THE STATUS OF SEYCHELLES DEMERSAL FISHERY

DRAFT

REPORT TO GOVERNMENT OF SEYCHELLES,
SEYCHELLES FISHING AUTHORITY

FOR

THE ODA FISH MANAGEMENT SCIENCE PROGRAMME,
MANAGEMENT OF TROPICAL MULTI-SPECIES FISHERIES PROJECT

MRAG LTD 1994

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SUMMARY

1. Management of Tropical Multi-species Fisheries is a project funded by the Overseas Development Administration of Great Britain through the Fish Management Science Programme. Seychelles Fishing Authority and MRAG Ltd are collaborating on this project with respect to the plateaux and banks demersal fishery which forms a case study. Additionally, the project includes a modelling component. This report presents a comprehensive review and analysis of the demersal fishery. Multi-species modelling will be described in a future document.

2. The fishery is described (Section 3) in relation to Seychelles geography and hydrology (Section 2). Analyses performed relate to catch and effort data (Section 5.1) and biological information (Section 5.2) for the demersal fishery.

3. Catches are described by vessel category, location and species (5.1.1). The greatest effort relates to whalers which account for the largest proportion of demersal landings. Total demersal catches peaked at 2,280 tonnes in 1991 and by far the greatest volume was caught from the inshore grounds of the Mahe Plateau (Sector 1). Catch and effort at all other locations was light. Dominant species in the catch were *Bourgeois* (*Lutjanus sebae*), *Job Gris* (*Aprion virescens*), *Batrican* (*Pristipomoides filamentosus*), *Vara vara* (*Lutjanus bohar*), *Maconde* (*Epinephelus chlorostigma*) and *Capitaine Rouge* (*Lethrinus nebulosus*). With the exception of *Vara vara* these were the key species for biological study. Species composition varies with location.

4. Catch rates by boat category and location are described (5.1.2). Changes in catch rate within boat categories could be attributed to the introduction of new vessel designs and improved gear technology. This also accounted for some observed changes in species composition (eg. schooners targeting deeper water species; shift from schooners to whalers predominantly fishing in an area, eg. sector 3). Seasonal and depth effects were also apparent. It was thus necessary to stratify data by boat and gear type, and to standardise catch rates for seasonal (and depth) effects. Assuming constant catchability, standardised catch rates are an index of abundance of the demersal resource.

5. With the exception of Sector 1, no long term declines in catch rate were observed at the level of the fishing sector, indicating that resources at locations around the edge of the Mahe Plateau and distant from it are lightly exploited and the biomass has remained constant. Evidence from the mother-ship dory fishing venture, however, indicated that short and long term local depletion has occurred. Locally depleted areas in some cases had not recovered over periods of 2 years and this highlights the need for more location specific data collection than the present 'sector'. The rate of recovery of depleted areas was assessed.

6. In sector 1 standardised catch rates indicated that the biomass of demersal species in 1993 had decreased to one fifth of its level in 1989 due to the high fishing effort and catches removed. The decrease principally related to lutjanidae which showed a marked decline in catch rate. Catch rates of serranids and lethrinids remained relatively unchanged although their proportion in the catch increased.

7. The Fox biomass dynamic production model was applied to data for sector 1. However, the total catch and catch rate data appear to be inconsistent - catches in 1993 remained high despite a huge decrease in catch rate suggesting a 20 times increase in effort, which is not believed to have occurred. This questions the validity of the raised catch values (eg. misreporting of location may have attributed a greater catch to sector 1 than actually was taken) or the catch rate data (eg annually aggregated data may mask trends eg. that boats in 1993 may be less efficient than those in 1989). Closer re-examination of the data is required. Preliminary estimates of biomass and MSY from this analysis were 6280 t and 422 t respectively, compared to 8400 t and 1000 t derived from trawl survey information. Current estimates of catch ($\sim$1,200 t) exceed MSY. The dramatic decrease in catch rates indicates that demersal resources in sector 1 are under threat but more work is required to establish current biomass.

8. Biological data related to fish exploited by schooners and research vessels. None of the data related to the heavily fished sector 1 and thus population demographic variables derived for the key species relate to lightly exploited stocks. Population structure (minimum and maximum lengths and sex ratio) was described (5.2.1). Reproductive parameters are assessed (length at maturity) and seasonality of reproductive events is established (5.2.2). The highest catch rates in fact coincide with the period of greatest reproductive activity, March-May. Gear selectivity parameters are described (5.2.3). Lc_{50} for handlines, the length at which there is 50% probability of all fish at that length being caught, was similar to Lm_{50}, the length at which 50% of female fish reach maturity, for *A. virescens, L.sebae* and *L. nebulosus*. For *P. filamentosus* fish are caught considerably smaller than Lm_{50} indicating a danger of recruitment over fishing. Gear type also affects Lc_{50} and gill nets and traps caught smaller fish than handlines. Particularly for *P. filamentosus* this could have serious consequences. Growth and mortality parameters and length-weight relationships have yet to be re-estimated using stratified data. Estimates from aggregated data are already available in the literature.

9. Modelling : Catch rate data for sector 1 indicates species composition changes and depletion. This is a good candidate for application to the multi-species model MIDAS. Unfortunately, however, it has been shown that there are inconsistencies in this data which need to be further investigated prior to modelling. The data for sector 1 and for whalers is the one in which we have least confidence. Unfortunately the better schooner data shows no

multispecies effects and the excellent mothership data only indicates short term effects and is not immediately applicable to MIDAS. Next, whilst population demographic variables have been estimated for key demersal species, these relate to fish caught in lightly exploited locations, and details may differ for the heavily exploited sector 1.

10. *P. filamentosus*. This species is of particular importance since it forms the major part of the catch from intermediate depths and is the target of the new deep bottom set gill-net fishery being developed. As such special reference is made to certain points. Firstly, the total catch of this species presented in this report may in fact be an under-estimate : catches are derived from published SFA statistics which raise sampled catches to estimate the total. The vessels exploiting this species are classed as schooners, but most schooners will not fish in the same way or at the same depths, thus, when raised, catches may be estimated incorrectly (see ??). Next, the data indicate that mesh size and gear type significantly affect size at first capture with serious management implications. Although not a multi-species response, this project will model the effect of changing size at first capture in relation to length at maturity in order to provide management advice in relation to gear type, mesh size and exploitation of this species. Preliminary analyses indicate that at the present small size at first capture in relation to length at maturity, the stock could be eliminated at relatively low levels of fishing effort.

11. Specific recommendations arising from this report are :

- New boats entering the fishery such as the Cygnus vessels and the 22 m La Digue schooners should not be classed together with the existing schooner fleet. They fish differently and have a different fishing power and this will lead to errors when sampled data is raised to estimate total catches. New statistical categories should be established.

- Details relating to specific fishing location are critical. Attempts should be made to improve location specific details obtaining more detailed information than fishing sector. Particularly for the new vessels with satellite navigation systems location should be recorded as latitude and longitude.

- Although there will be a number of different statistical boat categories, as far as possible the same data collection form should be used enabling a fully integrated fisheries information system. Data from different categories will thus be more easily compared.

