best combination of parameters is that which produces a growth curve with the highest Rn value (in this report the values shown are Rn*1000). A seasonalised growth curve may also be fitted to the data by employing the Response Surface Analysis routine to identify the best WP and C values and seeding these with L_{oo} and K into the Automatic Search routine.

For the example of male *P.filamentosus* the seeded values were:

(i) Those obtained from the Gulland and Holt plot of the modal progression analysis

(ii) L_{oo} obtained from the Wetherall *et. al.* plot of ELEFAN II

(iii) L_{max} (see Chapter 5, this report)

For each combination of parameters growth curves were computed both with and without seasonal oscillation. The results for each computation appear in Table 7.2.3 for this example, but for the remaining species / sex only those parameters of the growth curve considered to best fit the data are shown.

In order to compare the growth curves with those achieved by other authors Munro's phi prime test (Munro and Pauly, 1983) was applied. Species within the same family have very similar values of phi prime. If two values of phi prime representing alternative estimates of growth parameters of the same stock, or of stocks of the same species, differ greatly it indicates that one (or both) of the estimates are biassed.

$$\text{phi prime} = \text{Log}K + 2*\text{Log}L_{oo}$$

TABLE 7.2.3. ESTIMATES OF THE VON BERTALANFFY GROWTH PARAMETERS DERIVED FOR MALE *P. FILAMENTOSUS*

ANALYSIS PERFORMED	GROWTH PARAMETERS L_{oo}	K	WP	C	t0	SSD Rn*	SS	SL	MUNRO Phi'
Gulland and Holt	85.59	0.44							3.508
VONBER/LFSA-July	85.59	0.45			-0.333	20.9			3.518
-Jan	85.59	0.34			-0.834	2.07			3.396
ELEFAN I									
(i)	85.80	0.30				166	9	52	3.344
(ii)	73.20	0.40				159	1	44	3.331
(iii)	77.60	0.53				158	4	54	3.499
(i) / seasonal	85.10	0.39	0.65	0.90		176	3	44	3.451
(ii) / seasonal	73.20	0.47	0.75	1.00		200	11	72	3.536
(iii) / seasonal	77.60	0.33	0.80	0.70		188	1	44	3.291

* SSD for VONBER, Rn for ELEFAN I

FEMALES

The length frequency data for female *P. filamentosus* appears in Table 7.2.4 and the mean lengths of the components identified by the Bhattacharya method, arranged to show positive growth (as much as possible) with time appear in Table 7.2.5. The Gulland and Holt analysis of the modal progression indicated by highlighted data produced values of L_{oo}=136.13 cm and K=0.122. A number of other progressions were attempted but a more satisfactory result was not obtained. Since these values were considered unrealistic the VONBER analysis was not performed. ELEFAN I was next used to analyse the data using as the starting L_{oo} that derived for males above, L_{max}, and that calculated by the Wetherall *et. al.* method. L_{max} gave the best fitting growth curve, the parameters of which are given in Table 7.2.8. with and without seasonal oscillation.

TABLE 7.2.4. *PRISTIPOMOIDES FILAMENTOSUS* FEMALES, LENGTH FREQUENCY DATA, NOVEMBER 1989 - DECEMBER 1990.

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
29											1	2		1
31		1		1		6	2		1		2	0	2	2
33	1	0		1	3	7	6	1	1		2	2	2	5
35	3	2		3	7	9	5	3	6	4	2	3	3	5
37	6	3		4	4	7	6	5	12	2	3	8	4	1
39	7	4	4	9	13	11	14	11	8	2	13	33	10	6
41	9	9	6	7	14	25	9	13	22	2	15	15	9	7
43	10	5	1	5	10	21	18	16	15	1	13	21	13	8
45	10	22	5	7	16	15	6	6	6	0	4	25	14	8
47	13	17	1	5	10	9	15	4	5	1	7	16	6	11
49	3	6	4	7	8	12	14	2	5	1	16	23	16	18
51	11	8	8	3	13	10	5	3	5	0	26	15	17	11
53	16	7	9	9	14	7	6	4	6	1	19	17	14	9
55	8	11	3	5	5	8	8	0	9	0	12	12	11	9
57	6	6	2	7	4	6	7	1	7	1	13	23	5	15
59	7	4	0	3	9	10	3	1	6	0	15	11	11	12
61	6	3	11	2	11	7	5	3	2	1	12	19	18	15
63	7	3	0	3	5	6	9	0	2	1	2	12	18	11
65	3	1	1	1	7	4	9	1	1	1	2	6	7	4
67	1	1	4	4	7	3	4		0		2	4	6	7
69	2	1	2	5	4	3	6		1		0	7	10	1
71	0	2	2		1	3	3		1		1	3	2	1
73	1											1		1
75												0		1
77												2		
Sum	130	116	63	91	165	189	160	74	121	18	182	280	198	169

n = 1,956.0

TABLE 7.2.5. MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.4.

MONTH	MODES IDENTIFIED						N
11		38.7	**44.8**	**52.8**	59.3	63.1	130
12		41.2	**45.4**	**54.9**	62.0		116
1		40.4		51.8		67.3	63
2		39.5	45.4	53.3	62.5		91
3	35.2	43.9	51.6	60.5	66.7		165
4	**34.6**	41.6	**49.5**	**59.4**			189
5	33.7	41.8	48.1	55.4	63.8	69.9	160
6	33.7	42.6					74
7	**40.4**		49.5	55.3			121
8	34.0						18
9	**41.2**		**50.9**	58.7			182
10	39.3	44.6	52.7	61.5	69.1		280
11	**42.5**		**51.5**	**62.3**			198
12	33.0		49.0	61.1			169

First, all analyses were attempted with ELEFAN MPA which is easier to use than LFSA. Certain months proved particularly difficult to fit and next, in the LFSA analysis, those with a sample size of less than 100 were excluded. May, July and October still proved difficult to obtain a satisfactory result. The highlighted figures were those selected for the Gulland and Holt analysis after plotting the data and following potential growth curves - it may be seen that it proved difficult to identify consistent positive growth within cohorts with this data.

TOTAL

The length frequency data collected for the total sample of *P. filamentosus* each month is indicated in Table 7.2.6. The mean lengths of the components identified by the Bhattacharya method, arranged to show positive growth with time, appear in Table 7.2.7.

TABLE 7.2.6. *PRISTIPOMOIDES FILAMENTOSUS*, MALES, FEMALES AND UNDETERMINED : LENGTH FREQUENCY DATA, NOVEMBER 1989 - DECEMBER 1990.

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
25										1				
27										2	2			
29		1	1		1	2				0	3	6		1
31		3	1	6	5	8	2	2	2	1	4	0	5	3
33	9	3	2	3	13	14	12	5	5	1	3	9	5	7
35	8	4	3	8	22	18	12	12	16	6	3	13	8	7
37	13	5	8	15	17	27	18	17	34	4	10	23	10	5
39	25	22	24	23	32	34	27	28	32	7	30	65	14	10
41	29	29	36	25	49	62	33	41	54	7	34	47	22	22
43	26	26	39	21	37	60	52	39	34	8	32	60	34	14
45	41	38	47	19	57	61	41	25	14	1	14	65	27	22
47	41	33	43	21	49	55	41	12	9	2	23	50	23	22
49	22	32	33	21	63	80	39	11	8	2	36	68	35	36
51	61	33	39	15	61	71	34	13	12	1	52	50	53	30
53	69	34	29	22	42	55	38	13	14	2	44	46	41	36
55	52	28	32	24	45	51	24	6	16	0	36	36	30	36
57	57	15	17	17	39	47	17	4	11	1	25	52	27	37
59	38	25	10	23	48	56	23	4	17	1	39	37	35	48
61	46	16	23	9	43	76	22	4	10	3	30	65	49	42
63	44	14	17	12	32	65	27	4	6	1	19	32	45	45
65	28	11	17	14	26	60	30	4	5	4	11	30	26	24
67	16	11	11	9	15	29	16	2	1	1	5	22	11	17
69	26	4	10	19	21	41	20	2	1	2	4	26	19	12
71	8	4	4	5	6	22	10	3	4		4	11	8	7
73	7	2	4	3	2	11	3	1			0	6	4	3
75	3	1	0	1	1	2	6	1			2	0		1
77	1	1	2		1	1	3					2		1
79							1							1
Sum	670	395	**452**	**335**	**727**	**1008**	**551**	**253**	**305**	**58**	**465**	**821**	**531**	489

n = 7,241

In order to achieve positive growth with time it was necessary to assume that certain components existed which were not identified by the Bhattacharya method. These are indicated by '?' in Table 7.2.7. After plotting these results graphically, those components indicated by light print either did not conform to positive growth with time or produced an ill fitting curve when the components were connected. These points were excluded from the modal progression analysis, and so were all points in 'Cohorts' 1 and 2. Cohorts 3 - 6 could be fitted easily, whilst 7 required that a large number of points were excluded. Cohorts 8 - 12 also apparently fitted well. The Gulland and Holt analysis of the modal progression of cohorts 3 - 12 produced negative values for the growth parameters. Using only cohorts 3 - 6 produced values of L_{oo}=67.73 cm and K=0.5064. (When the ill fitting cohort 7 was included, L_{oo}=170.48 cm and K=0.11. Using only cohorts 3 and 4, L_{oo}=77.233 cm and K=0.4265). This analysis was not taken further, and ELEFAN I was next used to establish the parameters of the best fitting growth curve, the results of which appear in Table 7.2.8.. The best curve used the value for L_{oo} derived from the Wetherall et. al. plot as the starting point.

TABLE 7.2.7. MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.6.

MONTH	MEAN LENGTHS OF COMPONENTS IDENTIFIED											
	1	2	3	4	5	6	7	8	9	10	11	12
NOV					33.806	?	41.242	?	47.136	53.124	57.801	61.951
DEC				32.000	?	?	40.450	45.786	52.472	?	59.912	63.954
JAN							42.073	46.225	50.975	?	61.487	
FEB				31.442	?	40.745	?	49.025	54.133	59.138	64.573	69.699
MAR					35.348	41.455	?	49.746	56.063	59.985		
APR				34.581	?	41.325	46.145	50.018	?	61.910	69.834	
MAY			29.000	34.001	?	43.313	49.714	?	59.866	65.077	69.893	75.184
JUN					41.876	?	51.814	58.117	62.001	65.845	71.058	
JUL				37.851	41.953							
AUG			35.630	40.009	?	48.000						
SEP		30.794	?	41.421	?	?	52.002	59.478				
OCT			39.524	?	44.946	?	52.299	60.083				
NOV		32.000	?	43.307	?	51.305	?	61.604				
DEC	27.000	34.601	41.351	?	46.008	49.9 54.0	58.050	62.197	67.895			

TABLE 7.2.8. BEST ESTIMATES OF THE VON BERTALANFFY GROWTH PARAMETERS DERIVED FOR *P. FILAMENTOSUS* WITH ELEFAN I.

SEX	ANALYSIS PERFORMED	GROWTH PARAMETERS							MUNRO
		L_{oo}	K	WP	C	Rn	SS	SL	Phi'
M	non seasonal	85.80	0.30			166	9	52	3.344
M	seasonal growth	73.20	0.47	0.75	1.00	200	11	72	3.536
F	non seasonal	77.60	0.275			163	9	40	3.219
F	seasonal growth	77.60	0.285	1.00	0.85	178	2	44	3.235
ALL	non seasonal	74.25	0.420			217	9	41	3.365
ALL	seasonal growth	74.25	0.420	0.85	0.70	268	10	65	3.365

AGE AT LENGTH FROM OTOLITHS

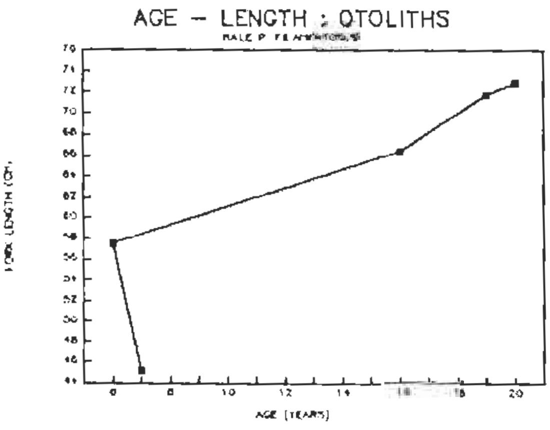
The study of growth is essentially the determination of size (fork length) as a function of age. In temperate waters year rings are laid down on hard parts of fish such as scales and otoliths due to changes in the rate of growth between winter and summer. Such rings may be counted to determine age. In the tropics the lack of distinct seasons means that it is difficult if not impossible to identify such annual rings, and although recently techniques have been developed to count daily rings (see Ralston and Miyamoto, 1981; Radtke, 1987) they are expensive and require sophisticated equipment such as scanning electron microscopes. However, due to the hydrographic changes occurring over the Mahe Plateau it was considered possible that annual rings could be observed and otoliths from 5 male and 5 female *P. filamentosus* were sent to Mr B. Bedford formerly of the Ministry of Agriculture, Food and Fisheries laboratory at Lowestoft in the U.K.. A copy of his report is appended.

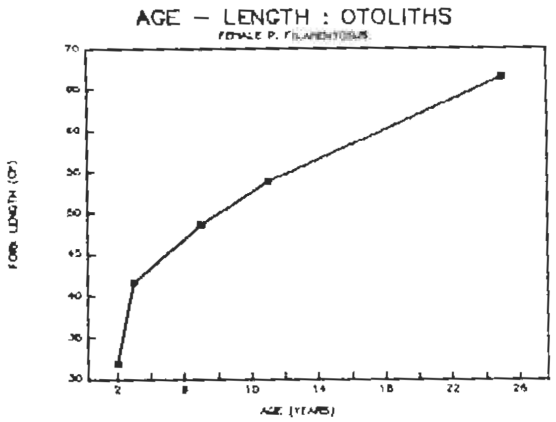
The otoliths examined revealed similar structures and patterns to those observed in temperate water fish, and whilst on the basis of such a small sample it was not possible to state that these were definitely year rings it is a distinct possibility. The rings were not easy to define but nevertheless were apparent. The 'ages' assigned to these fish are shown in Table 7.2.9. and figures 7.2.1 - 7.2.3.

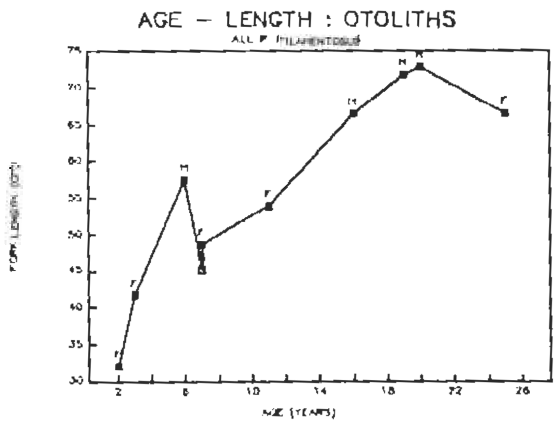
TABLE 7.2.9. AGE AT LENGTH FOR MALE AND FEMALE *P. FILAMENTOSUS* FROM OTOLITH DATA

SEX	LENGTH	AGE	NOTES
M	45.2	7	
M	57.5	6	
M	66.5	16	15-18
M	71.8	19	15+ poss 19
M	72.9	20	15+ poss 18-21
F	32	2	2?3
F	41.7	3	
F	48.7	7	
F	53.9	11	
F	66.6	25	15+ poss 25

FIGURES 7.2.1-3 LENGTH AT AGE FOR MALE, FEMALE AND ALL *P. FILAMENTOSUS*







The method of Stomatopoulos and Caddy (1989) was used to determine the von Bertalanffy growth parameters from this data. Owing to the small sample size little emphasis should be placed on the results presented below. K ranged from 0.0575 for females to 0.1018 for the total sample, which differs considerably from the results based on length frequency data.

FEMALES

AGE (YRS)	Y LENGTH	X Xt	XY	Y2	X2
2.00	32.0000	-0.18	-5.61129	1024.00	0.03
3.00	41.7000	-0.25	-10.4724	1738.89	0.06
7.00	48.7000	-0.49	-23.8991	2371.69	0.24
11.00	53.9000	-0.65	-35.2334	2905.21	0.43
25.00	66.6000	-0.91	-60.6183	4435.56	0.83
count	sum Y	sum X	sum XY	sum Y2	sum X2
5.00	242.9	-2.48109	-135.834	12475.35	1.590383

RESULTS				
	K=	**0.0964**	**L_{oo}=**	**70.04157**
	a=	27.440	L0 =	27.44049
	b=	-42.601	t0 =	-5.158
	r=	-0.9826		
	r2=	0.9654		

MALES

AGE (YRS)	Y LENGTH	X Xt	XY	Y2	X2
7.00	45.2000	-0.33	-14.9771	2043.04	0.11
16.00	66.5000	-0.60	-39.9984	4422.25	0.36
19.00	71.8000	-0.66	-47.7199	5155.24	0.44
20.00	72.9000	-0.68	-49.8171	5314.41	0.47
count	sum Y	sum X	sum XY	sum Y2	sum X2
4.00	256.4	-2.28082	-152.512	16934.94	1.380283

RESULTS

K=	**0.0575**	L_{∞} =	**98.11897**
a=	18.967	L0 =	18.96730
b=	-79.152	t0 =	-3.742
r=	-0.9999		
r2=	0.9998		

TOTAL

AGE (YRS)	Y LENGTH	X Xt	XY	Y2	X2
7.00	45.2000	-0.51	-23.0353	2043.04	0.26
16.00	66.5000	-0.80	-53.4550	4422.25	0.65
19.00	71.8000	-0.86	-61.4220	5155.24	0.73
20.00	72.9000	-0.87	-63.3829	5314.41	0.76
2.00	32.0000	-0.18	-5.89476	1024.00	0.03
3.00	41.7000	-0.26	-10.9742	1738.89	0.07
7.00	48.7000	-0.51	-24.8190	2371.69	0.26
11.00	53.9000	-0.67	-36.3100	2905.21	0.45
25.00	66.6000	-0.92	-61.3736	4435.56	0.85
6.00	57.5000	-0.46	-26.2823	3306.25	0.21
count	sum Y	sum X	sum XY	sum Y2	sum X2
10.00	556.8	-6.04765	-366.949	32716.54	4.268498

RESULTS

K=	**0.1018**	L_{∞} =	**75.22297**
a=	25.776	L0 =	25.77639
b=	-49.447	t0 =	-4.123
r=	-0.934		
r2=	0.872		

7.2.2. *APRION VIRESCENS*

Length frequency data for male and female *A. virescens* sampled each month appears in Tables 7.2.11. and 7.2.12. For females there were only 4 months when the sample size exceeded 100 individuals, and no significant result could be obtained using the method of Bhattacharya and modal progression analysis described above (\1). For males the sample size was greater than 100 for 9 months but the MPA similarly did not produce a meaningful result. Consequently, the results of the Bhattacharya and subsequent analyses are not reproduced here for males and females separately.

TABLE 7.2.11. LENGTH FREQUENCY DISTRIBUTIONS OBSERVED FOR *APRION VIRESCENS* NOV 1989 - DEC 1990 (MALES)

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
29	2					1								
31	2		1			0								
33	0		4	5	7	3								
35	0	1	2	6	10	10	1							2
37	2	1	0	1	12	6	2			1		1		2
39	3	0	0	0	0	4	1	1	2	1		2		3
41	6	0	5	4	3	2	0	0	3	3	2	2	4	6
43	0	3	4	3	3	2	3	0	3	0	0	12	6	2
45	0	4	11	15	4	8	3	1	0	0	1	7	5	9
47	1	1	1	6	8	2	1	1	3	1	0	7	9	10
49	1	2	5	2	0	4	2	0	6	0	0	4	12	7
51	4	2	1	8	8	3	0	3	1	0	0	7	10	11
53	1	8	2	1	14	4	2	1	4	2	2	6	19	6
55	3	3	4	4	8	6	0	0	8	0	0	5	15	0
57	7	6	2	4	6	7	5	0	3	1	4	3	7	4
59	9	5	5	3	14	10	10	0	4	0	1	14	30	15
61	6	5	3	5	21	3	5	1	8	5	2	12	20	19
63	9	1	4	10	16	11	8	1	9	0	9	13	26	22
65	8	5	8	11	15	15	9	2	9	0	8	14	22	14
67	7	3	10	8	19	8	10	0	8	4	11	28	17	10
69	12	7	19	9	21	11	9	1	6	3	12	37	32	21
71	13	3	15	9	29	22	8	0	11	0	12	35	43	15
73	12	2	13	3	27	21	8	2	6	4	10	31	49	17
75	16	1	10	9	26	20	0	3	5	0	7	18	28	11
77	6	1	2	7	21	9	1	0	2	1	4	15	9	2
79	5	3	1	2	10	8	2	2	0	0	4	21	8	8
81	1	1	2	2	3	6	1		2	1	3	8	5	5
83	0	0		1	4	2	1		3		0	10	2	3
85	0	1		0	3	5	1				1	1	1	
87	1			0	1	1						2	0	
89				0	0								1	
91				0	0									
93				1	1									
Sum	137	69	134	139	314	214	93	19	106	27	93	315	380	224

n = 2,264.

\1)Only samples with more than 100 individuals were included in the Bhattacharya analysis.