- Gear specific information must also be collected for each trip in order to monitor changes occurring with time. Thus hook size and mesh size information should be recorded as a matter of routine. Equipment fitted to vessels should be noted (fish finders, GPS, echo sounder etc) and a database of changes maintained. This should be integrated with catch and effort information such that the timing of specific events in the fishery may be determined.

- Biological and length frequency data should be related to a specific vessel trip. In this way total catch, effort and location specific information will be known. The biological and catch effort database should be fully integrated.

- Biological and length frequency information should be collected from the heavily exploited sector 1.

- Management policies for the inshore whaler fishery and the offshore fishery targeting *Pristipomoides filamentosus* require urgent attention.

1. INTRODUCTION

The Management of Multi-species Tropical Marine Fisheries (MTMF) is a project implemented through the British Overseas Development Administration (ODA) Fisheries Management Science Programme (FMSP). The project addresses the problems of managing multi-species fisheries in developing countries where resources for data collection for stock assessment and management purposes may be limited. It aims to examine the influence of fishing pressure on the dynamics of interacting multi-species fish stocks, to identify minimum data requirements enabling sensible analysis and management of such resources, and to highlight possible management measures to enhance yields and ensure sustainability. Case study fisheries (Seychelles, Tonga, Mauritius) are examined in conjunction with a modelling exercise to explore the dynamics of these resources. MRAG have developed a Multispecies Interactive Dynamic Age Structured model (MIDAS) for this purpose. The project is more fully explained in the FMSP and Country project memoranda, and will be presented in a forthcoming project report.

Of the case studies, Seychelles demersal fishery is the most complex involving the greatest number of species, a number of different fishing vessel types and a number of different gear types to exploit the resource. However, a well established data collection programme has been in operation since 1985 and some earlier information is available. There is also a considerable literature (see Bibliography). This interim report presents a review of historical information (in particular, Mees (1992b) describes the demersal fishery, parts of which are reiterated for completeness) and updates analyses relating to Seychelles demersal fishery.

2. SEYCHELLES GEOGRAPHY AND HYDROLOGY

2.1. Seychelles, General Description

The Republic of Seychelles consists of some 100 widely scattered islands (land area, 453 km^2) between 5° and 10°S and 45° and 56°E in the Western Indian Ocean. The Exclusive Economic Zone encompasses 1,374,000 km^2 of which only 48,019 km^2 of ocean cover depths of less than 200 m, the remainder is over depths of 1,000 - 1,500 m. The shallow areas are composed of plateaux and banks (Fig 1, Table 1).

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 coralline islands on this and the other plateaux are sparsely inhabited.

TABLE 1 : The total and fishable areas (km^2) of Seychelles banks and plateaux at shallow (0-75m) and intermediate (75-150m) depth strata, and the length (km) of the 100 m depth contour.

LOCATION / STRATA	SHALLOW STRATA TOTAL	FISHABLE	INTERMEDIATE STRATA LENGTH	AREA
MAHE PLATEAU				
- Inshore		6000.0		
- Offshore		6500.0		
- Trawlable		14000.0		
TOTAL	43300.0	26500.0	998.0	374.0
SEA BANKS / MOUNTS				
Small Constant	170.0	102.0	55.6	13.8
Bar Savat + sea mount	48.0	28.8	50.0	12.5
Correira bank (3 mounts)	17.4	10.4	33.3	8.3
Adelaide bank	6.6	4.0	11.1	2.7
Sea mount 20	6.6	4.0	11.1	2.7
Constant bank	590.0	354.0	114.8	28.7
Fortune bank	600.0	360.0	120.4	30.1
TOTAL	1438.6	863.2	396.3	98.8
OUTLYING ISLANDS/PLATEAUX				
Amirantes plateau	3900.0	2340.0	433.4	108.3
Desroches plateau	400.0	240.0	77.8	19.4
Platte plateau	340.0	204.0	63.0	15.7
Coetivy plateau	420.0	252.0	83.3	20.8
Providence farquhar	1250.0	750.0		
Cosmoledo	350.0	210.0		
Alphonse	190.0	114.0	55.6	13.8
TOTAL	6850.0	4110.0	713.1	178.0
GRAND TOTAL	51588.6	31473.2	2107.4	650.8

The remaining islands and plateaux to the south and west of the Mahe plateau are all coralline in nature and include the Amirantes plateau, the Alphonse group, the Providence and Farquhar group and the Aldabra-Cosmoledo group.

The Fortune Bank lies south of the Mahe Plateau and has no emergent features. The bank tends to be shallower and more coralline 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. There are other smaller submerged banks in this area.

2.2. Hydrological Conditions

The climate consists of : the Northwest Monsoon from mid November to mid March followed by an inter - monsoon period of light variable winds and frequent calms; the South East Trade Winds from the end of May to October which average 12 knots and frequently limit fishing activity; a second inter - monsoon period during October - November.

Air temperature varies little throughout the year (mean daily minimum, 24-25°C; maximum, 27-30°C). Rainfall may occur throughout the year but is greatest in December and January. A strong gradient exists from 1500 - 2000 mm on the eastern granitic islands to less than 1000 mm in the western coralline islands such as Aldabra.

The hydrology of the Seychelles is affected by the eastward flowing Equatorial Counter Current 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. The southern islands lie in the west flowing South Equatorial Current, the northern in the east flowing Equatorial Counter Current. For the Mahe Plateau Tarbit (1980) described the prevailing conditions which are summarised in Table 2.

TABLE 2 : 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 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. Clock wise circulation occurs SE of Plateau.	Mainly southerly modified to SE/SW by the edges of the 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°C in S	Upwelling occurs along the southern edge of the Plateau
THERMOCLINE	A dome of cold water occurs S of Plateau, Thermocline at 20 -30m	Over plateau between 18-27°C; cool water, 16°C at 75m below S edge of Plateau		Surface and bottom temperatures over Plateau similar. No definite thermocline		A well defined thermocline occurs at 75 - 100m W and E of Plateau and <35m S & W	Thermocline stabilises at 35 - 40 m
TEMPERATURE							
SURFACE	26-28°C	26.5-29°C		28.5-31°C	29-31°C	26°C	26°C
20-29 m		26.4°C		28.6°C		25.7°C	
30-39 m		24.3°C		28°C		25°C	
40-49 m		23.3°C		27.1°C		23.2°C	
50-59 m		21.8°C		25.8°C		23.7°C	
60-69 m		20.2°C		24.5°C		23.2°C	

3. SEYCHELLES DEMERSAL FISHERY

3.1. Fisheries policy and legislation

The relatively large area of shallow banks and plateaux in Seychelles provides the potential for an important demersal fishery which has developed to involve a number of different vessel types and means of exploitation. The fishery has been shaped also by past and existing policy and legislation, now summarised.

The objectives for the fisheries sector relevant to the demersal fishery are (Anon 1989) :

- The creation of maximum amount of work opportunities
- The maximisation of foreign exchange earnings
- The creation of optimum linkages with other sectors
- The ensurance of stable development in the industry
- The conservation of marine resources in order to ensure long term viability of the industry

Seychelles Fishing Authority (SFA) is required to collect and analyse statistical and other information on fisheries and to prepare and keep under review plans for the development and management of fisheries. The legislation is in place for the Minister (of Agriculture and Fisheries) to prescribe management measures including : closed seasons, closed areas, gear specifications, fishing methods or gear types, specification of species sizes or other characteristics of aquatic organisms that it is permitted or forbidden to catch, and schemes for limited entry into the fishery (Fisheries Act, 1986).

Certain regulations are directly relevant to the demersal fishery. By law, a local fishing vessel licence is required before fishing is permitted in Seychelles waters, and except for research purposes under licence, foreign vessels are excluded from fishing within territorial limits or on the surface of, and up to 5 nautical miles beyond the edge of the plateaux (continental shelf, defined by the 200 m depth contour. Fisheries Act, 1986; SFA, 1986a). Fishing for demersal species by means of trawl nets is prohibited. Regulations specific to demersal fish species do not exist except in as much as they are included incidentally in other regulations, eg. the restriction of mesh size in the trap fishery which occasionally catches a number of demersal species.

As a consequence the demersal fishery is exploited solely by locally owned vessels, and predominantly by hooks and lines which tend to target the top predators (Lutjanidae, Lethrinidae and Serranidae). Locally high exploitation rates in near-shore areas led to a Government policy to limit the number of outboard- and to promote inboard powered vessels capable of fishing more distant locations. The policy of distributing fishing effort more evenly and further offshore inevitably implies a requirement for more capital intensive fishing methods and larger boats and progress has been slow. To improve the situation, recent policy has also been to move away from parastatal management of the fishing fleet towards entrepreneurial ownership.

Declines in catches and the number of vessels operating, particularly further offshore, have resulted in fleet rehabilitation plans and a number of projects are outlined in the 1990-1994 National Development Plan (Anon, 1989). Particularly relevant are the fleet replacement programme, fishing boat construction, schooner fleet management, promotion of demersal fisheries in the outer islands, development of fisheries technology, fisheries extension programme, and various infrastructure development projects. These programmes have led to the introduction of new vessel designs and fishing methods.

Infrastructure to support fisheries development has been provided or is planned and includes provision of marketing facilities, ice, and outlets for fishing equipment. In line with recent policy, marketing practices have been relaxed and the state monopoly removed.

3.2. The fishing fleet : vessels and fishing gear

Seychelles was un-populated until the eighteenth century. Fishing for demersal species was confined to coastal areas near centres of population and today is concentrated around the granitic islands. The coralline islands are sparsely inhabited and local exploitation will have had minimal impact. Seychelles schooner fishery was established in 1974 when these boats were introduced to allow fishing on the offshore banks and periphery of the Mahe and Amirantes Plateaux. Foreign mothership-dory operations were licensed to fish in the Amirantes, Cosmoledo and Providence and Farquhar between 1974 - 1977 (Ratcliffe, 1975; Harris, 1980). Whalers have increasingly targeted demersal species since the mid 1980's and developments in the schooner fishery since that time have resulted in more efficient vessels with a greater range and better means of exploiting the demersal resource. Between 1991 and 1993 a Seychelles mothership-dory venture operated. Thus fishing pressure has increased only relatively recently and for the outlying islands exploitation has been sporadic.

The demersal fishery is thus prosecuted from a number of different vessel types. For statistical purposes these are defined by the following categories :

Pirogues : any fishing boat equipped with up to 15 hp outboard motor, including un-powered boats. Types include traditional wooden canoes; fibreglass boats. Fishing range limited to coastal areas.

Outboards : Boats with an outboard motor of greater than 15 hp. Types : mostly an introduced design of fibreglass hull known as the mini-mahe; some larger wooden vessels. Fishing range limited to near-shore.

Whalers : Any undecked inboard powered fishing boat (may have a small fore-deck). Types : traditional clinker built wooden hulls; introduced fibre-glass design Lekonomie and Lavenir. Fishing range limited to Mahe Plateau except in calm weather when occasionally whalers may go as far as the Amirantes. Most fishing trips are daily, but trips of 3-4 days are made.

Schooners : fully decked inboard powered fishing boats. Types mostly wooden hull vessels of traditional design; ADB promoted wooden vessels known as 'la Digue' boats after the boat yard of construction; converted pole and line vessel; Swedish design fibre glass vessel. Fishing range limited only by size of vessel and extreme weather conditions. Trips may last several days.

Research : the SFA research vessel 'Etelis' a pole and line vessel; newly introduced multi-purpose Cygnus fibre glass vessels (1994); other vessels in development stage prior to full incorporation into the fishery. Range and trip length as the Schooners.

Mothership - Dory fishing venture. Fishing range unlimited, duration up to 3 months.

Mees 1989c describes the fleet structure. Schooners are discussed by Mees (1990b) and the mothership venture by Mees (1991b; 1992c; in press). Briefly, the number of outboards and pirogues had decreased with time, but the policy of promoting inboard powered vessels led to considerable increases in the number of whalers rather than schooners. This shifted fishing pressure from coastal reefs slightly but did not achieve the objective of increasing effort at more distant fishing grounds, in fact causing an increase in fishing pressure in near-shore locations.

The number of schooners declined up to 1989 (see Michaud, 1988; Parker, 1988; Mees, 1990b). The introduction of the new La Digue vessels was not entirely successful and the promotion of the offshore demersal fisheries fleet remains a problem. Socio-economic factors restrict the development of the fishery (Mees, 1990c;d) in addition to technological problems. The Cygnus vessels are the latest attempt to address this problem.

The mothership-dory fishing venture achieved the objectives of increasing the yield of demersal fishery resources and exploiting distant fishing locations, increasing exports, and increasing employment. However, this privately run operation was not financially viable and failed in 1993 after 7 voyages.

The predominant fishing method employed for demersal species by all boat categories is hook and line. Pirogues and outboards may also deploy fish traps but the proportion of demersal species is negligible (see Annual statistical reports : Moussac, 1987a; 1987b; 1988a; Mees, 1989b; 1990a; 1991a; Mees and Grandcourt, 1992; Grandcourt, 1993). Whalers may target either carangidae or demersal species using hook and line. Increasingly demersal species are being targeted although the carangid fishery is the traditional target of this category.

The schooners and mother-vessel target demersal species. Hooks and lines have traditionally been used, but electric fishing reels were promoted through the SFA extension programme and have successfully been taken up by a number of schooners. They were also fitted to the dories for the recent mothership operation. Catch rates are increased by up to 30 % (Bautil, 1988; Mees, 1990b). Drop-line fishing was tested by SFA but has not commercially been adopted. Deep bottom set gill net fishing for demersal species was developed by SFA and is employed commercially by one of the larger La Digue schooners. This technique is also being developed with the new Cygnus vessels.

The existence of a number of different vessel types and fishing methods has significant implications both for the analysis of the data (effort must be standardised) and management of the fishery.