TABLE 7.2.12. LENGTH FREQUENCY DISTRIBUTIONS OBSERVED FOR *APRION VIRESCENS* NOV 1989 - DEC 1990 **(FEMALES)**

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
29	3	1	1									1		1
31	0	0	1	1	2				1			0		3
33	0	1	4	5	6	3			0			0		0
35	0	0	1	11	12	4	1		0			1		2
37	2	1	2	1	8	5	2	3	0			0	1	4
39	6	0	2	0	6	3	3	1	1	3		0	0	4
41	1	1	2	3	3	0	2	0	0	1	2	1	2	4
43	2	3	8	7	5	0	1	1	1	1	2	9	8	2
45	1	1	6	13	8	4	1	0	0	0	1	5	9	5
47	0	0	7	6	3	2	0	0	0	1	0	1	1	9
49	0	1	1	3	4	4	2	1	1	1	0	6	16	10
51	1	3	4	3	2	2	2	1	2	1	0	4	9	4
53	1	3	1	3	2	1	3	0	4	0	0	3	13	4
55	0	3	1	2	1	3	1	0	4	1	0	2	13	2
57	3	4	0	2	1	3	2	0	6	2	1	6	7	2
59	0	3	1	7	2	2	9	0	5	4	0	12	27	10
61	1	0	3	0	9	4	0	0	6	1	1	13	16	14
63	3	1	4	0	4	5	5	0	4	1	3	7	36	6
65	4	3	6	8	4	3	4	1	4	0	2	6	23	5
67	0	6	3	3	9	6	6	0	2	0	5	11	8	5
69	4	2	7	3	12	2	3	0	2	0	3	18	18	18
71	4	4	6	7	12	1	3	1	2	0	3	10	16	11
73	8	1	7	3	6	6	7	2	3	0	1	10	12	6
75	5	3	8	1	7	6	1	3	1	2	2	10	15	3
77	4	1	1	2	9	2	1	0	0		5	7	5	1
79	2	1	2	2	8	2		1	1		0	6	2	1
81	2	0	1		2	4			1		1	3	1	1
83	2	1	0		1	3			1		1	0		0
85	0		0		0	1			0			1		1
87	0		0		0	1			1					
89	2		0		1				0					
91			0		1				1					
93			0						0					
95			0						0					
97			1						1					
Sum	61	48	91	96	150	82	59	15	55	19	33	153	258	138

n = 1,258.00

Length frequency data for the total number of individuals sampled each month appears in table 7.2.13. The mean lengths of the components identified by the Bhattacharya method for the total monthly samples of *A. virescens*, arranged to show positive growth with time appear in Table 7.2.14. The Gulland and Holt analysis of the modal progression indicated by highlighted (in italics) data produced values of L_{OO}=92.598 cm and K=0.2481 for the first 4 cohorts, but inclusion of more cohorts in the analysis produced an unrealistic result. The difference in length between cohorts corresponded approximately to the difference observed over a 6 month period. This suggested 2 recruitment periods each year and thus ages were arbitrarily assigned to the mean lengths identified in cohorts 1-4 with birthdates of January 1st and July 1st. VONBER of LFSA was used to estimate the growth parameters shown in Table 7.2.15

ELEFAN I was next employed to analyse the data using as the starting L_{∞} that derived above from the Gulland and Holt analysis, that from the VONBER analysis, L_{max}, and that calculated by the Wetherall *et. al*. method. L_{max}, refined through the Response Surface Analysis gave the best fitting growth curve, the parameters of which are given in Table 7.2.15. with and without seasonal oscillation. ELEFAN I was also used to analyse the data for male and female *A. virescens*.

TABLE 7.2.13. LENGTH FREQUENCY DISTRTBUTIONS OBSERVED FOR *APRION VIRESCENS* NOV 1989 - DEC 1990 (TOTAL)

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
25			1											
27			0											
29	5	1	2		1	1						1		1
31	2	1	2	2	2	0			1			1		4
33	2	1	8	16	20	7			0			0	1	0
35	3	2	4	23	28	14	6		0			2	0	4
37	6	4	2	2	21	13	6	3	0	1		1	3	6
39	11	0	2	2	9	12	4	2	3	5		2	2	8
41	7	4	8	12	14	2	2	0	4	5	5	4	10	13
43	2	7	16	13	13	4	4	1	4	1	6	25	22	7
45	1	5	22	40	20	13	6	1	3	0	2	18	16	20
47	2	2	20	24	16	6	1	1	6	2	1	10	12	25
49	2	5	13	17	15	10	7	1	8	1	0	13	33	22
51	5	9	6	20	20	7	3	5	4	2	0	12	23	19
53	4	14	5	5	26	14	9	1	9	4	3	11	40	17
55	3	8	9	10	18	16	3	0	13	1	1	11	33	4
57	11	13	6	14	17	18	12	0	14	6	9	18	21	7
59	12	11	12	19	32	26	22	0	13	5	6	37	78	31
61	12	7	15	18	51	16	13	2	19	6	8	40	52	44
63	18	6	14	34	41	35	26	1	15	6	17	41	80	39
65	32	12	31	38	41	34	33	4	17	5	16	46	71	25
67	26	18	36	36	64	29	33	1	22	6	20	62	37	26
69	31	16	64	44	70	52	26	1	22	8	36	79	73	51
71	33	15	58	53	97	70	34	3	26	0	43	70	83	34
73	49	16	57	35	93	49	28	10	19	6	31	66	82	28
75	53	18	60	30	78	56	10	8	23	7	27	53	57	21
77	34	5	20	24	63	30	9	1	7	5	19	36	19	5
79	23	9	16	12	38	27	4	4	4	1	7	50	12	9
81	9	1	9	5	29	23	2	1	7	1	10	24	17	8
83	6	3	4	6	14	15	1	1	4		6	17	4	7
85	3	3	3	2	9	11	1	0	0		2	5	3	2
87	2	0	2	2	3	7	1	0	2		1	5	0	
89	4	1	1	1	2	0	1	1	1			1	1	
91	1	0	2	0	1	3	0		2			0	1	
93		0	0	1	1		0		0			1		
95		0	0				1		1					
97		0	1						1					
99		1	0											
101			1											
Sum	414	218	532	560	967	620	308	53	274	84	276	762	886	487

n = 6,441.00

TABLE 7.2.14. MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.13

MONTH	COHORTS IDENTIFIED									
	1	2	3	4	5	6	7	8	9	10
NOV			38.706	?	51.608	?	57.670	65.757	?	74.485
DEC				43.373	?	52.886	57.991	?	67.612	73.965
JAN		33.333	?	45.687	?	55.465	61.358	66.260	71.348	
FEB		34.000	42.092	45.918	51.020	59.303	?	65.484	71.012	
MAR		35.100	45.340	?	52.948	?	61.402	68.370	72.061	75.964
APR		36.160	45.243	49.821	54.030	59.255	63.955	?	70.918	
MAY		35.886	44.480	49.825	?	59.022	66.290	?	73.058	77.057
JUN				51.000	?	?	65.000	70.385	73.762	
JUL		42.000	?	48.887	57.148	62.005	66.076	70.712		
AUG		40.000	?	52.666	?	62.000	?	?	74.725	
SEP		42.284	?	?	57.688	63.888	68.220	71.940	74.913	
OCT		44.504	?	?	?	63.334				
NOV		43.438	49.624	53.976	59.527	65.182	?	71.789		
DEC	40.879	46.059	?	?	?	62.015	69.403			

TABLE 7.2.15. ESTIMATES OF THE VON BERTALANFFY GROWTH PARAMETERS DERIVED FOR *APRION VIRESCENS*

ANALYSIS PERFORMED	GROWTH PARAMETERS L_{oo}	K	WP	C	t0	SSD Rn*	SS	SL	MUNRO Phi'
VONBER/LFSA-TOT cohorts 2-5 only	84.857	0.294			-0.688	47.7			3.326
ELEFAN I - TOTAL									
non seasonal	104.00	0.260				186	4	34	3.449
seasonal growth	104.50	0.260	0.95	0.75		175	13	58	3.453
MALES									
non seasonal	95.00	0.290				159	13	59	3.418
seasonal growth	95.50	0.240	0.75	0.75		184	12	42	3.336
FEMALES									
non seasonal	108.00	0.140				203	6	67	3.213
seasonal growth	106.50	0.140	0.85	0.75		241	5	60	3.201

* SSD for VONBER, Rn for ELEFAN I

7.2.3. *LUTJANUS SEBAE*

Length frequency data for male and female *L. sebae* sampled each month appears in Tables 7.2.16. and 7.2.17. For females there were 9 months when the sample size exceeded 100 individuals, and no significant result could be obtained using the method of Bhattacharya and modal progression analysis described above (\1), or by assigning ages to the length data and applying the VONBER analysis. For males the sample size was greater than 100 for 7 months but the MPA similarly did not produce a meaningful result. Consequently, the results of the Bhattacharya and subsequent analyses are not reproduced here for males and females separately.

TABLE 7.2.16 : *LUTJANUS SEBAE* - MALES, LENGTH FREQUENCY DATA SAMPLED BETWEEN NOVEMBER 1989 AND DECEMBER 1990

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
21						1								
23		1	1		1	0	1							
25	1	0	1	1	2	1	0					2	1	1
27	0	0	2	1	2	2	0					1	1	2
29	4	0	1	2	5	4	1		1		1	7	0	3
31	0	0	1	6	4	7	1		1		2	4	1	10
33	2	3	1	4	14	4	2		2		0	3	0	7
35	0	1	0	9	5	11	0		4		0	4	2	10
37	1	0	3	7	4	7	1		4	1	1	1	1	6
39	0	0	3	3	11	6	0		5	1	1	3	2	8
41	2	0	2	5	5	6	1		2	2	1	4	1	6
43	1	0	1	5	2	1	1		0	0	0	8	0	5
45	2	0	1	4	2	5	0		2	3	0	5	3	3
47	4	1	2	3	3	5	0	1	1	0	2	1	4	4
49	7	1	0	4	3	2	1	1	1	0	1	2	4	1
51	8	0	0	6	4	2	0	3	0	0	0	2	6	0
53	15	4	1	6	6	4	2	1	0	0	2	7	6	4
55	13	1	1	4	8	6	0	0	3	2	1	2	5	1
57	15	2	2	6	13	8	1	0	1	1	1	6	6	4
59	24	2	2	6	10	7	5	0	2	2	4	12	10	1
61	28	4	3	5	19	11	6	2	7	6	6	17	3	3
63	10	2	3	6	15	10	3	1	7	5	3	13	8	4
65	25	1	5	8	17	8	4	0	6	3	5	15	8	3
67	11	3	2	12	8	14	2	2	4	3	0	13	9	6
69	21	1	5	9	5	8	2	1	1	1	9	16	8	7
71	10	4	4	7	18	9	6	3	2	0	7	20	9	9
73	17	2	1	5	16	7	4		2	0	6	16	9	3
75	23	2	2	11	9	8	2		4	1	6	6	8	2
77	12	2	1	7	5	3	3		2		4	8	7	0
79	13	2		5	6	2	2		2		4	8	2	3
81	5	3		2	4	3	0		0		1	8	2	1
83	1	1				1	1		1		2	2	3	
85	1											0		
87												1		
Sum	276	43	51	159	226	173	52	15	67	31	70	217	129	117

n = 1,626

\1)Only samples with more than 100 individuals were included in the Bhattacharya analysis.

TABLE 7.2.17.: *LUTJANUS SEBAE* - FEMALES, LENGTH FREQUENCY DATA SAMPLED BETWEEN NOVEMBER 1989 AND DECEMBER 1990

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
19			1											
21			1									1		
23		1	1	1	6	2					1	3		
25	2	3	6	2	4	5	2				1	5		
27	2	2	6	5	10	6	5		5		3	4		1
29	1	3	9	4	11	8	2		3		2	15	1	3
31	2	3	12	12	13	13	2		4	1	6	12	1	11
33	4	1	3	11	20	12	4		7	0	7	5	1	6
35	1	1	8	11	13	6	5		5	2	6	9	2	6
37	2	2	3	1	16	12	0		8	7	5	4	3	11
39	0	1	2	4	10	13	1		5	2	4	5	2	9
41	3	0	0	4	10	4	3	1	3	2	4	7	1	8
43	2	2	2	4	11	6	2	0	4	4	5	4	2	6
45	1	0	0	7	6	2	1	0	6	4	4	5	5	4
47	1	5	1	2	7	0	2	0	1	1	6	7	6	2
49	5	3	1	7	7	4	1	1	8	2	2	6	9	4
51	12	0	1	10	8	5	3	0	2	2	2	17	7	4
53	11	4	3	8	7	11	1	0	5	4	3	10	16	3
55	19	7	1	10	11	11	5	0	5	6	2	22	12	0
57	24	11	4	17	20	16	3	1	4	3	10	11	8	4
59	28	9	7	12	27	13	5		9	6	15	24	10	7
61	26	3	5	18	32	13	8		10	1	7	26	10	6
63	28	6	6	19	26	12	7		8	2	5	19	8	3
65	23	6	2	13	14	12	6		3	1	14	21	12	3
67	6	3	2	9	8	9	3		2	0	4	6	6	1
69	8	1	2	4	6	6	2		2	3	2	12	9	3
71	1	0		1	0	2	1				1	4	1	2
73		0			0	1						1	1	1
75		0			1	0							1	
77		1				0							1	
79						1								
Sum	212	78	89	196	304	205	74	3	109	53	121	265	135	108

n = 1,952

Length frequency data for the total number of individuals sampled each month appears in Table 7.2.18. The mean lengths of the components identified by the Bhattacharya method for the total monthly samples of *L. sebae*, arranged to show positive growth with time appear in Table 7.2.19. The Gulland and Holt analysis of the modal progression indicated by highlighted (in italics) data produced values of L_{oo}=112.1 cm and K=0.1531 for cohorts 2-5, but inclusion of more cohorts in the analysis produced an unrealistic result. The difference in length between cohorts corresponded approximately to the difference observed over a 6 month period. This suggested 2 recruitment periods each year and thus ages were arbitrarily assigned to the mean lengths identified in cohorts 1-4 with birthdates of January 1st and July 1st. VONBER of LFSA was used to estimate the growth parameters shown in Table 7.2.20. (Inclusion of data from more than cohorts 2-5 in the VONBER analysis similarly produced unrealistic results).

ELEFAN I was next employed to analyse the data using as the starting L_{oo} that derived above from the Gulland and Holt analysis, that from the VONBER analysis, L_{max}, and that calculated by the Wetherall *et. al.* method. L_{oo} derived through the VONBER analysis and refined through the Response Surface Analysis gave the best fitting growth curve, the parameters of which are given in Table 7.2.20. with and without seasonal oscillation. ELEFAN I was also used to analyse the data for male and female *L. sebae*.

TABLE 7.2.18 : *LUTJANUS SEBAE* - ALL SAMPLED LENGTH FREQUENCY DATA BETWEEN NOVEMBER 1989 AND DECEMBER 1990

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
19			4						1					
21	3	1	4	1	9	4	2		3			1		
23	0	4	10	5	19	4	2		6		1	3		
25	5	3	13	6	23	9	4		9		2	8	2	1
27	2	4	15	11	28	9	9		8		7	9	1	5
29	7	3	21	15	33	16	8		9		3	29	2	6
31	6	4	21	29	34	28	7		8	1	10	23	4	30
33	4	5	12	22	52	25	7		14	0	8	19	3	17
35	3	2	13	25	26	25	6		15	4	8	21	6	24
37	3	2	12	16	32	20	4		15	10	10	12	8	28
39	1	1	5	15	28	26	2		12	5	7	14	6	22
41	6	0	4	13	21	14	5	1	6	5	5	16	5	18
43	3	2	5	12	25	9	4	0	5	8	6	15	3	17
45	5	0	1	13	17	11	1	1	10	12	8	14	11	7
47	5	6	5	9	16	9	3	1	3	3	13	11	13	8
49	17	4	1	13	19	9	5	2	11	5	6	17	20	7
51	26	1	1	19	21	12	6	4	2	5	2	25	17	5
53	35	9	6	19	25	22	6	1	8	8	8	31	25	9
55	42	8	8	21	38	22	9	0	9	14	6	36	21	1
57	58	17	9	28	50	39	11	2	6	8	17	27	15	11
59	86	13	18	30	64	33	20	2	18	17	24	59	26	12
61	81	10	13	28	76	41	15	3	21	13	19	62	21	11
63	63	9	10	39	67	35	16	3	21	9	23	48	25	10
65	78	11	10	34	55	33	18	0	17	7	30	55	28	9
67	34	8	11	29	32	32	8	2	15	4	14	35	16	8
69	39	5	9	20	27	23	7	1	6	5	20	39	25	13
71	17	4	5	16	36	20	9	3	5	0	16	32	17	17
73	22	3	2	11	21	16	11		4	1	10	27	11	6
75	27	2	3	12	22	12	5		5	1	7	12	12	2
77	15	6	2	12	10	7	3		3	0	12	10	10	0
79	17	2		5	12	3	2		3	1	8	9	2	3
81	12	6		3	7	4	0		2		2	9	2	1
83	3	1			1	1	1		1		2	2	3	
85	1				1							0		
87												1		
Sum	726	156	253	531	947	573	216	26	281	146	314	731	360	308

n = 5,568

TABLE 7.2.19 : THE MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.18

MONTH	COHORTS IDENTIFIED												
	1	2	3	4	5	6	7	8	9	10	11	12	13
NOV 89				29.780			41.442	46.006	50.910		60.170	68.812	74.684
DEC 89		23.656		32.391				47.173	56.739		64.773		
JAN 90			29.668		36.077		42.247	47.683	54.382	59.515	64.065		
FEB		23.724	31.409		35.961	39.971	45.243	51.890	58.948		63.881		
MAR		24.084	29.645	33.637	37.978	42.622	48.146	52.037					
APR		26.000	31.807	36.035	39.885	45.304		54.000		61.371	66.134		
MAY		27.746	34.013				50.578		58.781	64.599		71.835	
JUN							50.666			62.000			
JUL	25.641		36.030			45.025	49.502	54.450	61.377	65.105			
AUG			37.138		43.724			55.000	59.962	63.964			
SEP	27.193		36.769	42.254		46.850			59.205	65.155	70.620		77.883
OCT		29.669	34.790	41.367	45.282		54.313						
NOV		31.413	37.214			49.452		59.455	64.915	69.951		74.661	
DEC 90		31.478	37.296	41.863		49.242	52.706	59.321	64.498	70.730			

TABLE 7.2.20. ESTIMATES OF THE VON BERTALANFFY GROWTH PARAMETERS DERIVED FOR *LUTJANUS SEBAE*

ANALYSIS PERFORMED	GROWTH PARAMETERS L_{oo}	K	WP	C	t0	SSD Rn*	SS	SL	MUNRO Phi'
VONBER/LFSA-TOT cohorts 2-5 only	92.92	0.157			-1.370	169.3			3.132
ELEFAN I - TOTAL									
non seasonal	95.12	0.307				147	11	46	3.444
seasonal growth	95.12	0.307	0.90	1.0		188	5	33	3.444
MALES									
non seasonal	90.00	0.380				148	9	74	3.488
seasonal growth	90.00	0.380	0.15	1.0		140	14	70	3.488
FEMALES									
non seasonal	84.00	0.270				175	14	30	3.280
seasonal growth	86.00	0.245	0.90	0.9		194	14	30	3.258

* SSD for VONBER, Rn for ELEFAN I

7.2.4. *EPINEPHELUS CHLOROSTIGMA*

TABLE 7.2.21. *EPINEPHELIS CHLOROSTIGMA*, ALL SAMPLED LENGTH FREQUENCY DATA, NOVEMBER 1989 - DECEMBER 1990.

ML\DATE	11	12	1	2	3	4	5	6	7	8	9	10	11	12
23.5									1				1	1
24.5				1	1			1	1	1	1		0	0
25.5	1		3	2	2	1	2	0	0	0	2	1	1	0
26.5	0	1	2	4	3	3	2	0	1	1	2	7	1	0
27.5	1	1	5	1	2	2	2	0	1	0	5	4	1	1
28.5	0	0	5	6	7	5	0	0	1	2	2	7	2	1
29.5	2	1	5	7	6	4	5	2	1	2	5	16	2	1
30.5	3	5	18	14	20	14	6	4	7	7	10	27	12	5
31.5	9	10	27	19	34	17	5	4	8	6	10	19	12	9
32.5	18	18	27	23	39	30	17	3	6	17	18	42	26	17
33.5	28	17	30	30	50	30	13	8	11	17	32	52	15	18
34.5	38	19	44	54	56	32	16	7	17	20	36	72	10	23
35.5	50	34	51	61	77	46	29	10	32	21	35	58	28	24
36.5	62	27	54	63	89	52	46	22	33	19	63	76	32	26
37.5	60	43	61	64	109	48	27	18	37	25	67	76	23	21
38.5	54	34	47	68	90	70	47	21	37	24	48	81	30	34
39.5	55	32	34	53	87	49	18	16	36	22	47	73	37	20
40.5	49	28	34	41	62	28	17	14	26	9	21	41	21	11
41.5	31	9	26	25	40	13	11	6	13	8	11	19	10	6
42.5	19	8	13	9	31	18	18	2	3	3	3	14	11	6
43.5	14	2	8	16	15	9	2	5	7	0	6	8	11	6
44.5	6	2	9	7	9	7	4	5	2	0	3	3	5	2
45.5	5	3	10	6	7	15	4	1	7	0	3	2	2	4
46.5	6	1	7	2	8	9	3	2	5	0	8	1	5	5
47.5	12	1	10	4	10	12	0	1	2	0	5	0	5	3
48.5	6	2	8	4	13	13	7	0	7	0	5	0	11	9
49.5	2	1	12	2	16	10	2	0	4	0	5	2	4	5
50.5	7	2	7	1	8	7	6	1	4	0	5	0	7	8
51.5	5	2	7	6	6	17	2		2	0	3	1	6	5
52.5	6	4	4	4	5	9	2		2	1	2	0	7	6
53.5	9	4	4	2	3	12	2		3	0	0	1	8	3
54.5	6	2	3	2	1	4	3		6	0	2	0	1	1
55.5	11	0	0	3	1	10	1		2	1	0	0	0	3
56.5	2	6	4	2	3	4	0		6		1	0	0	11
57.5	3	1	0	2		2	3		2			2	1	0
58.5	3	0	1	0		4	1		1			0	1	1
59.5	1	1		2		1	1		1			1		1
60.5	2	0		0		0	1		0			0		0
61.5	1	1		2		1	1		1			1		1
62.5	2						1							
Sum	589	322	580	612	910	608	327	153	336	206	466	707	349	298

n = 6,463.00

Length frequency data for *E. chlorostigma* appears in Table 7.2.21. The analysis was performed on all fish sampled each month, no data relating to sex having been recorded. The means of the components identified by the method of Bhattacharya, arranged to show positive growth with time appear in Table 7.2.22. The Gulland and Holt plot based on cohorts labelled 2-5 produced unacceptable growth parameters. Nevertheless ages were arbitrarily assigned to each length for the VONBER analysis of LFSA. The difference between cohorts appears to be similar to that over a period of 6 months suggesting that two cohorts are recruited into the population each year. The analysis applied to age at length data for all components identified produced a value for L_{oo} of greater than 150 cm. Considering only the values in cohorts 2-5 for 1990 acceptable growth parameters were resolved, indicated in Table 7.2.23 for all the data, and for the arbitrarily chosen birthdates of 1st January and 1st July (\1).