3.3. The fishery and fishing locations

Seychelles artisanal fishery is described by Lablache *et al* (1988) and Mees (1989a). The demersal fishery produced 20-40% of the total landings of approximately 5000 t per annum during the period 1985 -1993. Demersal species, however, constituted around 75% of all exports (Mees, 1992b). Thus this sector of the artisanal fishery is particularly important for meeting the defined objectives of the fisheries sector.

Demersal species occur in both sandy flat bottom areas suitable for trawling, and rough and coralline substrates. However, the concentration of fish is not sufficient to support a handline fishery except in the rough / coralline areas and on the drop-offs of the banks and plateaux. Fishable areas given in Table 1 are those suitable to support a handline fishery. This has been estimated for the Mahe Plateau where the fishable area is approximately 60% of the total. This proportion was applied to the other locations in estimating fishable area[1]. It should be noted that fishable areas are not uniform and include good and bad fishing zones. Also the territorial behaviour of most demersal species means that fishable areas are separate entities from which emigration and immigration will be low. They are consequently sensitive to fishing pressure and recovery from depletion may be slow. Mees (in press) has examined recovery rates.

To improve analysis the banks and plateaux have been stratified into fishing sectors, and specific fishing locations within these sectors are also identified (Fig. 2; Table 3). Sub stratification by depth was as follows : shallow (0-75 m, mostly on the surface of the plateaux); intermediate (75-150 m, at the drop off of banks and plateau); deep (>150 m). The shallow stratum on the Mahe Plateau was further sub-stratified into : inshore areas (corresponding with sector I in Table 3); offshore banks and peripheral edge zone of the Plateau rim; trawlable grounds.

[1] Areas given in Table 1 derive from a number of sources and there is some variation in the estimates. Refer to Mees (1992b) for detailed explanation

TABLE 3 : A description of the fishing grounds and sectors

F_GROUNDS	DESCRIPTION OF FISHING GROUNDS	SECTOR
	MAHE PLATEAU AND ASSOCIATED BANKS	
OUT	10 MILE RADIUS OF MAHE / PRASLIN GROUP	1
N; NNE; NNW	BIRDS,DENIS,NORTH EDGE	2
NE	NORTH EAST EDGE	3
E; ENE	TOPAZE BANK	4
ESE	LA JUNON BANK	5
SE	SOUTH EAST EDGE	6
S; SSE;	SOUTH EDGE	7
SW	SOUTH WEST EDGE	8
W; WNW; WSW	OWEN THOR ROBERTS BANKS	9
NW	NORTH WEST EDGE	10
	BANKS TO SOUTH OF MAHE PLATEAU	11
COE	Coetivy	11
CON	Constant	11
COR	Correira	11
FOR	Fortune	11
SAV	Bar Savat	11
SCO	Small Constant	11
	OUTLYING ISLANDS AND PLATEAUX	
PLA	PLATTE	12
AMI	AMIRANTES GROUP	13
AFR	African Banks - All Atolls	13
ALP	Alphonse	13
BIJ	Bijoutier	13
BOU	Boudeuse	13
DEN	Desnoeufs	13
DES	Desroches Atoll	13
ETO	Etoile	13
FRA	St. Francois	13
IDS	Ile Du Sud - Near Poivre	13
JOS	St. Joseph	13
MAR	Marie Louise	13
POI	Poivre	13
REM	Remire	13
	PROVIDENCE / FARQUHAR GROUP	14
FAR	Farquhar Group - Unspecified	14
PRO	Providence Group - Unspecified	14
WIZ	Wizard Reef	14
BUL	Bulldog Bank	14
CER	Cerf Island	14
M25	Bank marked '25' between CER and FAR	14
ALD	ALDABRA GROUP - UNSPECIFIED	15
SDM	SAYA DE MAHLA BANK	99

It must be stressed that the stratification of fishing grounds and fishing sectors is a statistical and analytical convenience. Neither the fishing grounds nor the sectors necessarily encompass a discrete population of fish. It has been stated that fishable areas are not uniform and that due to the territorial nature of most reef and demersal species adult emigration and immigration will be low. Thus these types of fishery may be regarded as consisting of meta-populations associated with specific features, or patches of habitat, interconnected through larval or other means of dispersal - whilst the fish on different patches of habitat may belong genetically to a single population, from a fisheries point of view each patch contains a single population.

The Mahe Plateau is shallow and in practice many patches of habitat will be close together. It may be assumed that some mixing of adult fish occurs between patches, between fishing grounds, and even between sectors on the Plateau. Since data collection is not sufficiently detailed to relate catches to a specific feature or patch of habitat it is necessary to utilise this assumption and the definition of the area encompassing a discrete fish population become a matter of convenience. The area chosen may or may not be valid, and this uncertainty must be understood when interpreting the results of fisheries models applied to these data. Beyond the Mahe Plateau fishing sectors are separated physically and geographically. In these cases it is not valid to assume a single population (although there may be fish of the same genetic stock).

3.4. Potential yield from the demersal fishery

Demersal fish potential by hook and line at coralline banks along the Muscarine ridge in the Indian Ocean was first surveyed by Wheeler and Omaney (1953). Fishable (ie rough grounds suitable for handlining) and non fishable areas were first identified. Subsequently trawl surveys were conducted in the non-fishable (ie by handline) grounds. Estimates of the demersal fishery resource in Seychelles have largely been confined to the granitic Mahe Plateau based upon the swept area method applied to the trawl surveys. These estimates will tend to under-estimate fish populations in the rough grounds where greater concentrations occur, and in deeper water. For the rough (fishable) grounds, length cohort analysis has been applied to representative species in order to determine population size, and depletion assessments have also been used.

TABLE 4. Biomass and potential yield estimates (tonnes) available to a commercial handline fishery on demersal stocks in Seychelles (From Mees, 1992b)

LOCATION / STRATA	SHALLOW STRATA BIOMASS	MSY	INTERMED. STRATA BIOMASS	MSY	DEEP MSY	TOTAL MSY EST. < 150 M	TOTAL
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
Bar Savat + mounts	40.3	4.8	68.8	17.2	6.0	22.0	28.0
Correira bank	14.6	1.8	45.7	11.4	4.0	13.2	17.2
Adelaide bank	5.5	0.7	14.9	3.7	1.3	4.4	5.7
Sea mount '20'	5.5	0.7	14.9	3.7	1.3	4.4	5.7
Constant bank	495.6	59.5	157.9	39.5	13.8	98.9	112.7
Fortune bank	504.0	60.5	165.6	41.4	14.4	101.9	116.3
TOTAL	1208.4	145.0	543.4	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	114.4	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	3579.4	894.9	252.9	6182.3	6435.2

For demersal fish resources in trawlable areas, 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 nm^2 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. On rough grounds, 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). Mees (1992b) reviewed previous estimates of biomass and yield from the demersal fishery and presented revised estimates by location and depth stratum based on analysis of new information (Table 4).

The yields for the offshore banks and rough ground (fishable areas) are considered to be an under-estimate. Catches are significantly below the potential yield and there is scope to more than double the present catch. Locally, however, depletion has occurred and particularly in inshore areas catches exceed potential yield (see Mees, 1992b; Annex 5). Potential for further development of the fishery lies in the more distant locations and intermediate and deep depth strata.