ELEFAN I was applied to the data with initial starting parameters based on the results from the VONBER analysis, L_{max}, and the value for L_{oo} derived from the Wetherall *et. al.* plot. The best fit resulted from the Wetherall *et. al.* method. The results are indicated in Table 7.2.23

TABLE 7.2.22. MEAN LENGTHS OF THE COMPONENTS IDENTIFIED BY APPLYING THE METHOD OF BHATTACHARYA TO THE DATA IN TABLE 7.2.21

MONTH	'COHORTS' IDENTIFIED							
	1	2	3	4	5	6	7	8
NOV					36.876	40.577	43.410	47.596
DEC			32.887	35.838	37.956	40.529		
JAN		28.000	31.826	34.928	37.614	?	44.873	47.882
FEB		26.000	32.578	35.034				
MAR		26.420	32.155	34.187	37.891			
APR		26.730	31.183	36.610	38.973			
MAY			32.820	36.465	38.925	42.183	45.012	50.524
JUN		31.275	33.998	36.798	38.999	43.817		
JUL		31.534	34.170	36.006	39.159	43.768		
AUG		30.890	33.007	37.870				
SEP	27.500	31.000	34.743	37.642	39.641			
OCT	26.776	30.384	34.419	37.110	38.997	40.925		
NOV	29.000	32.591	36.450	39.575	42.716	48.442		
DEC	31.575	35.451	38.774	40.957	46.228			

May also cohort 9 : 53.004 cm

TABLE 7.2.23. ESTIMATES OF THE VON BERTALANFFY GROWTH PARAMETERS DERIVED FOR *EPINEPHELUS CHLOROSTIGMA*

ANALYSIS PERFORMED	GROWTH PARAMETERS L_{oo}	K	WP	C	t0	SSD Rn*	SS	SL	MUNRO Phi'
VONBER/LFSA-JAN	59.522	0.269			-1.152	29.16			2.979
(cohorts -JULY	70.999	0.164			-2.022	27.15			2.917
2-5 only) -ALL	52.388	0.360			-0.926	51.23			2.995
ELEFAN I									
non seasonal	64.45	0.175				182	7	57.5	3.058
seasonal growth	64.40	0.190	0.50	0.35		199	7	57.5	2.897

* SSD for VONBER, Rn for ELEFAN I

\1) It is valid to exclude the larger cohorts since they are based on a smaller sample size and the lengths and ages assigned will be less reliable.

7.3. MORTALITY

Mortality in fish populations arises through natural causes and through fishing activity. The total mortality of a fish population (Z) is the sum of these two components, natural mortality (M), and fishing mortality (F).

The total mortality coefficient, Z, was derived through length-converted catch curve analysis (originally introduced by van Sickle, 1977) and Jones' length cohort analysis (Jones, 1984). Routines CCURVE and LCOHOR of LFSA were employed. The natural mortality, M, was estimated by the method of Pauly, (1980) which correlates M with the von Bertalanffy growth constants and the annual mean water temperature, T (^{o}C). The ELEFAN II routine was employed, and F, the fishing mortality was obtained by subtraction (F=Z-M). (Note ELEFAN II was also used to derive estimates of Z. These were slightly higher than those derived through CCURVE of LFSA. However, the LFSA output was used in subsequent calculations since LFSA routines were used).

TABLE 7.3.1 CATCH (TONNES) PER MONTH (1990) BY SPECIES AND BOAT TYPE.

SPECIES / MONTH	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
P. FILAMENTOSUS													
SCHOONERS	33.9	17.3	22.1	37.7	22.3	2.2	4.2	0.8	7.1	14.8	17.8	15.1	195.3
WHALERS	2.4	0.3	7.2	9.5	3.6	0.0	0.0	0.0	0.4	5.5	1.9	7.7	38.5
SMALL BOATS													
TOTAL	36.3	17.6	29.3	47.2	25.9	2.2	4.2	0.8	7.5	20.3	19.7	22.8	233.8
L. SEBAE													
SCHOONERS	5.1	10.8	17.3	12.6	4.6	0.2	6.0	6.7	9.4	12.6	6.1	11.8	103.2
WHALERS	11.2	48.0	48.1	29.9	9.1	3.4	8.7	5.9	13.9	16.2	11.4	7.4	213.2
SMALL BOATS	2.5	3.8	0.1	5.2	2.2	2.2	1.8	1.4	3.2	2.5	9.8	1.3	36.0
TOTAL	18.8	62.6	65.5	47.7	15.9	5.8	16.5	14.0	26.5	31.3	27.3	20.5	352.4
A. VIRESCENS													
SCHOONERS	4.2	8.2	11.9	11.6	2.4	0.3	3.4	4.7	4.2	5.5	2.9	4.1	63.4
WHALERS	53.9	36.4	67.3	36.1	40.8	11.2	26.1	13.6	36.1	20.0	18.2	62.7	422.4
SMALL BOATS *	3.0	6.4	3.9	2.6	2.8	4.8	3.6	2.3	4.7	4.0	8.3	3.7	50.1
TOTAL	61.1	51.0	83.1	50.3	46.0	16.3	33.1	20.6	45.0	29.5	29.4	70.5	535.9
E. CHLOROSTIGMA													
SCHOONERS	2.9	3.9	2.7	4.0	1.9	1.7	4.8	8.0	2.6	1.9	2.2	2.8	39.4
WHALERS	5.0	6.9	10.1	6.2	3.1	0.9	4.2	7.4	9.0	4.5	3.6	4.1	60.0
SMALL BOATS	2.0	3.0	5.5	5.4	2.2	2.0	1.0	0.2	2.1	1.7	0.1	1.9	27.1
TOTAL	9.9	13.8	18.3	15.6	7.2	4.6	10.0	10.6	13.7	8.1	5.9	8.8	126.5

* Assumes that total catch of 'Job' for small boats was Job Gris. For whalers it was 92 % the rest being the deeper water Batrican so this assumption appears valid. Prior to 1990 details of catch by species for the above (except Maconde) was not available for small boats and whalers.

Input data for mortality estimates were the cumulated monthly length frequency sample data raised to the total catch per month.

The length frequency sample was converted to weight at length using the length weight relationships derived in Section 7.1. (or from data available in the literature) and the number of fish sampled was raised to the total catch through application of the appropriate routine in ELEFAN III. Mean water temperature at depth was taken from Table 1 (after Tarbit, 1980). The von Bertalanffy growth parameters used were those derived in Section 7.2, above (non seasonal model). Catch data per month is given in Table 7.3.1 for each species.

7.3.1. *PRISTIPOMOIDES FILAMENTOSUS*

The total sampled length frequency data per month (ie, males females and undetermined sex) was raised to the total number caught as indicated in Table 7.3.2., based on the catches reported in Table 7.3.1.. The following length-weight relation ship was employed:

$$W(Kg) = 0.00005353 \times FL(cm)^{2.7004}$$

TABLE 7.3.2. TOTAL CATCH OF PRISTIPCMOIDES FILAMENTOSUS PER MONTH (No's), 1990.

ML\DATE	1	2	3	4	5	6	7	8	9	10	11	12	TOTAL
25								8					8
27								15	14				29
29	35		17	35				0	21	62		17	187
31	35	130	86	142	38	10	15	8	28	0	69	50	611
33	69	65	222	249	229	25	38	8	21	92	69	117	1204
35	104	173	376	320	229	60	122	45	21	133	111	117	1811
37	277	374	291	481	343	85	260	30	69	236	139	83	2618
39	830	497	547	605	514	140	245	53	207	667	195	167	4667
41	1246	540	838	1104	629	206	413	53	234	482	306	367	6418
43	1350	454	633	1068	991	195	260	61	221	615	472	233	6553
45	1626	410	975	1086	781	125	107	8	97	667	375	367	6624
47	1488	454	838	979	781	60	69	15	159	513	319	367	6042
49	1142	454	1077	1424	743	55	61	15	248	698	486	600	7003
51	1350	324	1043	1264	648	65	92	8	358	513	736	500	6901
53	1004	475	718	979	724	65	107	15	303	472	570	600	6032
55	1107	518	770	908	457	30	122	0	248	369	417	600	5546
57	588	367	667	837	324	20	84	8	172	533	375	617	4592
59	346	497	821	997	438	20	130	8	269	380	486	800	5192
61	796	194	735	1353	419	20	76	23	207	668	681	700	5872
63	588	259	547	1157	514	20	46	8	131	328	625	750	4973
65	588	302	445	1068	571	20	38	30	76	308	361	400	4207
67	381	194	257	516	305	10	8	8	34	226	153	283	2375
69	346	410	359	730	381	10	8	15	27	267	264	200	3017
71	138	108	51	392	190	15	31		27	113	111	117	1293
73	138	65	34	196	57	5			0	62	56	50	663
75	0	22	17	36	114	5			14	0		17	225
77	69		17	18	57					21		17	199
79					19							17	36
Sum	15641	7236	12381	17944	10496	1266	2332	442	3206	8425	7376	8153	94898
Sample													
no.	452	335	727	1008	551	253	305	58	465	821	531	489	5995
wt.	1.05	0.81	1.71	2.65	1.36	0.44	0.55	0.1	1.09	1.98	1.42	1.37	14.53
Catch	36.3	17.6	29.3	47.2	25.9	2.2	4.2	0.8	7.5	20.3	19.7	22.8	233.8

Since the von Bertalanffy growth parameters are considered to be preliminary and require further refinement the sexes were not treated separately and the VBGF parameters were pooled giving an average for both sexes of L_{∞} = 81.7 cm and K = 0.2875. These values were used with a mean water temperature of 22°C for depths of 70m and greater in the estimation of the mortality coefficients.

Using the above data the length - converted catch curve gave a Z value of 0.811 (see Figure 7.3.1). M was calculated as 0.534 giving an F value of 0.277. The result from the length converted cohort analysis (Table 7.3.3.) with M = 0.534, and a terminal exploitation rate (F/Z) of 0.45 (the value giving a constant F/Z in the last groups) gave a mean value for F of 0.294 for the fully exploited part of the stock (> 50cm), which is consistent with that derived from the former method.

Mees (1990) indicated that *P. filamentosus* was caught in all fishing areas (See Section 2.1) by schooners, but that it was not a target species everywhere, the largest catches deriving from the southerly locations. Table 7.3.4. indicates catch and effort by fishing location over the period January 1985 - July 1990 for schooners (after Mees, 1990).

TABLE 7.3.4. CATCH AND EFFORT DETAILS BY FISHING LOCATION (F_G) FOR *PRISTIPOMOIDES FILAMENTOSUS* (PF) CAUGHT BY SCHOONERS DURING THE PERIOD JANUARY 1985 TO JULY 1990

F_G	KG PF /TRIP	% PF IN CATCH	PF CATCH (KG)	TRIPS PF CAUGHT	% TOTAL TRIPS/F_G
ALP	313.00	16.90%	421.8	1	100.00%
AMI	442.52	22.20%	19082.6	43	32.32%
PLA	29.25	3.27%	78.8	3	50.00%
???	155.95	15.11%	34255.2	220	40.85%
OUT	723.82	30.61%	18532.7	26	47.50%
E	214.51	19.92%	19078.5	89	47.83%
ENE	29.50	2.96%	79.5	3	50.00%
ESE	106.35	8.48%	3439.6	32	45.28%
N	237.02	25.53%	6068.7	26	31.67%
NE	267.72	23.36%	18399.4	69	46.36%
NNE	539.02	43.11%	3631.9	7	55.56%
NNW	50.00	7.05%	336.9	7	17.86%
NW	114.59	11.91%	8801.9	77	35.40%
S	139.16	11.43%	10501.6	75	50.45%
SE	772.16	38.78%	107176.1	139	58.52%
SSE	769.04	36.51%	29017.5	38	66.67%
SSW	796.67	47.73%	3220.7	4	42.86%
SW	172.80	13.20%	4424.4	26	41.30%
W	221.50	16.89%	35221.6	159	44.03%
WNW	214.70	17.68%	19963.4	93	47.26%
WSW	27.00	2.58%	363.8	13	58.82%

TABLE 7.3.3. JONES' LENGTH COHORT ANALYSIS FOR *P. FILAMENTOSUS* CAUGHT IN 1990 USING THE PARAMETERS : Loo = 81.7cm, K = 0.2875 per year, M = 0.534 per year.

Interval	C	X*)	N	F/Z	F	Z	W+)	meanN*)	meanN*W	C*W
0- 2	0	1.0233	986227.5	0.0000	0.0000	0.5340	0.0002	83092	14.4	0.0
2- 4	0	1.0239	941856.1	0.0000	0.0000	0.5340	0.0013	81322	106.1	0.0
4- 6	0	1.0245	898429.8	0.0000	0.0000	0.5340	0.0045	79548	358.8	0.0
6- 8	0	1.0252	855951.0	0.0000	0.0000	0.5340	0.0107	77766	834.3	0.0
8-10	0	1.0259	814423.8	0.0000	0.0000	0.5340	0.0208	75978	1578.5	0.0
10-12	0	1.0266	773851.6	0.0000	0.0000	0.5340	0.0354	74182	2625.6	0.0
12-14	0	1.0274	734238.4	0.0000	0.0000	0.5340	0.0553	72378	4000.9	0.0
14-16	0	1.0282	695588.0	0.0000	0.0000	0.5340	0.0811	70568	5721.8	0.0
16-18	0	1.0291	657904.5	0.0000	0.0000	0.5340	0.1134	68750	7798.5	0.0
18-20	0	1.0301	621191.8	0.0000	0.0000	0.5340	0.1529	66924	10234.8	0.0
20-22	0	1.0311	585454.3	0.0000	0.0000	0.5340	0.2002	65089	13028.2	0.0
22-24	0	1.0322	550696.5	0.0000	0.0000	0.5340	0.2557	63246	16170.5	0.0
24-26	8	1.0333	516922.8	0.0002	0.0001	0.5341	0.3200	61394	19647.7	2.5
26-28	29	1.0345	484130.4	0.0009	0.0005	0.5345	0.3937	59529	23439.7	11.4
28-30	187	1.0359	452312.4	0.0060	0.0032	0.5372	0.4774	57644	27517.0	89.2
30-32	611	1.0373	421343.0	0.0201	0.0110	0.5450	0.5714	55710	31830.7	349.0
32-34	1204	1.0389	390982.4	0.0403	0.0224	0.5564	0.6762	53695	36311.6	814.2
34-36	1811	1.0406	361105.0	0.0617	0.0351	0.5691	0.7925	51582	40880.2	1435.2
36-38	2618	1.0424	331749.0	0.0904	0.0530	0.5870	0.9207	49350	45434.6	2410.2
38-40	4667	1.0445	302777.9	0.1571	0.0996	0.6336	1.0611	46878	49743.7	4952.2
40-42	6418	1.0467	273077.7	0.2142	0.1456	0.6796	1.2144	44080	53530.1	7793.8
42-44	6553	1.0492	243120.7	0.2299	0.1594	0.6934	1.3809	41103	56759.3	9048.8
44-46	6624	1.0519	214618.2	0.2457	0.1739	0.7079	1.5611	38086	59456.2	10340.5
46-48	6042	1.0550	187655.9	0.2438	0.1722	0.7062	1.7554	35096	61608.6	10606.2
48-50	7003	1.0585	162872.5	0.2904	0.2186	0.7526	1.9643	32038	62935.1	13756.3
50-52	6901	1.0624	138760.8	0.3092	0.2391	0.7731	2.1883	28865	63166.3	15101.3
52-54	6032	1.0669	116445.5	0.3047	0.2340	0.7680	2.4277	25776	62576.5	14643.6
54-56	5546	1.0721	96648.9	0.3128	0.2430	0.7770	2.6829	22820	61223.6	14879.2
56-58	4592	1.0781	78917.0	0.3004	0.2293	0.7633	2.9544	20022	59155.2	13566.5
58-60	5192	1.0853	63632.8	0.3607	0.3012	0.8352	3.2426	17234	55885.8	16835.5
60-62	5872	1.0940	49237.3	0.4362	0.4131	0.9471	3.5479	14213	50427.7	20833.1
62-64	4973	1.1045	35775.3	0.4540	0.4440	0.9780	3.8707	11199	43348.5	19248.9
64-66	4207	1.1178	24822.0	0.4825	0.4979	1.0319	4.2114	8450	35587.2	17717.2
66-68	2375	1.1349	16102.5	0.4172	0.3822	0.9162	4.5704	6214	28400.8	10854.6
68-70	3017	1.1578	10409.2	0.5746	0.7214	1.2554	4.9481	4182	20693.6	14928.2
70-72	1293	1.1902	5158.9	0.4967	0.5269	1.0609	5.3448	2453	13115.0	6910.8
72-74	663	1.2392	2555.6	0.4648	0.4638	0.9978	5.7610	1429	8235.3	3819.5
74-76	225	1.3222	1129.2	0.3443	0.2804	0.8144	6.1971	802	4972.8	1394.3
76-78	199	1.4938	475.7	0.5028	0.5400	1.0740	6.6534	354	2360.7	1324.0
78 plus	36	0.0000	80.0	0.4500	0.4369	0.9709	7.1277	82	587.3	256.5
Total									1141304.6	233924.1

*) X = ((L8-L(i))/(L8-L(i+1)))^(M/2K)
*) meanN(i) = (N(i)-N(i+1))/Z(i).
+) W(i) = q*(L(i)^b+L(i+1)^b)/2
Mean F (L >= 50) : 0.2935 (weighted by stock number)

The total catch of *P. filamentosus* over the period January 1985 to July 1990 taken by schooners was 342.1 tonnes of which 5.7% was caught at locations distant from the Mahe Plateau. 5.4% was reported as being caught on the Plateau itself, and 10% was from unreported fishing grounds. Thus, assuming the unreported areas were in the same proportion to those reported, 88.9% of the total catch of *P. filamentosus* landed by schooners was caught on the offshore banks and periphery of the Mahe Plateau, the southerly locations especially.

For whalers only 0.61% of the total catch landed in 1990 was *P. filamentosus* and only 1.9% of fishing trips that year caught this species. Of the catch landed, 31.0% was from unreported locations, and 15.4% was from the Mahe Plateau itself. The largest proportion was reported as being caught at the eastern edge of the Plateau (which is also the closest to Mahe and so most accessible to whalers with a limited range), followed by the South eastern edge of the plateau. 84.6% of the *P. filamentosus* catch taken by whalers was from the offshore banks and periphery of the Mahe Plateau.

It is known that *P. filamentosus* is caught principally in the depth range 70 - 120 m and thus it is to be expected that the greater proportion of the catch will derive from the offshore banks and periphery of the Plateau. By reducing the estimate derived in Table 7.3.3 from length cohort analysis by 15% (\1) to take account of catches landed from the Plateau and outlying areas, the estimated biomass of *P. filamentosus* on the peripheral edge zone of the Mahe Plateau was 970 tonnes. This corresponds to a density of 2.59 mt/km^2 for an area of 374 km^2.

Gulland (1971) proposed that the Maximum Sustainable Yield of a stock may be determined by applying the formula:

$$MSY = 0.5 \times M \times B_0$$

where M is the natural mortality and B_0 the virgin biomass. However, Beddington and Cooke (1983) studied this commonly used formula and indicated that it generally produced an overestimate of the MSY. They produced tables that, given biomass, the natural mortality, M, the growth constant, K, and the age at first recruitment into the fishery, Tr, indicate the MSY as a proportion of the initial biomass.

For exploited stocks a modified equation was proposed (Cadima, in Troadec, 1977):

$$MSY = 0.5 \times Z \times B_1$$

\1) This gives exactly the same result as reducing the initial catch weight and numbers by 15% as inputs for length cohort analysis. Strictly, only length frequency data from the offshore banks and peripheral edge zone should have been used as input together with a reduced catch volume equivalent to that from those areas only. However, fish measured at the SMB Fish Division often originate from several boats making it impossible to determine exactly where the individuals measured for length frequency sample data were caught. Attempts have since been made to address this problem. For the purposes of the analyses presented here, the assumption is made that the 15% of the L-F sample representing outlying islands and the inshore areas of the Plateau exhibits the same structure as those from the offshore banks and edge zone. It should also be noted that in practice whalers seldom land to SMB so the sample data relates mostly to fish caught by schooners which is principally from the offshore areas.

where Z is the total mortality and B_1 the standing stock. Garcia, Sparre and Csirke (1989) also proposed a formula for determining MSY from exploited biomass. However, Beddington (pers. comm.) argues that these formulae should not be applied to an exploited stock which is not in equilibrium, and that it is invalid to do so. Instead, the exploited biomass estimate should be used as a 'best estimate of virgin biomass' in conjunction with the analyses in Beddington and Cooke (1983). This will of course lead to an underestimate of MSY depending upon the degree of exploitation of the stocks. If the latter is known, it is theoretically possible to work back to derive B_0.

For *P. filamentosus* with an initial recruited biomass of 970 tonnes, M = 0.534, K = 0.2875, and Tr = 3 years (30 cm+) the MSY is approximately 24 % of B_0, ie. 233 tonnes, equivalent to an annual sustainable yield of 0.623 t/km^2.