3.5. Commercially important species from the demersal fishery.

Species landed to the demersal line fishery are members of the Lutjanidae, Serranidae and Lethrinidae (Table 5). For vessels such as the schooners and mother-ship ventures which target bottom fish these families contribute in excess of 85% of the landed catch, the remainder consisting of carangids, barracudas, pelagic species such as tuna, and sharks. The small boats and whalers may catch a smaller proportion of demersal species.

The species of demersal fish are commercially important, and contribute up to 77% of all fish exported from Seychelles. Around 30% of the demersal landings are exported : 40% of all red snapper (mostly *Lutjanus sebae* and *L. coccineus*); 7% of *L. bohar;* 24% of Job fish (*Pristipomoides filamentosus* and *Aprion virescens*); 60% of *Epinephelus chlorostigma*; 31% of all other serranids; and 16% of all Lethrinids (Mees, 1992b). Thus it may be seen that the Lutjanids and Serranids are more valuable than Lethrinids and this may affect targeting during fishing. Similarly, due to fears of ciguaterra, *L. Bohar* may be avoided and the proportion exported does not reflect the volume landed. Nevertheless, there is also a high local demand for demersal species, particularly during the SE Trade Wind period when fishing is restricted and landings are lower.

Economic value and volume of fish landed indicated the following key species from the Seychelles demersal fishery : *L. sebae, P. filamentosus, A. virescens* and *E. chlorostigma* (Mees, 1992b). *Lethrinus enigmaticus* is the most important lethrinid, but its common name (Lascar) is shared by several species. *Lethrinus nebulosus* is another important lethrinid.

TABLE 5 : Demersal species described in Seychelles catch statistics.

SEYCHELLES NAME	LATIN NAME	OTHER DETAIL
Bourgeois	*Lutjanus sebae*	
Bordemar	*Lutjanus coccineus*	
Therese	*Lutjanus gibbus*	
Vara Vara	*Lutjanus bohar*	
Job gris	*Aprion virescens*	
Job jaune	*Apharaeus rutilans*	
Batrican	*Pristipomoides filamentosus*	
Carpe	*Gaterin spp*	LUTX :other lutjanids
Madras	*Lutjanus kasmira*	LUTX :other lutjanids
Vie. Maconde	*Epinephelus chlorostigma*	
Vie. Platte	*Epinephelus multinotatus*	
Tioffe	*Epinephelus morrhua*	
Croisant	*Variola louti*	
Vie. Rouge	*Epinephelus fasciatus*	SERX : other serranids
Vie. Ananas	*Cephalopholis miniata*	SERX : other serranids
M. Angar	*Cephalopholis sonnerati*	SERX : other serranids
Cheval di bois	*Epinephelus corallicola*	SERX : other serranids
Vie. Machata	*Epinephelus fuscoguttatus*	SERX : other serranids
Vie. Tukula	*Epinephelus tukula*	SERX : other serranids
Vie. Galfa	*Aethalopera rogaa*	SERX : other serranids
Vie. Crab	*Epinephelus malabaricus*	SERX : other serranids
Vie. Chatte	?	SERX : other serranids
Babone	*Epinephelus tauvina*	SERX : other serranids
Tukula	*Epinephelus tukula*	SERX : other serranids
Cap. Blanc	*Gymnocranius robinsonii*	
Guele longue	*Lethrinus elongatus*	
Lascar	*Lethrinus mahensa*	
Dame berrie	*Lethrinus crocineus*	
Cap. Rouge	*Lethrinus nebulosus*	
Guele de vin	*Lethrinus conchyliatus*	LETX : other lethrinids
Bacsous	*Lethrinus variegatus*	LETX : other lethrinids
Chouchoutte	*Gymnocranius griseus*	LETX : other lethrinids
Eclair	*Lethrinus lentjan*	LETX : other lethrinids

4. SAMPLING AND ANALYTICAL METHODS

Catch and effort data collection are achieved through Seychelles Catch Assessment Survey (CAS) implemented by SFA and fully described in SFA (1990). Analytical procedures are described in Mees (1990f). Briefly, a stratified sampling programme is conducted by boat category and landing site. The fishing skipper is interviewed and catch is recorded by species and weight. For whalers, a new data collection programme was introduced from July 1989. The previous system underestimated the catch of whalers undertaking trips of greater than one day (ie for demersal species, see Mees, 1992a). Total effort is recorded at four key sites and catches are sampled. For schooners the catch and effort of every boat is recorded, but frequently the catch is landed in parts : only records for which the total landed catch is known are included in the analysis. For the mother-ship - dory fishing operations an observer was placed on board the mother-ship for each voyage, and detailed census of catch and effort information was recorded for each dory trip. The amount of detail collected (location, depth, climate, current) differs by boat category (Table 6). The number of species recorded by boat category also differs.

TABLE 6 : The quality of data available from the CAS for each boat category

BOAT TYPE	QUALITY OF DATA					PERIOD
	C / F	SP. COMP	LOCATION	DEPTH	OVERALL	
SMALL BOATS	Yes	Crude	Assume all inshore	No : Assume shallow	Fair / poor	from '85
WHALERS	Yes	Crude -90 Good 90 +	Some data but poor reporting	No : Assume shallow	Fair	from '85
SCHOONERS	Yes	Good	Gross location reported	Since 1991	Good	from '83
MOTHERSHIP	Yes	Good	Lat / Long	Yes	Excellent	1991-93

Length frequency and biological information was recorded for certain key species (see 3.5; Mees, 1992b). For length frequency, boxes of incompletely gutted fish were sampled at random. The fish were measured (fork length, to 1 mm) and where possible sexed. Length data was obtained for all key species.

Biometric samples employed whole fish encompassing the extremes of the size range observed. They were weighed (to 1 g), measured (fork length to 1 mm) and sexed. Gonads were weighed (to 0.1 g). Maturity stage was assessed for females on a scale of 1 (immature) to 5 (spent) according to criteria established by micro and macroscopic examination. A Gonadosomatic Index (GSI) - the gonad weight in grammes / whole fish weight in kilogrammes - was calculated. Biometric data was collected for *P. filamentosus* and *A. virescens*.

Sampled data by boat category, length frequency and biometric data by species form the basis of the present study. Raised estimates of catch are derived from Annual Statistical Reports published by SFA.

5. ANALYSES

5.1. Catch and Effort Data

5.1.1. Total catch, effort and species composition per year by fishing location

Estimates of the total demersal fish catch and the effort (trips) applied per annum for most boat categories are available from SFA annual statistical reports (Table 7). The annual catch of demersal species for each location was derived (Annex 1, Table 8).

Table 7: The total demersal fish catch, and the effort (trips) applied to the demersal fishery for certain boat categories per annum (Schooner catch in 1984 is guesstimate).

DETAIL	BOATTYPE	83	84	85	86	87	88	89	90	91	92	93
EFFORT	WHALER	NA	NA	NA	NA	NA	NA	NA	4235	3746	4745	4615
EFFORT	SCHOONER	491	NA	356	518	628	504	371	349	456	596	170
EFFORT	MOTHERSHIP									1364	1686	1052
CATCH	SPORTS BOATS	NA	NA				0.0	0.0		0.0		
CATCH	SMALL BOATS	NA	NA	266.8	356.5	207.0	218.4	267.1	201.6	215.1	214.9	247.1
CATCH	WHALER	NA	NA	296.6	824.5	672.5	600.4	672.2	1139.1	1178.4	903.8	962.1
CATCH	SCHOONER	398.4	350.0	274.1	382.9	528.8	414.7	516.7	571.7	472.3	336.2	182.4
CATCH	MOTHERSHIP									419.0	541.2	327.5
CATCH	TOTAL	NA	NA	837.5	1563.9	1408.3	1233.5	1456.0	1912.4	2284.9	1996.1	1719.1

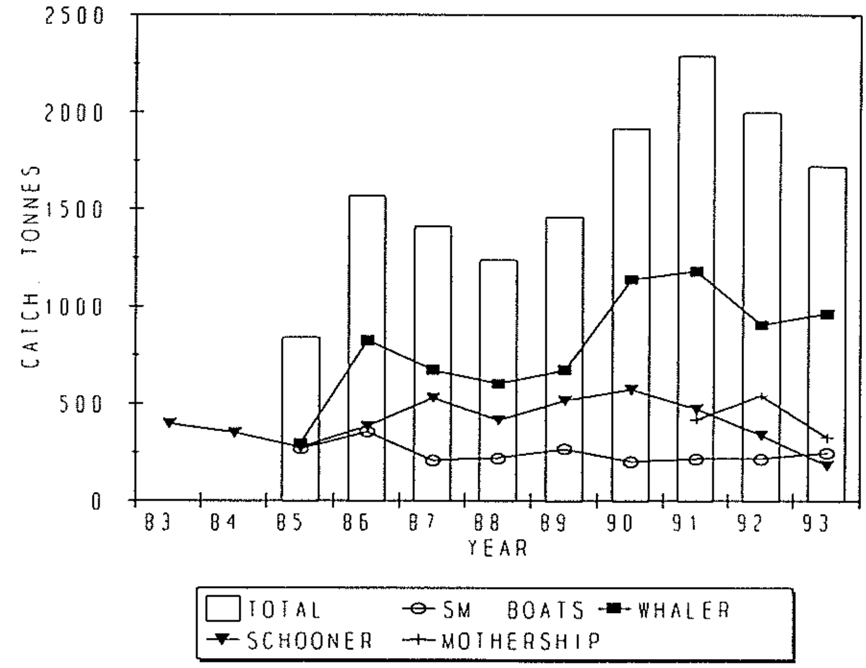
Table 8 : The total annual demersal fish catch by location

SECTOR	DETAIL	83	84	85	86	87	88	89	90	91	92	93
1	Inshore	NA	NA	525.0	1076.5	792.6	741.1	928.1	1305.9	1291.1	976.9	1115.1
2	N. Mahe Pl.	NA	NA	30.4	99.6	94.4	66.1	53.8	126.9	138.6	56.6	45.8
3	NE Mahe Pl.	NA	NA	37.8	40.6	62.7	20.3	17.7	21.0	26.4	21.8	12.8
4	Topaze Bank	NA	NA	37.6	40.3	45.5	63.7	44.5	43.6	43.7	89.1	64.9
5	La Junon Bank	17.2	14.9	22.1	11.3	26.3	4.4		9.7	23.3	25.1	31.0
6	SE Mahe Pl.	NA	NA	37.9	20.5	82.9	67.0	37.5	162.3	239.1	79.4	49.2
7	S Mahe Pl.	NA	NA	18.3	44.8	68.1	43.6	61.4	64.6	41.7	63.4	22.6
8	SW Mahe Pl.	8.6	11.3	9.2	6.8	33.8	10.2	16.8	12.9	16.6	5.4	7.0
9	W Mahe Pl.	NA	NA	46.1	162.7	83.5	144.6	215.6	109.8	95.3	55.9	49.1
10	NW Mahe Pl	NA	NA	24.7	54.7	67.3	50.5	51.0	33.1	42.1	44.7	24.4
11	Banks S MP									201.3	50.7	18.1
12	Platte	NA	NA	0.3	0.7	5.6	0.5	0.6		0.7	4.2	4.0
13	Amirantes	NA	NA	49.1	5.5	45.8	41.5	28.9	22.6	49.8	129.6	10.5
14	Providence / Farquhar									75.2	371.9	32.2
15	Cosmoledo/Aldabra										21.6	
99	Saya de Mahla											232.4

Demersal species are caught during approximately 60% of all fishing trips by small boats and whalers. For whalers the proportion has increased slightly since 1990. It is also apparent that nearly all trips made by whalers to more distant fishing grounds target demersal species (Table A1.2).

Demersal fish catches have fluctuated over time, reaching a peak in 1991 (Fig. 3). By boat category, whalers accounted for the approximately half the catch from 1985-1993, small boats between 10-20%, and schooners 30%. In recent years however, the proportion landed by schooners has decreased reaching 11% in 1993, and it is apparent that the volume landed by this boat category has decreased considerably since 1990. The volume landed by small boats has remained almost constant since 1985 whilst the landings by whalers have apparently increased (although catches were underestimated prior to 1990). The mothership venture made a significant impact accounting for 18%, 27% and 19% of demersal landings from 1991-93 respectively.

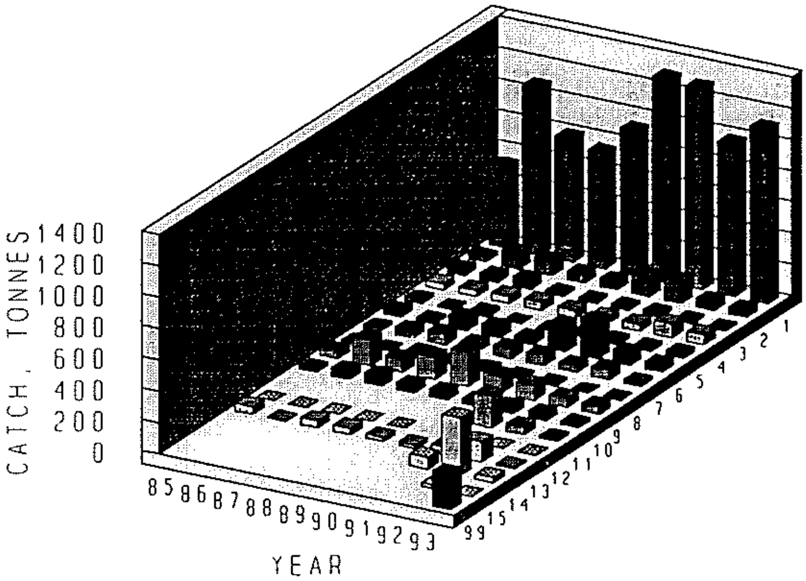
Fig. 3 : Total annual demersal fish catches by boat type aggregated over all locations.