Application of the length based Thompson and Bell model to the output from the Jones' length cohort analysis (using MIXFISH of LFSA) produced an MSY value of 279 tonnes per annum (0.75 t/km^2) with a seven-fold increase in fishing effort, at which point the standing stock would be 446 tonnes (Table 7.3.5). These results are considered unrealistic and reinforce the fact that the values for growth, mortality and production presented here should be regarded as preliminary estimates only requiring further refinement as more data become available.

Despite the reservations about these estimates, they would appear to be of the correct order. Information from the handline catches of Pecheur Breton indicate that at depths greater than 75m *P. filamentosus* form approximately 50% of the catch. Data from the SFA research vessel Etelis indicates that during commercial fishing trials *P. filamentosus* formed 54.2% of the catch of demersal species (excluding shark) for all gears used, 79.8% of the gill net catch, and 43.6% of the catch of handlines and droplines combined (Boulle, pers. comm.). Thus assuming equal catchability of all species in this depth range, the total sustainable yield for the intermediate depth zone is 1.25 - 1.5 t/km^2 or 466 - 560 t in total for the two estimates of MSY (area of fringing drop off is 374 km^2, see 2.1) applying a proportion of 50% for *P. filamentosus*.

TABLE 7.3.5. THOMPSON AND BELL LONG TERM FORECAST (units Kg) FOR DATA PRESENTED IN TABLE 7.3.3.

X	Yield	Mean Biomass
0.0000	0.00	1842637.87
1.0000	233739.96	1139549.75
2.0000	289952.68	891215.56
3.0000	311437.40	756166.06
4.0000	321171.84	668768.68
5.0000	325725.53	606900.18
6.0000	327656.56	560581.62
7.0000	328152.40	524513.06
8.0000	327827.34	495579.12
9.0000	327022.46	471814.93
10.0000	325937.15	451917.12
11.0000	324691.93	434985.84

MSY = 328152.4   X = 7   Biom.msy = 524513.1

Less 15% to eliminate inshore areas and outlying islands:

MSY = 278929.5   Biom.msy = 445836.1

7.3.2. *LUTJANUS SEBAE*

The catch of *Lutjanus sebae* per month by boat type was indicated in Table 7.3.1. For small boats, the entire catch may be assumed to derive from the inshore / central zone of the Mahe Plateau. Analysis of the data relating to whalers for 1990 indicated that 80% of trips landing *L. sebae* where the fishing grounds were recorded were in the inshore / central zone of the Mahe Plateau, and 67% of the catch of this species was from that area.

Data relating to schooners for the period January 1985 to July 1990 is indicated in Table 7.3.6 (after Mees, 1990). 3.5% of the catch of *L. sebae* over this period was caught in the inshore areas of the Mahe Plateau, and 0.3% from the outlying islands. Thus 96.2% of the schooner catch of this species originated from the offshore banks of the Mahe Plateau.

TABLE 7.3.4. CATCH AND EFFORT DETAILS BY FISHING LOCATION (F_G) FOR *LUTJANUS SEBAE* (LS) CAUGHT BY SCHOONERS DURING THE PERIOD JANUARY 1985 TO JULY 1990

YR	F_G	KG LS/ TRIP	% LS IN CATCH	CATCH OF LS (KG)	% OF TOT LS CATCH	NO TRIPS LS CAUGHT	% TRIPS LS CGT.
85	ALL	343.40	38.31%	88579.9	12.72%	258	72.66%
86	ALL	371.06	37.07%	150350.2	21.59%	405	78.22%
87	ALL	378.27	37.47%	188801.8	27.11%	499	79.48%
88	ALL	276.58	29.70%	103372.5	14.84%	374	74.16%
89	ALL	404.40	28.38%	108534.0	15.59%	268	72.34%
90	ALL	388.60	23.58%	55835.6	8.02%	144	68.42%
0	???	343.87	36.33%	162186.9	23.29%	472	87.72%
0	ALP	0.00	0.00%	0	0.00%	0	0.00%
0	AMI	71.63	5.20%	2220.1	0.32%	31	23.23%
0	PLA	0.00	0.00%	0	0.00%	0	0.00%
0	OUT	625.02	38.52%	24425.6	3.51%	39	72.50%
0	E	356.16	36.68%	56634.4	8.13%	159	85.51%
0	ENE	120.33	14.49%	486.4	0.07%	4	75.00%
0	ESE	581.77	49.24%	39198.9	5.63%	67	94.34%
0	N	157.01	20.00%	8674.9	1.25%	55	68.33%
0	NE	246.16	26.09%	31845.0	4.57%	129	87.27%
0	NNE	153.68	13.85%	1656.7	0.24%	11	88.89%
0	NNW	173.42	24.40%	3271.7	0.47%	19	50.00%
0	NW	238.16	27.17%	35945.1	5.16%	151	69.57%
0	S	475.90	44.42%	60283.3	8.66%	127	84.68%
0	SE	516.33	34.85%	89757.4	12.89%	174	73.30%
0	SSE	495.97	30.82%	24060.8	3.46%	49	85.71%
0	SSW	530.40	44.57%	2859.0	0.41%	5	57.14%
0	SW	374.49	35.55%	15644.2	2.25%	42	67.39%
0	W	359.35	32.53%	96850.3	13.91%	270	74.63%
0	WNW	253.40	26.38%	35513.5	5.10%	140	71.23%
0	WSW	240.83	21.23%	4868.0	0.70%	20	88.24%

The number of whalers landing bourgeois to SMB is negligible and thus length frequency data given in this report relates to stocks of *L. sebae* taken by the schooner fishery, and consequently to the offshore banks of the Mahe Plateau. Since different fishing pressures apply in the central and offshore zones of the Plateau it would be invalid to raise the sample numbers to the total catch from all areas. Thus in the following analyses only the schooner catch is used (reduced by 3.8% as indicated above), and estimates of mortality and production relate only to the stocks occurring on the offshore banks of the Mahe Plateau.

The total length frequency sample (males, females undetermined sex) was raised to the total number caught by schooners on the offshore banks of the Mahe Plateau, as indicated in Table 7.3.5. The following length-weight relationship was used, from Moussac (1988) :

$$W\ (kg) = 0.0000157 \times FL^{3.02}$$

The length converted catch curve analysis was applied to this data using the VBGF parameters derived by the Gulland and Holt plot and through application of ELEFAN I. A mean water temperature of 24°C for depths of 40 - 60 m was used. The M value derived was used as input for Jones' length converted cohort analysis. Neither of these sets of parameters produced a consistent F value from the two methods, and the estimated biomass was unrealistic. The VBGF parameters derived by Lablache and Carrara (1988) for this species were next used and similarly inconsistent results were achieved. These results are shown in Table 7.3.6, but the analysis was not taken further and the results of Jones' cohort analysis are not shown. The appropriate routines in LFSA were executed to derive these data. The equivalent routine in ELEFAN II gave slightly higher estimates for Z and F.

TABLE 7.3.5. THE TOTAL NUMBER OF L. SEBAE CAUGHT DURING 1990, 12 MONTHS DATA POOLED

ML\DATE	1990	ML\DATE	1990
19	35	63	2159
21	169	65	2089
23	352	67	1454
25	543	69	1376
27	719	71	1242
29	1002	73	847
31	1376	75	656
33	1263	77	487
35	1220	79	339
37	1178	81	212
39	1002	83	78
41	797	85	7
43	769	87	7
45	748		
47	663	Total (n)	33065
49	812	Sample (n)	5571
51	840	Catch (t)	103.2
53	1186		
55	1306		
57	1574		
59	2279		
61	2279		

TABLE 7.3.6. ESTIMATES OF MORTALITY FOR *L. SEBAE* BASED ON THE CATCH DATA IN TABLE 7.3.5 AND VARIOUS VBGF PARAMETERS.

METHOD			CATCH CURVE			COHORT AN.	
SOURCE for VBGF	Loo	K	Z	M	F	F	Biom.
Gulland+Holt plot	92.92	0.157	0.548	0.361	0.187	0.274	837.7t
ELEFAN I	95.12	0.307	1.157	0.557	0.599	0.757	278.9t
Lablache and Carara	96.00	0.230	0.891	0.460	0.438	0.567	387.9t

ELEFAN II was used to estimate the mortality coefficients for the sample data relating to males and females using the VBGF parameters given in Table 7.2.20 for non seasonally oscillating growth. The results were Z = 1.141, M = 0.650, F = 0.491 for males, and Z = 1.500, M = 0.530, F = 0.970 for females. The result of a higher fishing mortality for females is in agreement with the observed proportion of males and females in the catch reported in section 5.

7.3.3. *APRION VIRESCENS*

Length frequency data relating to *A. virescens* is derived mostly but not exclusively from whalers. 77% of the whaler catch of this species derived from the inshore areas of the Mahe Plateau during 1990. By contrast, only 2.3% of the schooner catch was from this area, 5.3% from the outlying islands, and the remainder from offshore banks of the Mahe Plateau (Table 7.3.7). The small boat catch derived entirely from the inshore areas of the Mahe Plateau. Thus, in the absence of accurate data relating to fishing location in respect to length frequency samples, it must be assumed that the sample relates to fish caught both inshore and offshore on the Mahe Plateau.

Table 7.3.1 indicates the catch of *Aprion virescens* per month in 1990. The length frequency sample data was raised to the total number caught per month using the following length weight relationship from Moussac (1988):

$$W\ (Kg) = 0.0000162 \times FL(cm)^{2.9095}$$

The data are shown in Table 7.3.8. These data were used with the VBGF parameters derived previously (L_{oo} = 104 cm, K = 0.26 pa) and a mean water temperature of 25°C for depths of 20 - 60 m to estimate the mortality coefficients using a length converted catch curve. This method was also applied to the sample data for males and females separately.

Using the above data the length - converted catch curve gave a Z value of 1.602. M was calculated as 0.496 giving an F value of 1.106. The result from the length converted cohort analysis (Table 7.3.8.) with M = 0.496, and a terminal exploitation rate (F/Z) of 0.4 (the value giving a constant F/Z in the last groups) gave a mean value for F of 0.956 for the fully exploited part of the stock (> 72cm), which is similar but less than that derived from the former method.

Mortality coefficients for males and females using the VBGF parameters derived in Section 7.2 were : males, Z = 1.296, M = 0.547, F = 0.749; females, Z = 0.989, M = 0.327, F = 0.662 indicating greater fishing pressure on males than females, as was observed.

TABLE 7.3.7. CATCH AND EFFORT DETAILS BY FISHING LOCATION (F_G) FOR *APRION VIRESCENS* (AV) CAUGHT BY SCHOONERS DURING THE PERIOD JANUARY 1985 TO JULY 1990

YR	F_G	KG AV/ TRIP	% AV IN CATCH	CATCH OF AV (KG)	% OF TOT AV CATCH	NO TRIPS AV CAUGHT	% TRIPS AV CGT.
85	ALL	130.36	13.43%	37288.6	13.7%	286	80.58%
86	ALL	119.79	11.33%	54053.5	19.9%	451	87.11%
87	ALL	83.17	7.93%	46091.7	17.0%	554	88.25%
88	ALL	108.34	11.46%	49081.7	18.1%	453	89.89%
89	ALL	169.55	10.11%	55140.5	20.3%	325	87.66%
90	ALL	220.42	10.07%	41009.7	15.1%	186	88.60%
0		94.56	9.64%	44089.7	16.2%	466	86.72%
0	ALP	50.00	2.70%	67.4	0.0%	1	100.00%
0	AMI	113.92	7.43%	13662.9	5.0%	120	89.90%
0	PLA	130.32	14.87%	702.5	0.3%	5	100.00%
0	OUT	147.61	7.37%	6365.3	2.3%	43	80.00%
0	E	83.76	8.13%	13319.0	4.9%	159	85.51%
0	ENE	206.00	21.50%	1110.4	0.4%	5	100.00%
0	ESE	62.81	5.21%	3978.1	1.5%	63	88.68%
0	N	124.88	13.45%	9255.7	3.4%	74	91.67%
0	NE	140.44	13.94%	17600.6	6.5%	125	84.55%
0	NNE	61.72	5.33%	748.6	0.3%	12	100.00%
0	NNW	155.36	17.81%	5652.7	2.1%	36	96.43%
0	NW	148.70	16.21%	28855.4	10.6%	194	89.44%
0	S	86.59	7.76%	11552.0	4.3%	133	89.19%
0	SE	132.73	7.35%	23610.0	8.7%	178	75.00%
0	SSE	118.67	6.27%	6076.8	2.2%	51	90.48%
0	SSW	49.86	3.51%	470.3	0.2%	9	100.00%
0	SW	92.50	7.66%	4736.7	1.7%	51	82.61%
0	W	138.81	12.24%	47512.5	17.5%	342	94.78%
0	WNW	157.32	14.45%	27984.1	10.3%	178	90.41%
0	WSW	201.77	18.08%	4078.5	1.5%	20	88.24%

The Jones' cohort analysis derived an estimate of B_1, the standing (exploited) biomass of 1835.6 tonnes. If the assumption is made that the sample data related to the inshore areas, reducing this estimate by 25% to account for the offshore catch by whalers and schooners gives a standing biomass of 1377 tonnes equivalent to 0.23 t/km^2 for the inshore areas (6000 km^2) available to a handline fishery. For M = 0.496, K = 0.260 and Tr = 3 the MSY is approximately 20% of B_0 (Beddington and Cooke, 1983), ie. 275 tonnes, equivalent to 0.046 t/km^2.

TABLE 7.3.8. JONES' LENGTH COHORT ANALYSIS FOR *A. VIRESCENS* CAUGHT IN 1990 USING THE PARAMETERS : Loo = 104cm, K = 0.26 per year, M = 0.496 per year.

Interval	C	X*)	N	F/Z	F	Z	W +)	meanN*)	meanN*W	C*W
10-12	0	1.0207	1149924	0.0000	0.0000	0.4960	0.0000	93192.0	1.6367	0.0000
12-14	0	1.0212	1103701	0.0000	0.0000	0.4960	0.0000	91371.4	2.5905	0.0000
14-16	0	1.0217	1058381	0.0000	0.0000	0.4960	0.0000	89546.3	3.8319	0.0000
16-18	0	1.0222	1013966	0.0000	0.0000	0.4960	0.0001	87717.9	5.3851	0.0000
18-20	0	1.0227	970457	0.0000	0.0000	0.4960	0.0001	85885.9	7.2700	0.0000
20-22	0	1.0233	927858	0.0000	0.0000	0.4960	0.0001	84049.7	9.5020	0.0000
22-24	0	1.0238	886169	0.0000	0.0000	0.4960	0.0001	82209.1	12.0926	0.0000
24-26	35	1.0244	845394	0.0009	0.0004	0.4964	0.0002	80363.1	15.0489	0.0066
26-28	0	1.0251	805498	0.0000	0.0000	0.4960	0.0002	78512.7	18.3743	0.0000
28-30	184	1.0258	766556	0.0048	0.0024	0.4984	0.0003	76649.8	22.0658	0.0530
30-32	448	1.0265	728354	0.0119	0.0060	0.5020	0.0003	74759.7	26.1118	0.1565
32-34	1507	1.0272	690825	0.0401	0.0207	0.5167	0.0004	72794.2	30.4787	0.6310
34-36	2489	1.0280	653212	0.0663	0.0352	0.5312	0.0005	70713.0	35.1166	1.2361
36-38	2017	1.0289	615649	0.0560	0.0294	0.5254	0.0006	68598.6	40.0252	1.1769
38-40	2056	1.0298	579607	0.0587	0.0309	0.5269	0.0007	66503.2	45.2054	1.3976
40-42	2839	1.0307	544566	0.0817	0.0441	0.5401	0.0008	64352.6	50.5746	2.2312
42-44	3106	1.0318	509808	0.0916	0.0500	0.5460	0.0009	62131.6	56.0664	2.8028
44-46	4932	1.0329	475885	0.1426	0.0825	0.5785	0.0010	59770.4	61.5427	5.0782
46-48	4201	1.0340	441306	0.1287	0.0733	0.5693	0.0012	57332.7	66.9739	4.9074
48-50	4137	1.0353	408668	0.1318	0.0753	0.5713	0.0013	54940.4	72.4314	5.4541
50-52	3882	1.0367	377281	0.1296	0.0739	0.5699	0.0015	52562.3	77.8292	5.7481
52-54	4175	1.0381	347328	0.1437	0.0832	0.5792	0.0017	50172.7	83.0676	6.9123
54-56	2960	1.0397	318267	0.1109	0.0619	0.5579	0.0018	47846.2	88.2089	5.4570
56-58	4382	1.0414	291576	0.1626	0.0963	0.5923	0.0020	45490.6	93.0298	8.9613
58-60	7686	1.0433	264630	0.2661	0.1799	0.6759	0.0023	42734.7	96.5975	17.3734
60-62	8603	1.0454	235748	0.3045	0.2172	0.7132	0.0025	39610.4	98.6348	21.4225
62-64	10122	1.0476	207498	0.3602	0.2792	0.7752	0.0027	36252.7	99.1386	27.6801
64-66	10597	1.0501	179395	0.3952	0.3241	0.8201	0.0030	32694.8	97.9019	31.7319
66-68	11229	1.0529	152581	0.4383	0.3871	0.8831	0.0033	29009.9	94.8587	36.7173
68-70	15620	1.0560	126963	0.5597	0.6305	1.1265	0.0036	24772.7	88.2263	55.6294
70-72	16282	1.0595	99056	0.6218	0.8154	1.3114	0.0039	19967.0	77.2633	63.0037
72-74	14767	1.0635	72870	0.6614	0.9689	1.4649	0.0042	15241.6	63.9327	61.9420
74-76	12685	1.0680	50543	0.7004	1.1597	1.6557	0.0045	10938.1	49.6276	57.5535
76-78	6805	1.0732	32433	0.6410	0.8856	1.3816	0.0049	7684.4	37.6345	33.3274
78-80	4871	1.0793	21816	0.6407	0.8845	1.3805	0.0053	5506.9	29.0553	25.7000
80-82	3649	1.0865	14214	0.6596	0.9610	1.4570	0.0057	3797.2	21.5434	20.7024
82-84	2221	1.0952	8682	0.6398	0.8810	1.3770	0.0061	2520.9	15.3523	13.5257
84-86	1000	1.1057	5210	0.5396	0.5814	1.0774	0.0065	1720.0	11.2252	6.5259
86-88	604	1.1189	3357	0.4969	0.4899	0.9859	0.0070	1232.8	8.6074	4.2171
88-90	321	1.1358	2142	0.4200	0.3592	0.8552	0.0075	893.7	6.6660	2.3941
90-92	253	1.1584	1377	0.4443	0.3966	0.8926	0.0080	637.9	5.0752	2.0128
92-94	70	1.1899	808	0.2363	0.1534	0.6494	0.0085	456.2	3.8660	0.5932
94-96	86	1.2372	512	0.3482	0.2649	0.7609	0.0090	322.6	2.9088	0.7752
96 lu	106	0.0000	265	0.4000	0.3307	0.8267	0.0096	320.5	3.0690	1.0148
Total									1835.6447	536.05

) meanN(i) = (N(i)-N(i+1))/Z(i). +) W(i) = q(L(i)^b+L(i+1)^b)/2

Mean F (L >= 72) : .9563 (weighted by stock number)

Application of the Thompson and Bell yield analysis to the data in Table 7.3.8. gave an estimate for the maximum sustainable yield of 590.45 tonnes per annum. Reduced by 25% to relate to the inshore areas this gives 443 t equivalent to 0.074 t/km². In 1990

A. virescens accounted for 37% of the demersal species caught by whalers. Assuming this proportion relates to the inshore areas, the estimated total yield from inshore areas would be 0.12 - 0.20 t/km^2, or 744 - 1200 t in total for the two estimates of MSY.

TABLE 7.3.9 THOMPSON AND BELL LONG TERM FORECAST FOR *APRION VIRESCENS*, BASED ON DATA FROM JONES' COHORT ANALYSIS IN TABLE 7.3.8.

X	Yield	Mean Biomass
0.0000	0.00	3684.71
0.5000	424.65	2317.94
1.0000	535.72	1833.41
1.5000	571.60	1594.82
2.0000	584.81	1445.76
2.5000	589.53	1338.19
3.0000	590.43	1253.86
3.5000	589.36	1184.39
4.0000	587.18	1125.34
4.5000	584.34	1074.04
5.0000	581.09	1028.75
5.5000	577.59	988.28

MSY = 590.45 Biom.msy = 1266.788
X = 2.921875

7.3.4. *EPINEPHELUS CHLOROSTIGMA*

The total landings of *E. chlorostigma* during 1991 by boat type are indicated in Table 7.3.1. Each of the boat types contribute a significant proportion of the landings. That caught by small boats originated from the inshore areas of the Mahe Plateau. For whalers, the fishing grounds were unreported in 54% of cases but of the remainder, 84% of the catch of this species was from the inshore areas. For schooners approximately 95% of the catch came from the offshore banks of the Mahe Plateau (Table 7.3.10).

Sampled length frequency data relates to both landings by schooners and whalers but not to small boats. It is not possible to assign the sample data to specific fishing grounds for 1990, or to make assumptions, as for the other species, that it was most likely derived from one location or another.

TABLE 7.3.10. CATCH AND EFFORT DETAILS BY FISHING LOCATION (F_G) FOR *EPINEPHELUS CHLOROSTIGMA* (EC) CAUGHT BY SCHOONERS DURING THE PERIOD JANUARY 1985 TO JULY 1990

YR	F_G	KG EC/ TRIP	% EC IN CATCH	CATCH OF EC (KG)	% OF TOT EC CATCH	NO TRIPS EC CAUGHT	% TRIPS EC CGT.
85	ALL	84.25	8.58%	20226.06	12.92%	240	67.63%
86	ALL	86.94	8.59%	33325.84	21.29%	383	74.00%
87	ALL	74.31	7.25%	39527.37	25.25%	532	84.70%
88	ALL	70.96	7.58%	28530.70	18.22%	402	79.78%
89	ALL	75.51	4.52%	21219.27	13.55%	281	75.74%
90	ALL	76.23	3.35%	12778.56	8.16%	168	79.82%
0		92.01	9.73%	43644.67	27.88%	474	88.22%
0	ALP	214.00	11.56%	288.38	0.18%	1	100.00%
0	AMI	59.39	2.87%	2961.21	1.89%	50	37.37%
0	OUT	82.03	4.32%	3426.79	2.19%	42	77.50%
0	PLA	39.27	4.57%	158.76	0.10%	4	75.00%
0	E	85.66	8.74%	14082.88	9.00%	164	88.41%
0	ENE	77.33	9.31%	312.62	0.20%	4	75.00%
0	ESE	90.52	7.33%	5733.18	3.66%	63	88.68%
0	N	66.53	8.55%	3944.79	2.52%	59	73.33%
0	NE	90.59	8.98%	11109.01	7.10%	123	82.73%
0	NNE	116.90	10.39%	1102.72	0.70%	9	77.78%
0	NNW	36.05	4.54%	874.44	0.56%	24	64.29%
0	NW	45.55	5.08%	6874.80	4.39%	151	69.57%
0	S	83.81	7.98%	10616.40	6.78%	127	84.68%
0	SE	86.97	4.86%	16525.03	10.56%	190	80.11%
0	SSE	95.34	4.96%	4753.69	3.04%	50	88.10%
0	SSW	45.88	3.79%	247.31	0.16%	5	57.14%
0	SW	67.90	5.62%	2836.51	1.81%	42	67.39%
0	W	60.94	5.40%	17081.24	10.91%	280	77.61%
0	WNW	62.00	5.78%	9106.92	5.82%	147	74.66%
0	WSW	50.12	4.57%	878.03	0.56%	18	76.47%

The sample data was raised to the total numbers caught each month, pooled for the year of 1990 (Table 7.3.11), using the following length-weight relationship, from Moussac (1988), relating to Total Length, as measured for this species :

$$W\ (kg) = 0.00000612 \times TL^{3.245}$$

TABLE 7.3.11. THE RAISED MONTHLY CATCH (NUMBERS) OF *EPINEPHELIS CHLOROSTIGMA*, POOLED FOR 1990.

ML\DATE	1990
23.5	76
24.5	151
25.5	353
26.5	655
27.5	604
28.5	957
29.5	1410
30.5	3627
31.5	4282
32.5	6675
33.5	7707
34.5	9747
35.5	11888
36.5	14483
37.5	14508
38.5	15037
39.5	12392
40.5	8186
41.5	4735
42.5	3299
43.5	2342
44.5	1410
45.5	1536
46.5	1385
47.5	1310
48.5	1939
49.5	1562
50.5	1360
51.5	1385
52.5	1058
53.5	957
54.5	579
55.5	529
56.5	781
57.5	302
58.5	227
59.5	176
60.5	25
61.5	176
62.5	25
TOTAL (N)	139836
Sample (N)	6478
Catch (MT)	126.5

The VBGF parameters L_{∞} = 64.45 and K = 0.175 were applied with a mean water temperature of 25°C to the data presented in Table 7.3.11. to derive the mortality coefficients. The length converted catch curve indicated that the fish experienced a higher mortality at sizes between 39 - 48.9cm total length than larger fish. Thus two estimates of Z were derived. For fish 39 - 44 cm TL, Z = 1.878; for fish greater than 49 cm TL, Z = 0.514. Pauly's formula for estimating M gave a value of 0.438 for a temperature of 25°C. Thus the respective values of F for each size range were 1.440 and 0.076.

The result from Jones' length converted cohort analysis (Table 7.3.12.) with M = 0.438, and a terminal exploitation rate (F/Z) of 0.15 (the value giving a constant F/Z in the last groups) gave a mean value for F of 0.079 for the fully exploited part of the stock (>= 49cm), which is consistent with that derived from the former method for that size range.

TABLE 7.3.12. JONES' LENGTH COHORT ANALYSIS FOR *E. CHLOROSTIGMA* CAUGHT IN 1990 USING THE PARAMETERS : Loo = 64.45cm, K = 0.175 per year, M = 0.438 per year.

Interval	C	X*)	N	F/Z	F	Z	W(t)+)	meanN*)	meanN*W	C*W
23-24	76	1.0310	1123835	0.0011	0.0005	0.4385	0.0002	152128	26.229	0.0131
24-25	151	1.0318	1057126	0.0023	0.0010	0.4390	0.0002	146564	28.925	0.0298
25-26	353	1.0327	992780	0.0057	0.0025	0.4405	0.0002	141050	31.692	0.0793
26-27	655	1.0335	930647	0.0109	0.0048	0.4428	0.0003	135569	34.507	0.1667
27-28	604	1.0345	870612	0.0105	0.0046	0.4426	0.0003	130142	37.353	0.1734
28-29	957	1.0354	813006	0.0172	0.0077	0.4457	0.0003	124764	40.207	0.3084
29-30	1410	1.0365	757402	0.0263	0.0118	0.4498	0.0004	119399	43.030	0.5082
30-31	3627	1.0376	703695	0.0678	0.0318	0.4698	0.0004	113890	45.731	1.4564
31-32	4282	1.0387	650184	0.0828	0.0396	0.4776	0.0004	108224	48.249	1.9090
32-33	6675	1.0399	598500	0.1296	0.0652	0.5032	0.0005	102379	50.512	3.2934
33-34	7707	1.0413	546983	0.1545	0.0800	0.5180	0.0005	96324	52.433	4.1953
34-35	9747	1.0427	497086	0.1981	0.1082	0.5462	0.0006	90083	53.945	5.8368
35-36	11888	1.0442	447882	0.2452	0.1423	0.5803	0.0007	83550	54.891	7.8102
36-37	14483	1.0458	399399	0.3013	0.1889	0.6269	0.0007	76666	55.118	10.4123
37-38	14508	1.0475	351336	0.3223	0.2083	0.6463	0.0008	69645	54.658	11.3860
38-39	15037	1.0494	306323	0.3538	0.2398	0.6778	0.0009	62693	53.587	12.8529
39-40	12392	1.0514	263827	0.3352	0.2208	0.6588	0.0009	56115	52.124	11.5107
40-41	8186	1.0536	226856	0.2703	0.1623	0.6003	0.0010	50449	50.820	8.2462
41-42	4735	1.0561	196573	0.1910	0.1034	0.5414	0.0011	45803	49.939	5.1626
42-43	3299	1.0587	171776	0.1525	0.0788	0.5168	0.0012	41852	49.296	3.8857
43-44	2342	1.0616	150146	0.1225	0.0612	0.4992	0.0013	38298	48.645	2.9747
44-45	1410	1.0648	131029	0.0840	0.0402	0.4782	0.0014	35083	47.970	1.9280
45-46	1536	1.0683	114253	0.0986	0.0479	0.4859	0.0015	32057	47.109	2.2573
46-47	1385	1.0722	98676	0.0980	0.0476	0.4856	0.0016	29115	45.913	2.1841
47-48	1310	1.0766	84538	0.1021	0.0498	0.4878	0.0017	26290	44.421	2.2134
48-49	1939	1.0816	71713	0.1588	0.0827	0.5207	0.0018	23450	42.394	3.5053
49-50	1562	1.0873	59502	0.1472	0.0756	0.5136	0.0019	20662	39.910	3.0171
50-51	1360	1.0939	48890	0.1466	0.0752	0.5132	0.0021	18073	37.250	2.8030
51-52	1385	1.1015	39614	0.1684	0.0887	0.5267	0.0022	15610	34.287	3.0420
52-53	1058	1.1105	31392	0.1536	0.0795	0.5175	0.0023	13310	31.116	2.4734
53-54	957	1.1212	24504	0.1632	0.0854	0.5234	0.0025	11202	27.842	2.3785
54-55	579	1.1341	18640	0.1243	0.0622	0.5002	0.0026	9315	24.587	1.5282
55-56	529	1.1502	13981	0.1366	0.0693	0.5073	0.0028	7636	21.379	1.4810
56-57	781	1.1707	10107	0.2297	0.1306	0.5686	0.0030	5979	17.739	2.3170
57-58	302	1.1977	6707	0.1323	0.0668	0.5048	0.0031	4523	14.207	0.9484
58-59	227	1.2347	4424	0.1331	0.0672	0.5052	0.0033	3376	11.213	0.7539
59-60	176	1.2888	2718	0.1445	0.0740	0.5120	0.0035	2375	8.334	0.6176
60plus	225	1.3751	1500	0.1500	0.0773	0.5153	0.0037	2910	10.779	0.8332
Total (tonnes)									1468.357	126.4925

*) X = ((L8-L(i))/(L8-L(i+1)))^(M/2K)

) meanN(i) = (N(i)-N(i+1))/Z(i).   +) W(i) = q(L(i)^b+L(i+1)^b)/2

Mean F (L >= 49) : .0793 (weighted by stock number)

The mean standing biomass (B_1) derived from Jones' cohort analysis was 1468 tonnes. Assuming this relates to the inshore and offshore areas fished by whalers and schooners on the Mahe Plateau this equates to a density of 0.12 t/km^2 for a total area of 12,500 km^2 (6000 km^2 inshore, 6,500 km^2 offshore). For M = 0.438, K = 0.175 and Tr = 2 years MSY is equivalent to 11% of B_0 (Beddington and Cooke, 1983), ie. 161 tonnes, equivalent to 0.013 t/km^2.

The Thompson and Bell long term yield analysis applied to length cohort data in Table 7.3.11 produced an estimate of the maximum sustainable yield of this species of 290 t per annum (Table 7.3.12). As with *P. filamentosus* the result (12 times increase in fishing pressure, low mean biomass) is questionable, but nevertheless, it is of the order expected and should be regarded as a preliminary estimate to be refined in the future. The MSY estimated is equivalent to 0.023 t/km^2. *E. chlorostigma* represented 6.9% of the demersal catch by schooners, 5.3% of the demersal catch by whalers, and 6.5% of the total demersal catch during 1990. Applying the latter proportion and assuming all handline species to be of equivalent catchability, the total MSY for all handline caught species from the inshore and offshore areas of the Mahe Plateau is 2484 - 4460 t, equivalent to 0.199 - 0.357 t/km^2 for the two estimates of MSY.

TABLE 7.3.12. THOMPSON AND BELL LONG TERM YIELD FORECAST FOR *E. CHLOROSTIGMA*, BASED ON DATA IN TABLE 7.3.11.

X	Yield	Mean Biomass
0.0000	0.00	1983.21
2.0000	194.76	1155.39
4.0000	256.26	823.69
6.0000	278.28	665.89
8.0000	286.52	579.88
10.0000	289.43	527.17
12.0000	290.14	491.46
14.0000	289.91	465.21
16.0000	289.28	444.69
18.0000	288.47	427.90
20.0000	287.60	413.71
22.0000	286.71	401.42

MSY = 290.12 Biom.msy = 487.1675
X = 12.29688

8. PRODUCTION ESTIMATES

Estimates of the demersal fishery resource in Seychelles have largely been confined to the granitic Mahe Plateau. They are based upon the swept area method applied to trawl surveys in four instances, and through application of length cohort analysis to a representative species to determine population size in one case.

For demersal fish resources, Birkett (1979) estimated the total biomass of the Mahe Plateau to be 42,000 tonnes, and Marchal *et. al.* (1981) estimated 75,000 tonnes. Tarbit (1980) estimates the biomass for 4176 square nautical miles of the Plateau covered by trawl surveys to be 80,000 tonnes. Kunzel *et. al.* (1983) estimated the total biomass for the whole of the Mahe Plateau to be 51,000 tonnes. Lablache and Carrara (1988) estimate a total biomass of large demersal fish exploitable by a handline fishery of 8,400 tonnes for the offshore banks of the Mahe Plateau (1,900 nm^2). Information from these surveys has subsequently been applied to determine the potential yield of demersal species available to a handline fishery (Lablache and Moussac, 1987; Lablache et. al. 1988; Lablache and Carrara, 1988).

It is argued that these resource estimates should be revised in relation to stratified fishing locations by depth and substratum fished. Revised estimates of the potential yield available to a handline fishery are presented by location and fishing stratum. Estimates of the potential yield take into account new information presented in this study and from analysis of the catches of the mothership-dory fishing operation of Pecheur Breton.

8.1. A REVIEW OF LITERATURE RELATING TO THE AVAILABLE DEMERSAL FISH RESOURCES IN SEYCHELLES

TARBIT (1980)

Tarbit (1980) based his estimate of biomass on the analysis of research cruises between 1972 and 1979 by the vessels KOYO MARU, PROFESSOR MESYATSEV (2 cruises, also reported by Birkett, 1979), DR FRIDTJOF NANSEN and NAKUA. These vessels undertook a total of 419 demersal trawl surveys of which 5 were conducted on Fortune Bank, 4 on the Amirantes Plateau and the remainder on the Mahe Plateau. Little trawling was conducted at depths of less than 45 metres and most of the trawlable ground was found to lie between depths of 50 and 65m on substrata composed of fine or silty sand. No trawlable ground was found to exist below 70m.

The total area of the Plateau was estimated to be around 11,000 nm^2 of which 4176nm^2 were trawlable. The estimated biomass for the trawlable area was 33,685 t from day trawls and 42,964 t from night trawls. Tarbit suggested that these figures were underestimates since they were based on one hour tows and did not allow for escapement. Two hour tows produced a greater catch per hour than one hour tows, and Tarbit also assumed 80% efficiency of the gear. Applying these two factors a revised estimate of the total biomass for the trawlable area was 80,000 t.

In total 280 species were recorded in the demersal trawl catches. These included a large number of species not normally taken by the demersal handline fishery. Tarbit estimated the Maximum

Sustainable Yield (MSY) from the trawlable areas by applying the following formula to 13 species of importance in the catch:

$$Y_{max} = 0.5xMB_0$$

where M=the natural mortality coefficient which varies according to species, and B_0=the original biomass. For these species (see Table 9 in Tarbit, 1980) the MSY was 10,727 t, equivalent to 15,300 t pa for all species, assuming a similar average mortality.

For the key demersal species estimates of the biomass obtained by the swept area method are available for *L. sebae* and *A. virescens* on trawlable grounds. Subtracting species not caught by handline a total biomass of large handline caught species may also be derived from Tarbit (1980), although this latter figure is still an overestimate since it is not possible to subtract all unwanted species. This data appears in Table 8.1. MSY has been calculated by the method of Beddington and Cooke (1983) using K, and M values quoted for the respective species. For the whole fishery a recruitment age, Tr of 3 years, mean M of 0.3 and mean K of 0.22 were assumed. The MSY is compared with that derived for *L. sebae* by Lablache and Carrara (1988, see also below) and for *A. virescens* (7.3.3. this report) for offshore and inshore areas respectively.

TABLE 8.1. : BIOMASS ESTIMATES FOR LARGE DEMERSAL SPECIES (AVAILABLE TO A HANDLINE FISHERY) ON TRAWLABLE SUBSTRATA (TARBIT, 1980) AND ESTIMATES OF MSY.

SPECIES	BIOMASS	% TOTAL	T/KM2	MSY	T/KM2	OTHER EST.T/KM2 From	To	Area
L. SEBAE	7348	34.21%	0.525	1102	0.079	0.054	0.058	OFF
A. VIRESCENS	1276	5.94%	0.091	252	0.018	0.046	0.074	INS
TOTAL	21482		1.533	1719	0.123			

KUNZEL *ET. AL.* (1983)

These authors analysed the results of 108 valid demersal trawls conducted by two German trawlers on the Mahe Plateau. The operation had commercial objectives so the trawls were not random but concentrated on grounds giving the best catch rates. Unlike Tarbit (1980) the estimate of biomass related to the total productive ground on the Plateau, and not just the trawlable areas. No adjustment was made for escapement, but factors leading to an overestimate of the biomass (non random samples) were assumed to balance those leading to an underestimate (escapement, smooth trawling grounds covered yet fish are known to aggregate in rough coraline areas). The total biomass for the Mahe Plateau was estimated as 51,000 tonnes: 32,338 t from 8,740 nm^2 of the central zone, and 19,000 t from 3,800 nm^2 of edge zone.

The species landed were classified as big marketable fish (14 families, about 33 species), small marketable fish (17 families, about 48 species) and trash fish. MSY was calculated using the formula $Y_{max} = 0.5xMB_0$ for the small fish, and $Y_{max} = 0.5xZB_1$ for the big fish since they were already exploited by handlines. Z is the exponential rate of total mortality (F+M) and B_1 the standing stock size during the survey. The MSY was 21,264 t pa in total of which 4,406 t were big fish (1,803 t central zone, 2,603 t edge zone) and 16,858 were small fish (12,564 central zone, 4.294 edge zone).

LABLACHE AND CARRARA (1988)

These authors used length frequency measurements relating to *Lutjanus sebae* (Bourgeois) taken from data collected in the above trawl surveys, and from samples of fish landed by schooners. Landings by schooners were also analysed. Using length cohort analysis they estimated the biomass of this species on the offshore banks of the Mahe Plateau (1,900 nm^2) to be 2,360t. They assumed that this species was representative of all fish exploited by the schooner handline fishery. Since it represented 28% of the catch the total biomass was estimated to be 8,400t. However, it should be noted that this represents the standing biomass of an exploited stock and does not represent the virgin biomass.

ESTIMATES OF POTENTIAL YIELD AVAILABLE TO A HANDLINE FISHERY

For trawlable substrata on the Mahe Plateau a density estimate relating to demersal fish species available to a handline fishery of 1.46 tonnes/sq. km (5.0 t/nm^2) was derived by Lablache and Moussac (1987) and Lablache *et. al.* (1988) from data presented in Tarbit (1980). This was achieved by examining the estimated biomass for handline caught species only, divided by the total area of trawlable grounds. Lablache and Carrara (1988) indicated that this may be an overestimate because Tarbit (1980) provides biomass estimates only for selected species and a total for the overall fishery. Thus it was not possible to subtract all the unwanted fish species from the calculation. (Note that from the same data Mees derived a slightly higher estimate of 1.53 t/Km2 - see above)

Lablache and Carrara (1988) provide density estimates for demersal fish species available to handline fisheries on the Mahe Plateau based on the above reports. This information is included in Table 8.2. Big fish species refer to those identified in Kunzel *et. al.* (1983).

TABLE 8.2. DENSITY ESTIMATES (T/NM^2) FOR DEMERSAL FISH IN SEYCHELLES

REFERENCE AREA	SURFACE AREA	ALL SPECIES	BIG FISH SPECIES	HANDLINE SPECIES	SURVEY PERIOD	REF.
CENTRAL	8740nm^2	3.70	0.80	0.50	1981	1
EDGE	3800nm^2	5.00	2.70	2.10	1981	1
TRAWLABLE	4176nm^2	19.15	5.30	5.00	1976-79	2
TRAWLABLE	7000nm^2	10.71	4.80	4.50	1980	3
BANKS	1900nm^2	-	4.40	4.40	1984-85	4

REF 1: Kunzel *et. al.* (1983); 2: Tarbit (1980); 3: Marchal *et. al.* (1981); 4: Lablache & Carrara (1988)

Lablache *et. al*. (1988) have utilised these density evaluations to derive estimates of total biomass and maximum sustainable yield of handline caught species on the Mahe Plateau. They use a value of 1.4 tonnes / km^2 (4.78 t/nm^2) being an approximate average of the estimates derived from Tarbit (1980) and Marchal (1981). They have defined the fishing grounds as inshore (0-35m depth), offshore banks (36-100m depth) and trawlable. By surface area, the offshore banks correspond to those in Lablache and Carrara (1988), and the trawlable grounds to those in Tarbit (1980). The inshore grounds (6000 km^2 / 1760 nm^2) are not defined elsewhere and do not correspond to the Central zone in Kunzel *et. al*. (1983). They apply the same density estimate to each of these areas and derive the following values for biomass: inshore 8,500 t (6000 km^2), offshore 9,000 t (6500 km^2), trawlable 19,600 t (14,000 km^2), Total 37,100 t (26,500 km^2 of fishable grounds of 43,300 km^2 total Plateau area).

MSY was calculated using the formulas:

i) $MSY = 0.4xMB$ (Gullands formula, 0.4 substituted)

and ii) $MSY = MB^{(Y/MB-1)}$ (Garcia, Sparre and Csirke, 1989)

Where B is the estimated biomass and M the natural mortality coefficient, given the value 0.3. From application of these formulae, the estimates of MSY on the Mahe Plateau were: (i) inshore 1,000 t, off shore 1,000 t, trawlable, 2,400 t, total 4,400 t; (ii) inshore 1,300 t, offshore 1,400 t, trawlable 2,200 t, total 4,900 t.

DISCUSSION OF RESOURCE ESTIMATES

In considering the above estimates of potential yield there are two important points to bear in mind. Firstly, apart from the estimate of Lablache and Carrara (1988) they relate to trawlable grounds, and secondly they relate principally to the Plateau surface at depths of less than 70 m.

Tarbit states that 'the as yet unsurveyed portion of the Mahe Plateau, some 7000nm^2, must bear populations of these species not included in this analysis' and that 'those areas not covered by the surveys will support similar populations at average densities'. Kunzel *et. al*. state that 'as a general observation, fish concentrate near reefs, slopes and edges of the sea bed' and that trawl catches confirmed this. They also state that 'most trawls were conducted on smooth trawlable grounds whereas the biggest fish concentrations are known to be in rough coraline areas'. Bean (Pers. Comm.) indicates that the most productive areas are on the drop off at the edges of banks and Plateaux which would not have been accessible to trawlers.

Next, the above estimates of biomass were based on trawls in depths of 50 to 60 m whilst at depths of greater than 75 m *Pristipomoides filamentosus* is known to become increasingly significant (Mees, 1990, Mees, 1991). This species was not referred to specifically in the above surveys and did not form a significant part of the landings (1\). Similarly, Lablache and Carrara (1988) base their estimates on *Lutjanus sebae* which is predominantly caught in depths of 60 m or less, and on the catches of schooners operating between 1984 and 1985. Mees (1990) examined the catches of schooners between 1985 and 1990 and found that whilst *L. sebae* was the target species in 1985 comprising 26.7% of the catch, by 1989 with the introduction of electric reels certain boats were targeting deeper water species and the proportion of *L. sebae* had fallen to 19%. *Pristipomoides filamentosus* on the other hand had increased from 2.1% of the catch in 1985 to 16% in 1989 (and the proportion was even greater for the first 6 months of 1990). Overall catch rates and catch volumes increased despite a fall in apparent effort, partly explained by the fact that a new stock was being targeted which had largely been unfished previously.