By location, around 65% of the demersal fish catch derives from inshore locations exploited by small boats and whalers. This may be an overestimate due to the poor reporting of location by whalers, but nevertheless, this sector is the most heavily exploited part of the fishery. By comparison all other locations are lightly exploited and removals with time have been intermittent (Fig 5). For example, sector 14 yielded 19% of all demersal landings in 1992 but had experienced no or very light fishing since the previous mothership venture to that location in 1976-77.

Available information indicates that locations distant from the centres of population are fished seldom by whalers, and most of the catch from these locations derived from the schooner and mothership operations (Table A1.4).

Fig. 4 : Demersal fish catches by location per annum



Species composition within Seychelles waters varies with latitude. Thus, that in the Aldabra / Cosmoledo and Providence / Farquhar groups is similar but different from that in the Amirantes 320 km to the north. Whilst the Amirante and Mahe plateaux are at similar latitude the coralline Amirantes support a different species composition to the granitic Mahe Plateau, and in commercial terms a greater proportion of high value species occur on the latter (see Lablache and Carrara,1984). Species composition also differs on banks within the same general location (see Mees, 1991b; 1992c), presumably related to substrate differences. Species composition may also be related to prevailing currents and other hydrological factors. Depth is another significant factor.

The earliest records of species composition by location within Seychelles were compiled by Omaney and Wheeler (1953) for 1948-9 (Table 9). Recent species composition of the demersal fish catch is available for the whole fishery in SFA annual statistical reports (not reproduced). Sampled data by boat type were employed to derive the species composition by location (Annex 1 Tables A1.5 - A1.21). Details for 1991 are illustrated (Fig. 5) as an example of the species composition observed. The predominant species were Bourgeois, Job Gris, Batrican, Vara vara, Maconde, and Capitaine Rouge (ie. the key species, 3.5). By location Bourgeois is predominantly caught in Sector 1, and is only important in catches from the Mahe Plateau (sector 1-10). The banks (Sector 11), Platte (12) and Amirantes (13) have minor catches of Bourgeois but otherwise the species composition is similar to the Mahe Plateau with a predominance of Lutjanids. By contrast Providence / Farquhar (14) and Aldabra / Cosmoledo (15) have a predominance of serranids and lethrinids (eg. 1993, Fig. 6). Some differences may be related to depth fished, and a high proportion of Batrican in the catch is an indication that fishing occurred at depths greater than 75 m).

For individual locations, the detail indicated in Tables A1.5-A1.21 is summarised by species group in Figs. 7-22. Historical information from Omaney and Wheeler (1953) and Ratcliffe (1974) and Harris (1977) is included.

Table 9 : Species composition recorded in 1948-49 by number of fish caught at different locations within Seychelles.

LOCATION SPECIES	Coetivy	Fortune	Constant	Platte	Farquhar & Providence	Aldabra	Amirantes & Desroches	Mahe Plateau
Bourgeois			4.6%				0.2%	2.0%
Bordemar								0.1%
Therese							0.4%	0.4%
Vara vara	20.0%	26.0%	4.6%	82.0%	14.0%	24.5%	67.0%	57.6%
Job gris		4.0%	1.0%		4.1%	1.0%	1.4%	2.0%
Job jaune								
batrican	20.0%		0.8%					0.6%
Lutx						1.0%		
Maconde	10.0%					0.4%		0.7%
V. Platte		1.4%	5.4%	1.4%	70.0%	8.0%	1.6%	6.7%
Tioffe								
croissant				4.0%		3.6%	1.4%	2.5%
Serx	10.0%				4.1%	44.2%	1.4%	0.6%
Cap. Blanc								0.7%
Guelle longue								0.7%
Lascar		56.0%	30.0%				18.7%	12.0%
Dame berrie						0.4%	0.2%	1.0%
Cap. Rouge		1.4%	21.0%	8.0%	4.1%	9.0%	2.4%	4.0%
Bacsous	33.0%	11.0%	13.0%	1.4%	4.1%	1.0%	1.0%	3.0%
Letx	10.0%					4.9%	0.8%	0.5%
Number of fish	10	73	129	74	49	273	491	1349

Fig. 5 : Species composition of the demersal catch (mt) landed by all boat types during 1992, by location.

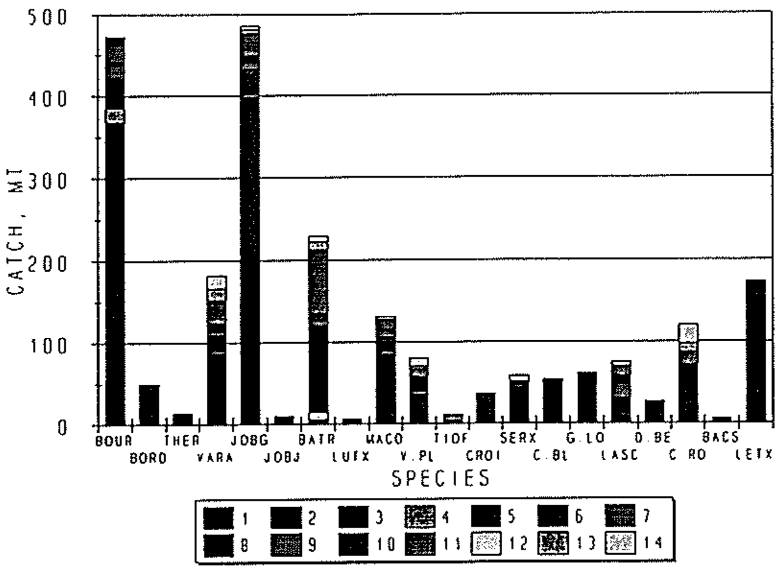
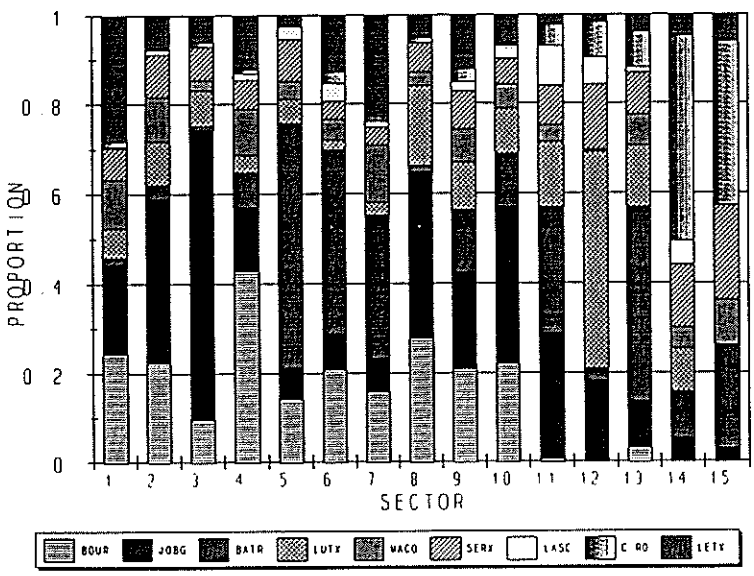


Fig. 6 : The proportion of the catch by sector represented by key species and species groups in 1993.