Thus it may be argued that the biomass and density estimates presented to date relate only to trawlable grounds to a maximum depth of 60 - 70 metres. These densities may not be applicable to rough ground or to depths greater than 70m. On the rough ground the substratum and habitat is reputed to support larger populations. In the deeper water discrete fish populations exist which were not assessed in the shallow water trawls. It is thus necessary to refine the biomass estimates based on fish densities in different strata thus:

1. Shallow water 0 - 75 m on the Mahe Plateau
   a) Inshore zone
   b) Offshore banks
   c) Trawlable grounds

2. Intermediate depths 75 - 150 m - drop offs of banks and plateaux

3. Deep bottom resources > 150 m - drop offs of banks and plateaux

Strata 2 and 3 are not confined to the offshore banks defined in Lablache and Carrara (1988) but relate to any part of the drop off of the Plateaux and Banks at those depths. In some parts the drop off shelves so steeply that fishing would be impossible, but Bean (SFA Masterfisherman / Operations Manager, Pers. Comm.) indicates that most parts of the edge zone of the Mahe Plateau, including those not traditionally fished are suitable for exploitation. Thus, whilst previous estimates claim to encompass the area to 100m depth they should be adjusted to represent stocks to 75 m depth . In Section 2.1 infact, no adjustment to the area fished was made since the surface area of the rim from 75 - 100m is negligible compared to the total Plateau area. Thus no adjustment to the estimates for this stratum is necessary.

1\) *Pristipomoides argyrogrammicus* was reported in Kunzel *et. al.* (1983) and formed 1.11% of the total catch. This species was also reported in Tarbit (1980) where the local name was given as Batrican. The volume of the catch represented by this species was not reported separately and so it was presumably not considered to be significant. Tarbit notes that *P. argyrogrammicus* was recently synonymised with *P. filamentosus* (Kami,1973).

Finally, it may be argued that estimates of MSY based on Gulland's formula ($MSY = 0.5MB_0$) are overestimates, and that those using formulae relating to the exploited biomass (eg. Cadima; Garcia *et. al.*) are invalid (as discussed in Section 7.3.1., after Beddington and Cooke, 1983). Taking the approach of Lablache *et. al.* (1988), and utilising $B_0 = 1.4$ t/km^2, average population dynamic parameters for all demersal fish of M = 0.3, and K = 0.22 the MSY is equivalent to 7% or 8% of the virgin recruited biomass for the ages of recruitment, Tr, of 2 and 3 years respectively (Beddington and Cooke, 1983). The value of MSY $= 0.4MB_0$ used by Lablache *et. al.* (1988) gave an MSY equivalent to 12% of B_0.

This tends to indicate that a downward revision of the present estimates would appear to be in order. However, the application of M = 0.3 may be somewhat conservative. For each of the key species studied M was greater (0.438 - 0.534). Ralston (1987) lists mortality rates for a number of snappers and groupers which range from 0.08 to 0.83 with the majority greater than 0.3. He also found that as a rough guide, M is equal to twice the value of K. Thus if M = 0.5 were substituted the MSY estimate becomes 10 - 13% of B_0 for Tr = 2 and 3 years respectively.

Next, the approach taken by Lablache and Carrara (1988) of raising up single species estimates to represent the whole stock, also adopted in this report, may be questioned. This approach not only assumes equal catchability of all species, but also assumes equal population dynamics (ie. growth, mortality and age at recruitment). This is illustrated in Table 8.3 by using the data from Table 8.1:

TABLE 8.3. : ESTIMATES OF THE TOTAL MSY AVAILABLE ON TRAWLING GROUNDS.

SPECIES	BIOMASS	% TOT	M	K	Tr	SPECIES MSY	TOTAL MSY
L. SEBAE	7348	34.21	0.480	0.230	2	1102	3221
A. VIRESCENS	1276	5.94	0.496	0.260	3	252	4242
TOTAL	21482		0.300	0.220	3		1719
TOTAL	21482		0.500	0.220	3		2793

Growth and mortality parameters for *L. sebae* were obtained from Lablache and Carrara (1988) and for *A. virescens* from this report. The age at first recruitment for *L. sebae* was 2 years and 3 years for *A. virescens*. For all species mean values of 0.3 and 0.5 for M were applied.

The total MSY for all species from individual species data was calculated as 3221 t from *L. sebae* and 4242 t from *A. virescens*, indicating that if the species chosen is not representative of the whole population, then taking this approach will lead to a significant miscalculation of MSY. Both estimates were significantly higher than that assuming mean parameters for the population as a whole. Ideally the MSY of each species should be calculated and summed. Owing to lack of data on sufficient numbers of species this is not possible and the best approach is to take the mean of the data available.

8.2. REVISED ESTIMATES OF THE BIOMASS AND MSY OF COMMERCIALLY IMPORTANT DEMERSAL SPECIES AVAILABLE TO A HANDLINE FISHERY

8.2.1. DISCUSSION OF THE BASIS UPON WHICH REVISED ESTIMATES ARE TO BE MADE

1. FOR THE SHALLOW WATER STRATA:

The mean population dynamics parameters for the shallow water species (*A. virescens, E. chlorostigma, L. sebae*), K = 0.22, M = 0.47 and Tr = 2-3 years, were applied to an estimate of B_0 = 1.4 t/km² to derive an estimate of MSY by the method of Beddington and Cooke (1983). MSY was equivalent to 10-12 % of B_0 with these parameters. This virgin biomass estimate which, as discussed above, relates to trawlable substrata, was applied also to the areas of the inshore and offshore fisheries. Estimates of the exploited biomass and MSY of individual species (see Section 7.3, and Lablache and Carrara, 1988) were raised up to represent all species (assuming equal catchability and population dynamics) in relation to area fished (inshore or offshore). The results are compared in Table 8.4.

TABLE 8.4. AVAILABLE ESTIMATES OF BIOMASS AND MSY FOR DEMERSAL SPECIES CAUGHT BY HANDLINE ON THE MAHE PLATEAU

SUB - STRATUM	DETAILS (Ref.:)	PREVIOUS ESTIMATES From (1)	To	FROM TRAWL DATA From (B,1;MSY,2)	To	L. SEBAE From (B,3;M,2)	To (3)	A. VIRESCENS From (2)	To	E. CHLOROSTIGMA From (2)	To
INSHORE	BIO/KM2	1.400	1.400	1.400	1.400			0.620	0.620	1.807	1.807
(6000 KM2)	BIOMASS	8500	8500	8400	8400			3722	3722	10842	10842
	MSY/KM2	0.167	0.217	0.140	0.168			0.124	0.200	0.199	0.357
	MSY	1000	1300	840	1008			744	1200	1194	2142
OFFSHORE	BIO/KM2	1.400	1.400	1.400	1.400	1.290	1.290			1.807	1.807
(6500 KM2)	BIOMASS	9000	9000	9100	9100	8400	8400			11746	11746
	MSY/KM2	0.154	0.215	0.140	0.168	0.194	0.209			0.199	0.357
	MSY	1000	1400	910	1092	1260	1357			1294	2321
TRAWLABLE	BIO/KM2	1.400	1.400	1.400	1.400						
(14000 KM2)	BIOMASS	19600	19600	19600	19600						
	MSY/KM2	0.157	0.171	0.140	0.168						
	MSY	2200	2400	1960	2352						

References: 1) Lablache *et. al.* (1988); 2) Mees, Present report; 3) Lablache and Carrara (1988)

In relation to the inshore areas Kunzel *et. al.* found substantially lower stock densities (see Table 8.2.) suggesting that the estimate for this area should be reduced. However, information relating to *Aprion virescens* (this report, 7.3) indicated a potential yield per unit area very similar to that derived from trawl surveys (although the biomass indicated was less). Information relating to *E. chlorostigma* suggested a higher stock density than derived from trawl surveys. Although, as pointed out above, raising single species data to represent the whole stock may lead to errors, the fact that these estimates are based on exploited biomass will in part compensate for overestimation arising from application of this technique, since they will underestimate the virgin biomass. Thus, on balance, it would seem justified to retain the estimate of 1.4 t/km^2 used by Lablache *et. al*. (1988) from trawl survey data for the biomass of this sub stratum.

For the offshore areas it has been argued that trawl survey data would underestimate the true stock density. The estimated density for offshore areas from cohort analysis applied to *L. sebae* was similar to that observed on the trawlable grounds suggesting no adjustment is necessary, whilst that based on *E. chlorostigma* suggests that upward revision is indeed required. However, since *L. sebae* was a target species for the schooner fleet, the proportion in the catch may not be representative of the true population structure and thus the total stock size (all species) would have been underestimated in the study of Lablache and Carrara (1988). In the case of *E. chlorostigma*, this species represents only a small proportion of the total demersal landings. Thus, by applying the method of raising up the estimated yield for this single species to the whole population of all species, any errors will be amplified. Thus, in the absence of further stock estimates it is considered expedient to be conservative and retain the estimate based on trawl survey data, but to highlight the fact that this estimate in all probability underestimates the resources available on the offshore banks.

The density of fish stocks on trawlable grounds have been established.

Thus for the shallow water stocks an estimate of the MSY will be based on the assumption that the virgin biomass is 1.4 t/km^2 for all strata. The mean population parameters M = 0.47; K = 0.22 and Tr = 3 years result in an estimate of MSY = 12% of B_0, ie. 0.168 t/km^2. The choice Tr = 3 rather than 2 resulting in a higher estimate of MSY appears justified for the reasons given above which argue that the MSY is probably underestimated, particularly for the offshore areas. The application of these values results in an MSY very similar to the lower estimate derived by Lablache *et. al*. (1988).

2. FOR THE INTERMEDIATE DEPTHS:

Two methods of deriving an estimate of the biomass available in this depth range (75 - 150 m) are presented. The first applied the estimated yield for *P. filamentosus* derived from cohort analysis to the whole resource at this depth on the assumption that this species (at 50% of the catch at this depth range) is representative of all fish in this fishery (see 7.3.1). The estimated sustainable yield was 466 - 560 tonnes per annum, equivalent to 1.25 - 1.50 t/km^2 for all species. The second relates to application of the Leslie constant catchability model (in Polovina, 1986) to data from the mothership dory fishing operation of Pecheur Breton on isolated sea mounts. Pecheur Breton fished intensively on the banks to the South East of the Mahe Plateau and accurate catch, effort and species composition data by depth were recorded and analysed (Mees, 1991).

In order to determine the virgin biomass the constant catchability Leslie model defines the catch per unit effort during a time interval of t ($CPUE_{(t)}$) as the product of catchability (q) and the mean population size present during the period t ($N_{(t)}$). If up to the beginning of the period t, $K_{(t)}$ fish have been caught and t is short, the population closed or isolated, and fishing pressure heavy enough that mortality from other sources is negligible, then,

$$N_{(t)} = N_{(0)} - K_{(t)}$$

where $N_{(0)}$ is the initial population size at the beginning of the experiment (t=0). The Leslie model then, is:

$$CPUE_{(t)} = q(N_{(0)} - K_{(t)})$$

This is the form of a linear regression from which q (the slope) may be derived. $N_{(0)}$ may then be calculated thus:

$$N_{(0)} = (CPUE_{(t)}/q) + K_{(t)}$$

For the Pecheur Breton data, rather than the number of individuals N, the weight caught has been applied.

An analysis of catch rates per day for *Pristipomoides filamentosus* (Mees, 1991) indicated that only at Correira Bank, Small Constant, and an isolated sea mount, M20, did catch rates fall with time and this was only substantial at the latter two. Catch rates were observed to fall at other locations but this could be attributed to a change in other factors so the data cannot be used. The following figures (8.1 - 8.3) illustrate the cpue and adjusted cumulative catch per day for the three locations mentioned, and the data and results of regression analysis follow (Tables 8.3, 8.4):

FIGURES 8.1 - 8.3 OBSERVED DAILY CATCH RATES AND ADJUSTED CUMULATIVE CATCH FOR *P. FILAMENTOSUS* AT SMALL CONSTANT, AND CORREIRA BANKS AND AT SEA MOUNT M20.

FIGURE 8.1. SMALL CONSTANT BANK
DAILY CPUE VS ADJUSTED CUMULATIVE CATCH

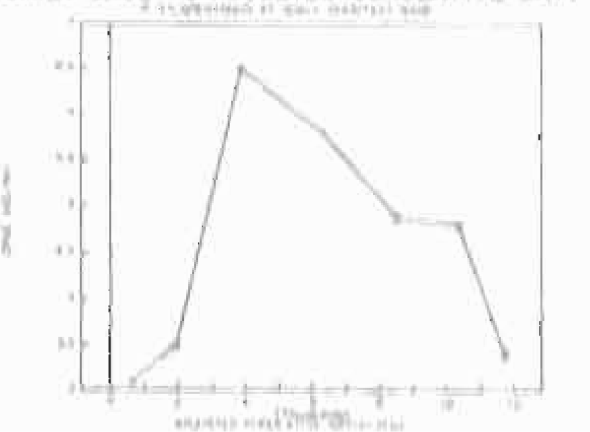


FIGURE B.2: CORREIRA BANK
DAILY CPUE VS ADJUSTED CUMULATIVE CATC

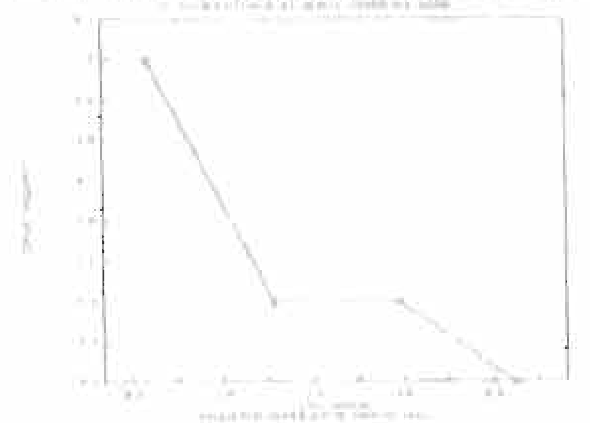


FIGURE B.1: SEA MOUNT M70
DAILY CPUE VS ADJUSTED CUMULATIVE CATC

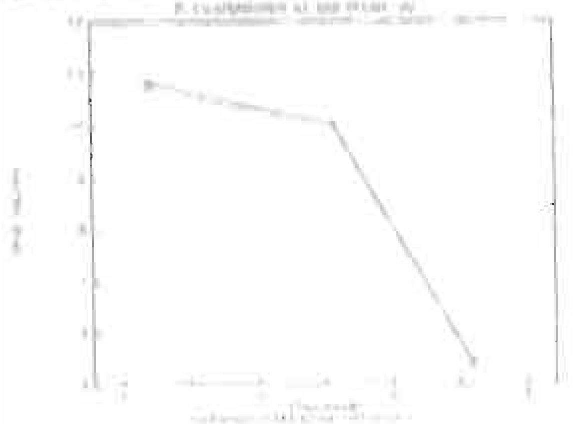


TABLE B.5: P. FILAMENTOSUS CATCH AND CPUE BY LOCATION

1. SMALL CONSTANT

DAY	CATCH	CPUE	AD.CUM.CAT
51	1238	5.1	618.0
52	1608	5.5	1040.5
53	2184	6.5	3007.0
54	2628	5.8	6542.0
55	1911	4.9	8510.5
56	1814	4.8	10275.0
57	929	3.4	11745.5

B(1)= 21766 kg q = 0.00035 kg/km

Regression Output	
Constant	7.990048
Std Err of Y Est	0.582751
R Squared	[illegible]
No. of Observations	5
Degrees of Freedom	3
X Coefficient(s) -0.00035	
Std Err of Coef. 0.000060	

2. CORREIRA BANK

DAY	CATCH	CPUE	AD.CUM.CAT
54	1340	5.9	670.0
55	1655	5.5	2072.5
56	1319	4.6	3562.5
57	1248	4.2	4852.0

B(1)= 28483 kg q = 0.00017 kg/km

Regression Output	
Constant	4.805108
Std Err of Y Est	0.186179
R Squared	0.807929
No. of Observations	4
Degrees of Freedom	2
X Coefficient(s) [illegible]	
Std Err of Coef. [illegible]	

CONTINUED:

3. SEA MOUNT '20'				Regression Output:	
DAY	CATCH	CPUE	AD.CUM.CAT		
67	2827	10.8	1413.5	Constant	12.98525
68	2625	10.0	4139.5	Std Err of Y Est	1.861731
69	1457	5.4	6180.5	R Squared	0.795954
				No. of Observations	3
N(0)= 11148 kg		q = 0.00108 kg/mh		Degrees of Freedom	1
				X Coefficient(s)	-0.00108
				Std Err of Coef.	0.000550

For Small Constant Bank the first two days of data were excluded on the assumption that *P. filamentosus* was not the target species (the depth fished was slightly less on these days than the latter ones). The regression was not significant when they were included. The results are shown below in relation to the fishing area and length of 100m contour at each location.

TABLE 8.6. ESTIMATED STOCK DENSITY BY LOCATION FROM THE RESULTS OF THE LESLIE MODEL APPLIED TO PECHEUR BRETON CATCHES

DETAILS / LOCATION		SCO	COR	M20	MEAN
LENGTH 100M CONTOUR	KM	55.6	33.3	11.1	
AREA AT 250M WIDE	KM^2	13.89	8.33	2.78	
CATCH	KG	12209	5444	6909	
ESTIMATED BIOMASS	KG	21266	28483	11148	
BIOMASS / CATCH		1.7	5.2	1.6	
BIOMASS kg / km		382.48	855.35	1004.32	747.38
BIOMASS kg / km^2		1531.03	3419.33	4010.07	2986.81

At the three locations concerned, *P. filamentosus* represented 50.17% of the total demersal catch. Thus the total virgin biomass, B_0, of demersal fish available to a handline fishery is 5973.62 kg/km^2 based on the mean value for *P. filamentosus* from the three locations. The MSY is calculated from the mean population parameters K, M, Tr and B_0 applying the method of Beddington and Cooke (1983, See 7.3.1). Tarbit states that for semi demersal predators such as *A. virescens* or *P. filamentosus* natural mortality is usually in the range 0.4 - 0.7. In this report a value of M = 0.534 was derived for *P. filamentosus*, which represents 50% of the stock, so 0.5 would seem a valid choice. K was 0.2875 for *P. filamentosus*, but the slightly lower value of 0.25 is used to represent the population mean. Tr was 3 years for *P. filamentosus* and is the assumed value for the whole stock in this stratum. For these parameters MSY is 22 % of B_0, ie. 1.314 t/km^2 (1). This figure is similar to the mean of the estimates derived by cohort analysis (1.375 t/km^2) which will be applied.

When using this figure, the following must be borne in mind :

i) Small Constant Bank has previously been fished by schooners so the estimate does not relate to 'virgin biomass'. Correira and Sea Mount '20' are unlikely to have been fished previously, or if so, only very lightly. The density estimate for these two banks was greater than that for Small Constant. Thus by applying the mean value, the total biomass may be underestimated.

ii) Pecheur Breton was fishing commercially and left each location as the catch rates began to fall. Thus the data is only limited (3 days in the case of M20), so the estimates may only be regarded as preliminary values to be refined with further research.

iii) Pecheur Breton may not have concentrated on *P. filamentosus* every day thus affecting catch rates and invalidating these data. Information relating to depth fished does however, indicate that for these data (see Mees 1991) *P. filamentosus* was the target.

Polovina et. al. (1990) have applied stock depletion models including the Leslie model to deep bottom stocks of demersal fish in the Pacific Islands and have derived the following estimates of biomass at the 200 m isobath : Marianas, 1.08 t/Km of isobath; Tonga, 0.81 - 4.60 t/Km; Fiji, 0.27 - 3.80 t/Km; Vanuatu, 0.16 - 1.24 t/Km; and Papua New Guinea, 0.11 - 1.78 t/Km. The lower limits tend to relate to islands or reefs (mean value = 0.38 t/Km), whilst the higher ones relate to sea mounts (mean value = 1.46 t/km).

For the Banks and Seamount 20 studied in Seychelles the range was 0.38 - 1.00 t/Km for *P. filamentosus* only, and 0.76 - 2.01 t/Km for all species at the 100m isobath. Although at a different depth, *Pristipomoides* species featured in most of the catches from the Pacific Islands and so these estimates may be compared. It may be seen that infact the Seychelles data compares favourably with that from the Pacific, falling within the range of values observed, and the mean value being approximately equal to that of the seamounts in the Pacific. The application of the mean value (rather than the maximum value observed) to estimate the biomass of the Mahe Plateau appears justified since the Pacific experience indicates that the production reported for Sea Mount 20 is likely to be higher than that for the fringing drop off of the Plateau.

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1) For P. filamentosus only, applying the population parameters derived for this species in this report to the mean virgin biomass above gives an MSY of 0.71 t/km^2 which is similar to the upper estimate from cohort analysis, and gives some confidence to the results from the two methods.

3. FOR DEEP BOTTOM RESOURCES:

There have been no stock estimates comparable to those on the Plateau. A survey of deep bottom crustacean resources was conducted by ORSTOM using FRV ALIS (Intes and Bach, 1987) and during this programme some line fishing for demersal fish resources was also performed. Of 11 stations covered only 5 were at depths of 150 m or greater, and the total catch from all 11 stations was only 1.87 tonnes of fish. The information obtained is not suitable for deriving stock estimates, but does provide some useful information on potential species composition at these depths. In addition to *Pristipomoides* spp., at greater depths *Etelis* spp. become important in the catch. These species are known to be of commercial importance. Further study would be required to establish the potential deep bottom fish resource.

As a rough guide, in addition to the data for the Pacific Islands reported above, relating to total biomass, Polovina (1987) reports an MSY for deep bottom fish resources in the Marianas [illegible] in the Pacific of between (65 - 280 Kg/nml (89 - 151 [illegible] of 200m contour, and of 272 Kg/nml (147 Kg/km) of 200m contour for the [illegible] in Hawaii.

(NOTE also that in Moss (1990) the Schaeffer production model was applied to catch and effort statistics relating to the key demersal species in order to determine stock size. However, the data did not provide conclusive results (see also Lablache and Carrara (1988)).

8.2.2. REVISED RESOURCE ESTIMATES FOR THE MAHE PLATEAU, AND ESTIMATES FOR OTHER PLATEAUX AND BANKS IN SEYCHELLES WATERS.

Table 8.7 indicates the estimated biomass and sustainable annual yield available to a demersal handline fishery by stratum (depth) and location. Estimates of the surface area of each stratum, and of the length of the 100m contour given in Table 2.1. were used as appropriate.

For the shallow water strata the estimate of 1.4 t/Km^2 (virgin biomass) used by Lablache et. al. (1988) was applied and MSY was estim[illegible] 0.168 t/Km^2 as derived above. Since only approx[illegible] of the total area of the Mahe Plateau was regarded as fishable (from Lablache et. al. 1988), this proportion has been applied to the other Banks and Plateaux also, giving a smaller yield.

For the inte[illegible]ediate depth range an estimate of the sustainable [illegible] t/km^2 was [illegible]ied, and the virgin biomass was [illegible] 5 t/km^2 being the mean of the [illegible]ion methods.

[illegible] of the 200m contour was [illegible] contour for the [illegible]ial yield the mean [illegible]pplied (120 estimate of the biomass for this stratum since the observations in the Pacific vary so greatly.

TABLE 8.7. BIOMASS AND POTENTIAL YIELD ESTIMATES AVAILABLE TO A COMMERCIAL HANDLINE FISHERY ON DEMERSAL STOCKS IN SEYCHELLES

LOCATION / STRATA	SHALLOW STRATA		INTERMEDIATE STRATA		DEEP WATER	TOTAL MSY ESTIMATES	
	BIOMASS	MSY	BIOMASS	MSY	MSY	< 150 M	GRAND TOT.
MAHE PLATEAU							
- INSHORE	8400.0	1008.0				1008.0	1008.0
- OFFSHORE	9100.0	1092.0				1092.0	1092.0
- TRAWLABLE	19600.0	2352.0				2352.0	2352.0
TOTAL	37100.0	4452.0	2057.0	514.3	119.8	4966.3	5086.0
SEA BANKS / MOUNTS							
SMALL CONSTANT	142.8	17.1	75.9	19.0	6.7	36.1	42.8
KAR SAVAI + SEA MOUNT	40.5	4.8	68.8	17.2	6.0	22.0	28.0
CORREIRA BANK (2 MOUNTS)	15.0	1.8	45.7	11.4	4.0	13.2	17.2
AMELATUE BANK	5.5	0.7	14.9	3.7	1.3	4.4	5.7
SEA MOUNT 20	5.5	0.7	14.8	3.7	1.3	4.4	5.7
CONSTANT BANK	495.8	59.5	157.8	39.5	13.8	98.9	112.7
FORTUNE BANK	538.0	64.5	165.6	41.4	14.4	101.9	116.3
TOTAL	1208.4	145.0	543.6	135.9	47.6	280.9	328.4
OUTLYING ISLANDS/PLATEAUX							
AMIRANTES PLATEAU	3276.0	393.1	595.7	148.9	52.0	542.0	594.0
DESROCHES PLATEAU	336.0	40.3	106.7	26.7	9.3	67.0	76.3
PLATTE PLATEAU	285.6	34.3	86.4	21.6	7.6	55.9	63.4
COETIVY PLATEAU	352.8	42.3	114.6	28.6	10.0	70.9	80.9
PROVIDENCE FARQUHAR	1050.0	126.0	0.0	0.0	0.0	126.0	126.0
COSMOLEDO	294.0	35.3	0.0	0.0	0.0	35.3	35.3
ALPHONSE	159.6	19.2	75.9	19.0	6.7	38.1	44.8
TOTAL	5754.0	690.5	979.0	244.8	85.6	935.2	1020.8
GRAND TOTAL	44062.4	5287.5	3579.6	894.9	252.9	6182.3	6435.2

9. SUMMARY AND DISCUSSION

A summary of all results is presented for each study species. The findings are discussed in relation to information on the same species studied previously in Seycheles or elsewhere.

9.1. *PRISTIPOMOIDES FILAMENTOSUS*

Of the key study species *P. filamentosus* is regarded as a deep water inhabitant. In this study, the depth range over which *P. filamentosus* were caught extended from 15 m to 137 m with a mean depth of between 72 - 84 m. The largest number were caught in the range 70 - 75 m. No sexual differences (sex ratio, frequency distribution) were apparent in relation to depth. In the Seychelles Agathine (Pers Comm.) confirms these findings and states that the usual depth at which *P. filamentosus* are caught is 70 - 112 m, whilst Intes and Bach (1989) report catching this species down to 250 m. Elsewhere, Brouard and Grandperrin record that this fish is usually caught at depths of less than 120 m in Vanuatu, although the range at which it is caught extends from 80 - 320 m.

During the study period (November 1989 - December 1990) 7,241 specimens of *P. Filamentosus* were measured in length frequency studies and 1,189 were examined in the laboratory in biometric studies. The maximum fork length observed was 79.8 cm for a fish of undetermined sex, and 77.6 cm for each of males and females. Larger specimens have been reported in Seychelles (Total length 89.0 cm, males ; 84.0 cm, females, Moussac, 1988) and Hawaii (Standard Length, 94.7 cm, Kikkawa, 1984). The mean length was approximately 50 cm, and was slightly less during the period June to August.

No appreciable sexual differences were recorded with respect to length frequency distribution, and the sex ratio did not differ significantly from unity (ie. equal numbers of each sex in the catch). This was true at all lengths except at the very greatest lengths recorded in LFS where more males were caught. Ralston (1981) also reported that the sex ratio for *P. filamentosus* in Hawaii did not differ significantly from unity whilst Kami (1973) observed more females than males in populations in Guam (M:F - 1:1.4) and Min *et. al.* recorded the opposite in the Andaman Sea (M:F = 1:0.76).

Sexual maturity was examined by means of visual observation of the gonads and by examining the gonadosomatic index (GSI). First maturity for the population is achieved at an estimated age of 3 years and a fork length of 40 - 42 cm for males and 36 - 38 cm for females, although indivduals may differ. The smallest female fish with a matured gonad measured 33.2 cm and the smallest spawning fish was 38.1 cm. Maturity stage was positively correlated to fork length, and a second peak in the GSI occurred at 50 - 52 cm for males and 46 - 48 cm for females. The difference of 10 cm between peaks corresponds approximately with 12 months growth (12 - 15 cm pa), and indicates that a greater proportion of the population reach maturity in successive years. 50 % of all female fish were mature at a length of 52 - 53 cm.

Ralston (1981) also concluded that first maturity was achieved at around 3 years for male and female *P. filamentosus* in Hawaii, and at the transition from the 30-35cm length class to the 35-40cm class, although he also observed a spawning female at 33 cm FL. By contrast, also for Hawaiian populations, Kikkawa (1984) found the minimum size at maturity for females to be 42.5 cm FL and the minimum size at spawning to be 52 cm. In relation to the length frequency distribution of the catch it may be seen that the first sizes recruited into the fishery are below the minimum size of sexual maturity, and that over 50% of the catch is less than 52 cm FL, the length at which half the females become mature. This could have serious consequences for the reproductive capacity of the stocks (see Conclusions).

Mature and spawning fish were observed throughout the year but there would appear to be a protracted spawning period from October to April with peaks of reproductive activity in the periods February to April and November to December. Fewer mature fish were observed between June and August. The peaks correspond with the intermonsoon periods. Data relating to the GSI indicates that the development of testes and ovaries coincide and follow this seasonal pattern.

Protracted spawning periods and year round production of gametes are reported by other authors, the particular times of peak activity being related to local conditions (Min, et. al., 1977; Ralston, 1981; Kikkawa, 1984). Ralston (1981) highlighted the low proportion of body weight represented by the ovaries (4% maximum in Hawaii) and argued that this was due to multiple spawning. High reproductive activity is achieved through a rapid turnover of small gonads in contrast to temperate water species which spawn once a year and have gonads between 10 - 31% of body weight. In the Seychelles the maximum proportion of body weight represented by the gonads was 1.45% (population mean as opposed to maximum of one individual).

The relative growth of different body dimensions against fork length was examined to assess sexual dimorphism and the possibility of discrete populations in different geographical areas. There was no evidence of sexual dimorphism. Body parts displaying isometric growth indicated no conclusive geographical differences, but examination of the positively allometric length weight relationship tended to indicate that the population in the North of the Plateau was significantly different from that in the South and East of the Mahe Plateau. That in the North showed no difference from the population in the Amirantes. On the basis of length weight relationships Tarbit (1980) concluded that populations of *Aprion virescens* on Fortune Bank and the Mahe Plateau were different, but no comparable work has been done for *P. filamentosus* in Seychelles. The length weight relationship for all fish sampled in the present study was

$$W(kg) = 0.00005353 x FL(cm)^{2.7904}$$

Length frequency data indicated that the mean length of fish caught in the North of the Plateau was significantly less than that of fish caught in the South and East, supporting the above observation. However, whether these observations truly reflect population differences or are an artefact of the data requires further study. Fish from the North were caught between September and January at a mean depth of 92.4m whilst those from the South were caught between January and July and in December at a mean

Depth of 79.9 m. The sample size from each of the Amirantes and East was small.

Since it was not possible to conclusively state that population differences occurred in different geographical areas all the data were pooled for further study of growth, mortality and production. This was necessary anyway since there was not a complete 12 month data set for either of the major geographical areas, North or South. Growth parameters were determined through modal progression analysis of length frequency data and application of routines in the software packages LFSA and ELEFAN.

The size difference observed between cohorts corresponded approximately to that observed over six months of data, suggesting 2 recruitment periods into the fishery each year. This would agree with the observation of two peak spawning periods each year. The data interpreted in this way gives a growth of 12 - 15 cm per year which is rather higher than observed in Hawaii where 7 - 8 cm per year were indicated from otolith studies (Ralston, 1981). The main group of islands in Hawaii lie at 19 - 22° N of the Equator and water temperatures might be expected to be less than those recorded on the Mahe Plateau, resulting in slower growth rates. Nevertheless the differences are large and require closer examination as more data become available.

Growth parameters derived are compared with those from other locations using Munro's Phi Prime.

SEX	K	L_∞	PHI'	SOURCE
M	0.300	85.80	3.344	This report
F	0.275	77.60	3.219	This report
ALL	0.420	74.25	3.365	This report
ALL	0.146	78.00	2.949	Ralston (1981 - 9 q)

The value of Phi' differs between the Hawaiian population and that in the Seychelles, again stressing the need to check the present results with additional data.

For the whole population the total mortality, Z, was estimated to be 0.811, the natural mortality, M, was 0.534 and fishing mortality, F, was 0.277. Jones' length cohort analysis gave an F value of 0.294. Ralston (1981) derived an estimate of natural mortality for *P. filamentosus* in Hawaii of 0.25. However, also in Hawaii, Ralston and Williams (1983) derived a value of 0.55 for M, and in Vanuatu Brouard and Grandperrin (1984) obtained a value of 0.53 which are similar values to that of the natural mortality reported for this species in Seychelles.

The production of this species was estimated from length frequency analysis and by application of the Leslie Constant Catchability Model to catch and effort data from a mothership dory fishing operation. The MSY was estimated to be between 233 - 279 tonnes from the former, or 0.62 - 0.75 t/Km^2, and 0.66 t/Km^2 from the latter for the fringing drop off of the Mahe Plateau. Other studies have shown that at the depth range at which *P.filamentosus* are caught they represent approximately 50% of the catch. Assuming equal catchability of all species the total MSY available to a handline fishery at depths between 75 - 150 m (fringing drop off) is 1.1 - 1.5 t/Km², equivalent to 466 - 560 t for the Mahe Plateau. The catch of *P. filamentosus* in 1990 was 233 tonnes from all fishing grounds indicating that there is room for expansion of this fishery, and to double existing catches.

Previous estimates of biomass and MSY have largely been based on trawl information carried out in water of depths of 60 m or less and on smooth grounds. These have underestimated the stocks on rough grounds and on the fringing drop offs of the Plateaux and Banks. This report identified a separate substratum relating to the depth range 75 - 150 m where productivity appears to be higher than on the Plateaux surface. *P. filamentosus* was the key species studied from this depth range and which has been used to derive the estimates of biomass for this sub stratum. This is the first time that the data has been presented in this way for Seychelles and revised estimates of the total biomass available to a handline fishery on demersal stocks was presented.

The total production and MSY per square kilometre of substrate based on data relating to *P. filamentosus* was considerably higher than the estimates based on the other key study species: *L. sebae*, total MSY (all species) 0.209 t/Km² (Lablache and Carrara, 1988); *A. virescens*, total MSY (all species) 0.120 - 0.200 t/Km² (Mees, this report); *E. chlorostigma*, total MSY (all species) 0.200 - 0.360 t/Km². However, the other species occur mostly on the plateaux at shallower depths. The surface area of the fringing drop off in the range 75 - 150 m occupied by *P. filamentosus* is limited due to the steeply shelving nature of the drop off. This limits the available habitat for this species and concentrates it, giving a higher relative production per unit area. Furthermore, a high degree of hydrodynamic activity occurs at the Plateaux edges (upwelling, temperature changes etc) which could contribute to relatively higher primary production in this region. Kunzel et. al. report greater production on rough ground and at the drop off of the Plateaux.

The high production of this species and limited vertical distribution mean that catch rates for *P. filamentosus* are high. Catch rates are also high at present since the deeper water fishery is a relatively new one and the stocks have not previously been subjected to significant fishing pressure. However, the total available biomass for exploitation is limited due to the small area of the fringing drop off (374 Km² for the Mahe Plateaux compared to a total fishable area on the Plateaux of 26,500 Km²). Thus stocks in this stratum will be more susceptible to overfishing since a larger proportion of the population may be exploited in a relatively smaller fishing area, and because the total size of the stock is not that great.

9.2. *APRION VIRESCENS*

Aprion virescens were caught over a wide depth range (15 - 137 m). The mean depth was 65 m and no differences between the sexes were observed in relation to depth. The largest fish caught measured 101 cm FL and the mean length was 64.66 cm. The frequency distribution was skewed towards large fish and the [illegible] h of males was significantly [illegible] frequency distribution of the sexes revealed more females at smaller sizes than males. Thus there was a significant correlation between sex ratio and increasing fork length. The sex ratio was significantly biassed in favour of males (1.8 M : 1 F), and during the intermonsoon periods which coincide with the peak reproductive periods, the number of males caught was more than twice the number of females.

Moussac (1988) reported fish of 112 cm TL in Seychelles, whilst the maximum length observed in Hawaii was 102.8 cm FL (Everson et. al., 1989). In contrast to this study, Everson et. al. (1989) recorded a similar number of males and females (1.05 M : 1 F) and also observed that there were more females than males at the greatest lengths. Fish in both studies were caught by hook and line. Moussac (1988), referring to trawl caught data, indicated that no sexual differences occurred in relation to the length frequency distribution of *A. virescens* in Seychelles. Thus, either males are more aggressive and take the hooks more readily in Seychelles than females, or the sex was incorrectly recorded from the remnants of the gonads of eviscerated fish employed in length frequency studies. The latter, whilst deserving attention, is not considered to be the case, and thus it may be concluded that this species in the Seychelles behaves differently from the same species in Hawaiian waters to baited hooks.

The smallest female with a mature gonad was 48.7 cm FL, the smallest spawning female measured 56.6 cm, and 50% of all females were mature in the size class 64 - 66 cm. Maturity stage was positively correlated with length. Whilst mature fish were observed throughout the entire year, spawning fish were mainly observed between September and April, with peaks of reproductive activity in September to November and March to April, corresponding with the intermonsoon period.

Unlike *P. filamentosus*, most fish caught by the commercial fishery were larger than the length at which 50 % of the population become mature. In East Africa (Talbot, 1960) reported that the minimum size at sexual maturity for *A. virescens* was 46.5 cm SL whilst in Hawaii Everson et. al. recorded a length of 42.9 cm FL. Similarly to Seychelles these authors reported a protracted spawning period but with periods of peak activity within the year. Other authors have found the peak periods in Seychelles to be between September and April (Lablache and Carrara, 1988; Moussac, 1988), and in East Africa where climatic conditions will be similar to Seychelles the peak periods were November to March (Talbot, 1960), and October, January and February (Nzioka, 1977).

Separation of length frequency data into cohorts indicated two recruitment periods per year, consistent with the spawning cycle, and a growth of approximately 10 cm per year. The growth parameters were as follows:

POPULATION	K	L_{oo}	Phi'
Seychelles (ELEFAN)	0.260	104.0	3.449
Seychelles (MPA)	0.294	84.9	3.326
Maldives	0.348	78.0	3.325
New Caledonia	0.310	65.6	3.125

Munro's Phi' indicates good agreement of the growth parameters with those for the same species in the Maldives (Van der Knapp et. al., 1988) and New Caledonia (Loubens, 1980) giving some confidence in the results, despite the difficulties in achieving consistent growth between cohorts in the method of Modal Progression Analysis (MPA).

The total mortality, Z, was estimated to be 1.602, natural mortality, M, was 0.496, and fishing mortality, F, was 1.106. Jones' length cohort analysis gave an F value of 0.956. For the Maldives population natural mortality, M, was estimated to be 0.490 (Van der Knapp et. al., 1988) which is similar to that in Seychelles. Fishing mortality was high, but this is consistent with the fact that Aprion virescens is the single most important species catch from the demersal fishery in terms of volume caught.

The biomass of *A. virescens* from the inshore areas of the Mahe Plateau was estimated to be 1377 tonnes. The annual MSY of this species was estimated to be 275 - 443 t from the Mahe Plateau, equivalent to 0.046 - 0.074 t/Km^2. This is approximately one tenth of the production per unit area calculated for *P. filamentosus* but relates to the surface area of the Plateau so the total volume of *A. virescens* available to a handline fishery on demersal stocks is greater than that of *P. filamentosus*. Present annual catches of this species are around 535 tonnes (from all locations), which exceeds the estimated sustainable catch from inshore areas indicating that these locations are fished to capacity. This agrees with the high estimate of F, the fishing mortality, and may explain the peculiarities in population structure reported in Seychelles not observed elsewhere. Assuming equivalent stock densities on the offshore areas the MSY would increase by 299 - 481 t to a total of 574 - 924 t for both strata.

9.3. *LUTJANUS SEBAE*

Lutjanus sebae was caught at depths from 25 to 110 m but the majority were caught between 55 and 70 m. Intes and Bach (1989) record the depth range in Seychelles as being to 80 m and Nageon (Pers. comm) indicates that the usual depth range is 50 - 55 m. In Hawaii this species occupies the range 0 - 100 m and is usually caught at 20 - 50 m (Ralston, 1981b), whilst in Vanuatu Brouard and Grandperrin (1984) record a depth range of 100 - 220 m, this latter being significantly deeper than the other reported depths.

The largest specimens observed were: males, 86.0 cm FL and females, 78.2 cm. The mean length was 53.9 cm for all fish, 58.9 cm for males and 50.4 cm for females. The difference between the sexes was highly significant, and the structure of the population also differed significantly, there being more small females. The sex ratio was biassed in favour of females (0.83 M : 1 F). With increasing fork length the ratio of males increased until at the largest lengths there were no females. Examination of the gonads of the females revealed that 74.5 % of all fish caught were immature.

Trawl survey data from Seychelles reported in Tarbit (1980) agreed with the sex differences in relation to population structure observed for line caught fish in this study, and the sex ratio was similar (0.67 M : 1 F). However, the majority of the fish were greater than 60 cm (10 % females and 12 % males were less), and very few immature specimens were recorded. In the Gulf of Aden Druzhinin and Filatova (1980) reported a sex ratio of 1.04 M : 1 F.

The size differences could be a result of different fishing grounds - flat trawlable areas may contain adult populations whilst the rough ground fished by line fishermen may contain juvenile / immature populations. If this is the case the trawlable areas act as nursery grounds. However, a more alarming interpretation could be that fishing pressure (*Lutjanus sebae* is the single most prized species, and small fish fetch a higher price than large ones) has resulted in a decrease in the mean length of fish caught and that females are predominantly being caught before they reach maturity, resulting in recruitment overfishing. Another argument could be that mature female fish are hook shy. This matter requires urgent attention to establish the cause of the differences observed.

The smallest spawning female recorded measured 51.3 cm FL. There was a positive correlation between size and maturity stage and 50% of the population were mature at 62 - 64 cm. Mature fish were observed throughout the year but peaks of reproductive activity occurred in October / November and March - May. Most females caught were below 62 - 64 cm FL.

Tarbit (1980) for trawled fish in Seychelles recorded a minimum length of 62.0 cm TL for a mature female and the peak reproductive activity occurred from December / January to April. In East Africa Talbot (1960) recorded a minimum size at maturity of 49.0 cm FL, and a spawning season of November to March. Lablache and Carrara (1988) for this species in Seychelles report two spawning periods, September to October, and February to April. These observations are in agreement with the present study.

Growth studies revealed two cohorts per year but the analyses fitted poorly with the growth models and it was difficult to achieve consistent positive growth between cohorts. Growth parameters derived were:

POPULATION	K	L_{∞}	Phi'
Seychelles (ELEFAN)	0.107	95.1	1.444
Seychelles (MPA)	0.157	92.9	1.113
Seychelles (1)	0.210	56.0	3.926
Seychelles (2)	0.320	98.0	1.327
East Africa	0.157	85.1	1.055

Despite the difficulty of fitting the length frequency data the growth parameters compare favourably with those of other authors in Seychelles when compared by means of Munro's Phi' (1, Lablache and Carrara, 1988; 2, Bach, 1991), but less well with data from East Africa (Talbot, 1960). However, when using these data to derive mortality coefficients inconsistent results were obtained and could not be employed to derive production estimates for this species. Treating the sexes separately similarly produced inconsistent results but confirmed that fishing pressure on females (F = 0.570) was higher than males (F = 0.510).