Figs 7 - 22 : Gross species composition observed at each sector from 1948 (where available) to 1993.

Fig. 7.

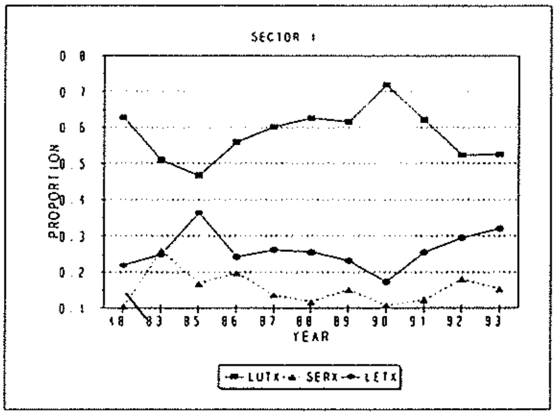


Fig. 8.

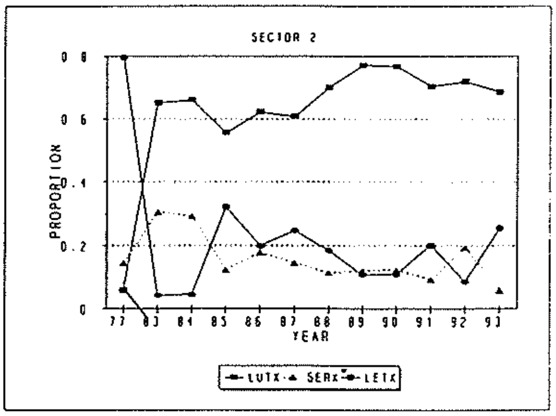


Fig. 9.

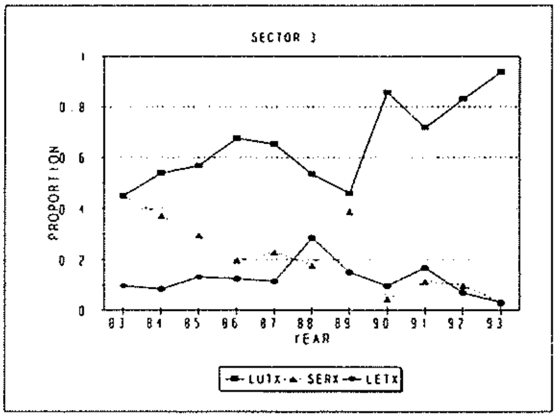


Fig. 10.

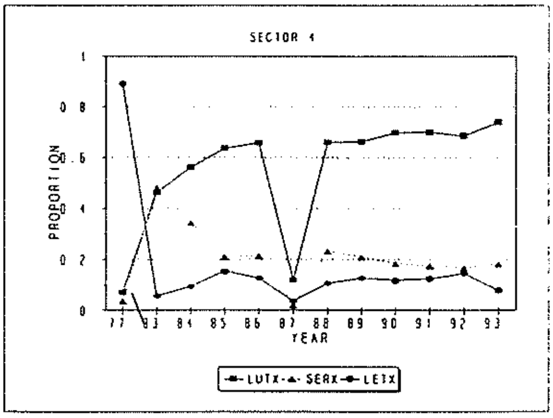


Fig. 11.

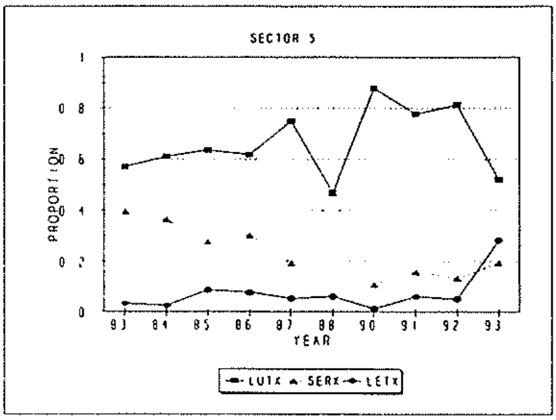


Fig. 12.

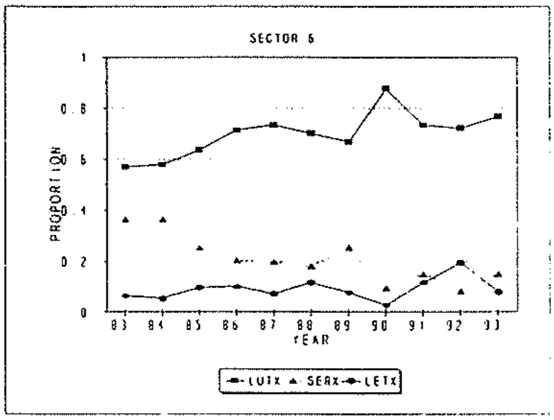


Fig. 13.

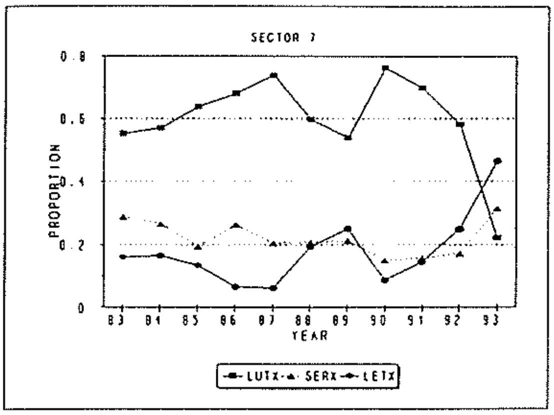


Fig. 14.

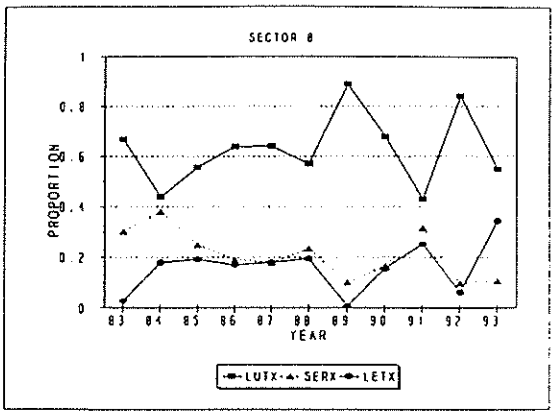


Fig. 15.

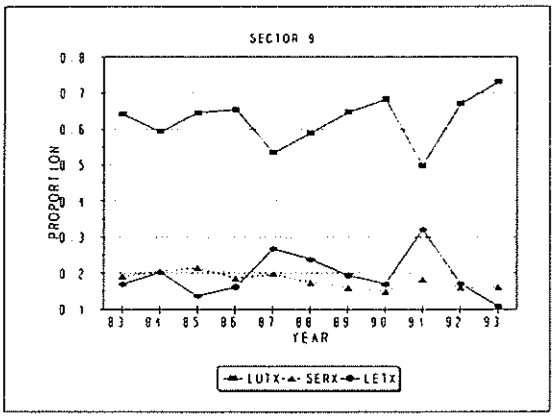


Fig. 16.