Lablache and Carrara (1988) estimated the total biomass of *L. sebae* to be 0.35 tonnes / Km² and the MSY from offshore banks to be 380 t pa. The total catch of this species landed in 1990 was 350 t, which is close to the maximum for the area described.

2.4. *EPINEPHELUS CHLOROSTIGMA*

E. chlorostigma was caught between 25 and 1[illegible]0 m. Most were caught in the range 50 - 80 m with a mean depth of [illegible] m. Intes and Bach report that they are caught to 250 m in Seychelles whilst Mageon (Pers. comm.) indicates that the usual range from which they are caught is 45 - 55 m. In Vanuatu Brouard and Grandperrin (1984) record a range of 80 - 120 m.

The species is a protogynous haermaphroditic with a sex ratio of 1 F : 0.417 M (see Moussac, 1986) so no data in relation to sex or reproduction was collected in the present study. The largest fish caught measured 65.4 cm TL and the mean was 30.1 cm. For all data pooled a single mode was apparent at 17.0 cm and few large animals were caught. Moussac (1988) recorded a maximum length of 71.0 cm, and Sanders et. al. (1988) of 65.0 cm, both for Seychelles populations.

The minimum size for sexual maturity recorded in Seychelles was 31.0 cm (Moussac, 1988) and in the Red Sea it was 28.0 cm (Ghorab, et. al.). Both are around the mode of the frequency distribution reported in this study, indicating that a large number of the catch were immature. Like the other species studied, peak spawning periods are reported to coincide with the intermonsoon periods in November and April (Sanders et. al., 1988).

Growth studies indicated the recruitment of two cohorts each year. The following growth parameters were derived:

POPULATION			
Seychelles	0.175	64.45	1.058
Seychelles (1)	0.1785	68.40	2.932
Kuwait	0.195	[illegible]	[illegible]

The estimates from the present study compare favourably with that by (1) Sanders et. al. (1988) in Seychelles, and by Mathews and Samuel (1987) in Kuwait.

Fish in the size range 19 - 48.9 cm experienced a greater mortality than larger fish. This was also observed by Sanders et al. (1988). Estimates of Z were 1.878 for the size group 19 - 48.9 cm and 0.514 for fish greater than 49 cm. Natural mortality, M was 0.438 with resultant fishing mortalities for each size range of F = 1.440 and 0.076 respectively. Jones' Length Cohort Analysis produced an F value of [illegible] for the terminal length groups. Sanders et. al. (1988) derived estimates of Z of around 2.1 for the smaller size group and 0.2 for the larger.

The total biomass of *E. chlorostigma* on the inshore and offshore areas of the Mahe Plateau was estimated to be 1468 tonnes, equivalent to 0.12 t/Km^2. The MSY from the Plateau was calculated to be 161 - 290 tonnes p.a. or 0.013 - 0.023 t/Km^2. The catch of this species in 1990 was 125 tonnes indicating the potential for a limited increase in landings.

10. CONCLUSIONS

Information relating to the population structure, population dynamics and production of key species from Seychelles demersal fishery has been presented in this report.

Data relating to length frequency and sex ratio of the populations of key study species will provide historical values against which future comparisons may be made when assessir .hese stocks. For *L. sebae* the present data compared to historical trawl caught data on the Mahe Plateau indicated a decrease in mean length of the population since the late 1970's, .nd also indicated that presently the major part of the catch consists of immature females whilst previously the majority were mature fish. This may be a result of heavy fishing pressure on stocks of this species. For *A. virescens* the length frequency structure did not differ from previously recorded data in Seychelles but the sex ratio compared to line caught Hawaiian populations was markedly different. It is not clear if this is a result of fishing pressure or of behavioural differences between the populations.

A combination of the analyses of length frequency data and relative growth indices for *P. filamentosus* indicated the possibility of discrete populations in different geographical locations. Tarbit (1980) also indicated that the populations of *A. virescens* on the Mahe Plateau and Fortune Bank were discrete. It is most likely the case that discrete populations of most demersal species exist where submerged water bodies and banks are separated by an expanse of water deeper than, say, 250m. However, from the present data it was not possible to separate all the potential variants (season, location, depth) and confirm the existence of discrete populations. Thus all data were pooled. However, the question of whether or not stocks are discrete is important. Different population dynamics may relate to different stocks in which case it is not valid to pool all the data. Furthermore, if stocks are discrete and without significant emigration or immigration then the possibility of overfishing certain areas is greater. Thus it is important where possible to obtain a good time series of data for each location, and to improve the reporting of location when statistics are collected. Although steps have been taken to improve this situation those collecting the data must rely on the fishermen to provide a reliable answer, and fishing location tends to be a sensitive issue.

From the data presented in this report relating to 3 Lutjanid species and from other data in the literature which includes the Serranidae it is now well established that Lutjanids and Serranids in Seychelles experience continual spawning throughout the year with peaks of reproductive activity corresponding to the intermonsoon periods. There are thus two peak periods per year around November and April, with slight variation from year to year according to the timing of the onset of each trade wind / monsoon period. The intermonsoon periods are also the peak fishing periods when the greatest catches are landed due to the favourable weather conditions.

The South East Trade Wind period from July to September is consistently a poor fishing season due to inclement weather conditions, and catch volumes fall in these months. However, this may not be regarded as a rest period for the fishery from a management point of view since little reproductive activity occurs at this time. Furthermore, hydrological changes occurring at that time resulting in lower water temperatures may retard growth. Bean (Pers. comm.) has reported that at the onset of this season although fish could be located on the echo sounder they would not take the hooks and those that did were torpid on hauling to the surface perhaps due to a temperature change. Thus catchability may also reduce in this season in addition to the difficulties caused by poor conditions.

The size at capture of a large proportion of the sampled catch was below the size at which 50% of the population reached sexual maturity for *P. filamentosus* and *L. sebae*, and for *E. chlorostigma* the major mode corresponded to this length. Only for *A. viresecens* was most of the catch above the size at which 50% reached maturity. Thus for the former species there is the potential of recruitment overfishing. However, there is some debate as to the optimum age / length at which a fishery should be exploited. Removing smaller fish is more energy efficient since growth is greatest in the early years, and by protecting large fish and preventing their exploitation a fishery may benefit since larger fish are more fecund. Nevertheless it is necessary for a certain number of fish to escape to grow into large fish and maintain such a system, and classically the approach has been to target larger fish above the size at maturity. The policy of the SMB Fish Division to pay a greater price for small fish exacerbates this problem.

Practically for a hook and line fishery it may not easily be possible to regulate the size of fish caught. Another management tool is to allocate nursery areas so that if recruitment overfishing were to occur the stocks could be replenished from the unfished stocks. The presence of fish on the trawlable surfaces of the plateau could act as such. Whilst trawling is illegal and the stocks are too dispersed to be fished by handlines these stocks remain relatively secure. However, recent proposals to exploit these stocks using gill nets or large scale fish traps would, whilst allowing the targeting of otherwise underutilised resources, result in the loss of this management tool.

Regarding the practicality of allocating nursery areas certain other questions remain: If the stocks are discrete then emigration will not occur to replenish depleted stocks on the rough grounds; What is the dispersal mechanism for eggs and larvae from the trawling grounds, and will settlement occur on the rough grounds ? If the stocks are not discrete but occupy the rough grounds at a certain phase of the life cycle and the smooth trawling grounds at another (this is one possible interpretation of the *L. sebae* data in this report) then depleting stocks on the rough grounds will also cause depletion on the trawling grounds (particularly in the example of *L. sebae* where hook caught fish on rough grounds were mostly immature female fish); How does the allocation of the trawlable areas as nursery grounds affect the estimates of sustainable yield from the fishery ? - presently 2350 tonnes of handline caught species are said to be available on a sustainable basis from smooth ground. Is it justified to assume this additional amount may be taken from the rough grounds or should the MSY estimate be reduced by this amount ?; Would the dispersal of eggs and larvae from the trawlable grounds of the Mahe Plateau be sufficient to replenish depleted stocks on distant banks and Plateaux (eg. Amirantes) or would separate nursery grounds be required.

Growth studies based on length frequency analysis proved challenging due to the difficulty of achieving consistent positive growth between cohorts separated through the Bhatacharya analysis. As a result modal progression analysis and the derivation of von Bertalanffy growth parameters was often rather subjective, and frequently unrealistic results were achieved. Thus the method of Pauly (1981) through application of ELEFAN I was used to derive these parameters. It has sometimes been argued that this method overestimates the value of K. However, in the absence of other information these results were used and as indicated in the discussion provided reasonable estimates for *A. virescens* and *E. chlorostigma* compared to other authors. The estimate for *P. filamentosus*, whilst requiring refinement, was also considered acceptable. The least reliable results related to *L. sebae*. ELEFAN I also allows inclusion of a seasonally oscillating model of growth. This model fitted the best in each case, as might be expected due to the seasonal hydrological changes. Seasonal oscillation was least pronounced for *E. chlorostigma*, perhaps because those in the samples derived from the Plateau surface and inshore strata where temperature changes would be less felt.

Owing to the difficulties of conducting modal progression analysis it would be pertinent to repeat these estimates as more time series data become available. It may also help to analyse 2 or three years of data pooled quarterly in order to increase sample sizes. Since the growth parameters are used in deriving mortality coefficients any errors will be reflected in subsequent analyses. Certainly all estimates given in this report, whilst providing preliminary information for use in management of the fishery, require refinement.

Estimation of growth by reading daily rings on otoliths of *L. sebae* has been achieved by Chauvelon (1990) using samples collected in Seychelles, and the procedure has been applied to other lutjanids including *P. filamentosus* elsewhere. However, this procedure is expensive and could not be achieved in Seychelles at present. The classical methods of reading annual or biannual rings on otoliths would appear possible from the limited sample of *P. filamentosus* and *A. viresecens* otoliths sent to a consultant in the UK, although the growth parameters differed from those derived through length frequency analysis. The consultant confirmed the presence of growth rings. Since the hydrological conditions on the Mahe Plateau change seasonally, since there is a peak of reproductive activity at certain times of the year, since the seasonally oscillating growth models fit the data best, and since subjective information indicates metabolism slows down at certain periods, there is a strong possibility that growth rates will differ throughout the year and that these changes will be reflected in the otoliths. Thus an otolith reading unit is to be established in Seychelles to develop this procedure.

The analyses were used to derive estimates of the biomass and annual sustainable yield of each species. Assuming equal catchability and population dynamics of all species, the relative proportions of the key species in the catch were employed to derive biomass and MSY estimates for the total fishery. These estimates relate to large species available to, and caught by, a demersal handline fishery only, and do not relate to all demersal species. It was argued that restratification by depth was necessary in order to adequately describe the demersal fishery. Having done this, revised estimates of biomass and MSY were produced which supersede all previous estimates. For the Mahe Plateau the revised estimate of MSY was 4960 t compared to 4,400 - 4,900 t previously. The MSY for all Plateaux, Banks and Islands was estimated to be 6,180 t to a depth of 150 m and 6,435 t if the depth range is extended below 150 m.

Biomass and MSY estimates were given in relation to location. The potential for depleting stocks on large Plateaux where populations are contiguous or overlapping is low compared to isolated banks and Sea Mounts. Dalzell (1990) describes examples from the Pacific where sea Mounts have been heavily fished and catch rates, and therefore populations, have not recovered. This highlights the limited potential for repopulating overfished areas by recolonisation from the planktonic phase. Thus fishing in such areas needs to be regulated to ensure sustainability of the resources. The intermediate depth strata, 75 - 150 m in which *P. filamentosus* occurs also requires careful monitoring. Although present catches are below the MSY for this stratum, the total yield available is limited due to the small area of fringing drop off. Stock densities are high within a narrow band making targeting the fish and overfishing easier.

In relation to fisheries by species, the data indicated that *A. virescens* in inshore areas of the Mahe Plateau were presently fished at or above their maximum. Assuming equal concentrations of *A. virescens* in offshore areas suggests that this species has not yet been overfished but within strata problems may exist. For *L. sebae* catches approached MSY for the offshore stocks but assuming similar stock densities elsewhere catches were below MSY. For *P. filamentosus* present catches were similar to the lower estimate of MSY indicating only limited room for expansion of this fishery (1), whilst for *E. chlorostigma* the present catches were below MSY indicating the stocks could sustain limited increased exploitation.

Thus it appears necessary to investigate methods of regulating the fishery on a species basis in addition to location and depth fished. For all species the demersal catches are around 2,000 tonnes per year, indicating the potential to more than double catches on the Mahe Plateau (if the trawlable areas are

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1) It should be noted that since this stratum consists of the narrow band between 75 - 150 m depth fringing the plateaux any small error in the estimation of the area will lead to significant errors in the estimation of the yield available. It would be useful to fully determine the width of this stratum at different points around the plateau in order to refine the estimate of the area.

Note also that data for 1991 just available (see abstract) indicates that *P. filamentosus* catches were significantly less in 1991 than 1990.

included), and triple catches from the whole of Seychelles demersal fishery resource. However, much of the present catch derives from the inshore areas of the Mahe Plateau, and limited amounts from the offshore banks. On the Mahe Plateau the potential for incresed catches lies within the trawlable areas, in the intermediate depth zone, and to a limited extent the offshore areas. Further areas suitable for exploitation tend to be the more distant locations off the Mahe Plateau requiring larger vessels. The species composition from the outlying areas tends to include a higher proportion of lower value species (see Lablache and Carrara, 1984) so the viability of exploiting these stocks must consider this factor in addition to the increased fuel costs.

On the question of regulating / managing the demersal fishery it may be seen that of the potential management tools each of the following are problematic for the reasons given above : nursery grounds, regulating size at first capture, introducing a non fishing fallow season (unless it coincided with what is traditionally the peak fishing season!). Regulating individual species catches is also difficult in a mixed fishery based on handlines, although a certain amount of targeting does take place. Alternative approaches are to work within the location specific MSY values and to limit the number of licensed vessels (effort) by vessel type, size, and range engaging in the fishery. Catch quotas could be set for specific locations and vessels to ensure equitable distribution of the catch. However, policing and monitoring such a system may prove difficult.

Thus it may be seen that in order to regulate the fishery a number of options are available, but each has its own drawbacks, and indeed regulation may not be what is required at the present time, although the structure for regulating the fishery should be established. Given that there appears to be room for expansion, what is infact required at the present time is a clearly defined policy for the further exploitation of this resource which determines the most benneficial way to develop the fishery. Ultimately this comes down to fleet composition. This must be both politcally and economically acceptable and will probably allow access to a number of different vessel types in different locations. For the 'outer islands' distant from Mahe the question is not just one of fleet composition: 2 mothership - dory operations are probably the most economically viable answer to the exploitation of these stocks. However, the development of outer island fishing centres each with its own infrastructure and fleet of vessels would promote island development. This would lead to spin offs which could not soley be treated in terms of economic viability alone, and indeed the economics would need to encompass more than just the fishing operations.

In order to establish such a policy it is suggested that a detailed social and economic appraisal is required based on different models of development for the demersal fishery, firstly on the Mahe Plateau and associated Banks, and secondly for the outer islands. With this information it will be possible to establish the appropriate fleet composition and a ceiling should be set for each boat type. If the present unregulated expansion of the fishery continues overcapitalisation in certain boat types (specifically whalers), and overfishing in certain locations (inshore and middle grounds of Mahe Plateau) will become a real problem, if it is not already.

Mees (1989b) proposed the maximum number of whalers (55) and schooners (35 schooners or Lavenir) to support a viable demersal fishery on the Mahe Plateau. In the light of the revised estimates of yield available they should be modified. In addition, since publication of that report gill net operations, and a mothership dory fishing operation have begun.

Table 9.1. indicates the number of each boat category required to fully exploit the yield available in each location. The numbers assume no other boat types are exploiting the stocks. They do not indicate that the stocks on the drop off, for example would support 14 schooners, 5 gill netters, and 1 mothership. Rather they indicate stocks would support 14 schooners, OR 5 gill netters, OR 1 mothership. An equilibrium would need to be achieved between the numbers of each category depending upon the development strategy adopted for the fleet as a whole. The numbers also do not take into account economic yield, simply biological yield, and thus it may not be economically feasible to invest in the number of vessels indicated in any one category. The economic viability of both whalers (Nageon, 1987) and schooners operating with the catch rates indicated is already in question (Parker, 1988).

The following details were employed in Table 9.1:

Whalers - 0.396 t/trip of demersal species, 40 trips/year (Mees, 1992 : unpublished analyses of whaler database for 1991, based on Mahe results). These are restricted to the inshore areas.

Schooners - 1.5 t / trip, 23 trips/year (demersal species only, 12.5 m laDigue schooners with electric reels, Mees 1990). These are restricted to the Mahe Plateau and drop off except in good conditions.

Gill netters - (fibre glass Cygnus type) 3 t/trip, 36 trips/year (estimated, Bean Pers. comm. - presently 22.5 m schooner Taurus catches on average 3.5 t/trip 22 trips/year with gill nets). These will target the fringing drop off of the Plateaux.

Mothership - Dories - 300 kg/dory/day (demersal species), 12 dories, 200 fishing days per year (See Mees, 1991). This operation is not restricted to any location and appears to be an efficient way of exploiting the stocks, particularly those distant from Mahe.

TABLE 9.1. AN ESTIMATE OF THE NUMBER OF VESSELS OF EACH BOAT TYPE REQUIRED TO FULLY EXPLOIT THE DEMERSAL FISHERY YIELD BY LOCATION

STRATUM	MSY	WHALERS	SCHOONERS	GILL NETTERS	M.SHIP+ 12 DORY
MAHE PLATEAU					
INSHORE	1008	62.7			
OFFSHORE	1092	67.9	31.7		1.5
TRAWLABLE	2352				
DROP OFF	514		14.9	4.8	0.7
TOTAL	4966	130.6	46.6	4.8	2.2
OTHER LOCATIONS					
PLATEAUX	835		24.2		1.2
DROP OFF	380		11.0	3.5	0.5
TOTAL	1215	0.0	35.2	3.5	1.7
GRAND TOTAL	6181	130.6	81.8	8.3	3.9

The mean existing fleet size during 1991 (mean number operating per month) was 86 whalers, of which 68 engaged primarily in the demersal fishery, 20 schooners, 1 gill netter (Taurus, Verseau may also begin this method shortly), and 1 mothership dory operation. The present increase in the number of whalers is of some concern since these boats are restricted in range and exploit that part of the stock which is already heavily fished (inshore and midddle ground areas of Mahe Plateau). By December 1991 there were a total of 90 whalers fishing of which 77 engaged in the demersal fishery, exceeding the maximum number required to exploit the inshore resources. The whalers also fish the middle ground and in good weather the offshore banks. Thus it is difficult to say that the number has exceded the maximum possible. However, what can be construed is that as the number of whalers increases more pressure is excerted on stocks close to Mahe thus forcing these boats to fish further afield. It is to be questioned whether this is desirable given that they are uncomfortable vessels and not ideally suited to long fishing trips (Nageon, 1987). It is considered that the nubers of vessels in this category should not continue unchecked, thus limiting potential number of more suitable vessel types to exploit the offshore stocks.

It should be noted, however, that the term 'Whalers' includes traditional wooden boats and fibreglass Lekonomi and Lavenir. Unpublished analyses indicate that the Traditional and Lekonomi whalers favour shorter trips and fish on the plateau rather than at the periphery, whilst Lavenir undertake longer trips to the more distant fishing grounds. Thus the above argument applies principally to traditional and Lekonomi whalers. The number of Lavenir actively fishing in March 1992 was only 5, ie a small proportion of the total whaler fleet.

No estimate was made for the number of boats required to exploit the trawlable grounds. Here stocks are too dispursed to be viably fished by handline so a new method (gill nets, traps) will need to be developed if it is intended to exploit them, and boats will need to be suitably equipped. No estimate of potential catch rates is available.

Finally, although there appear to be some species and location specific problems in relation to exploitation of the demersal fishery resources, overall, the fishery has the potential to expand. However, any expansion should be managed carefully and strict policy guidelines need to be introduced now. This is particularly the case now that more efficient methods (eg, drop lines and gill nets) and operations (eg. mothership - dory fishing operations) are being introduced. This is not to say that such changes should be resisted, rather they should be promoted if they increase the efficiency and profitability of the exploitation of Seychelles demersal fishery resources. However, to ensure full exploitation of this valuable resource whilst at the same time ensuring sustainability of the resource requires careful management.

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BIOMETRIC STUDY OF | *Aprion virescens* | F/Method

BOAT NAME :	TYPE :	SKIPPER/OWNER:

FISH NO.:

DURATION OF FISHING TRIP FROM: TO:	FISHING DETAILS LOCATION : DEPTH RANGE :	DATE OBSERVED

MEASUREMENT BEFORE EVISCERATION

TOTAL LENGTH:	FORK LENGTH:	STANDARD LENGTH:
WHOLE WEIGHT:	LENGTH OF FIRST DORSAL SPINE:	DIAMETER OF EYE:

DISTANCE OF FIRST DORSAL SPINE FROM MOUTH:	PRE-OPERCULE:
DISTANCE BETWEEN LATERAL LINE & 1st DORSAL SPINE:	OPERCULE:

EVISCERATION

SEX:	GONAD WEIGHT:	MATURITY STAGE:	LIVER WEIGHT:

GONAD'S DESCRIPTION:

WEIGHT SAMPLE FOR FECUNDITY
SAMPLE 1
SAMPLE 2
SAMPLE 3

REMOVAL OF OTHOLITHS ——> YES/NO

MEASUREMENTS AFTER EVISCERATION

TLe:	FLe:	STe:	GUTTED WEIGHT: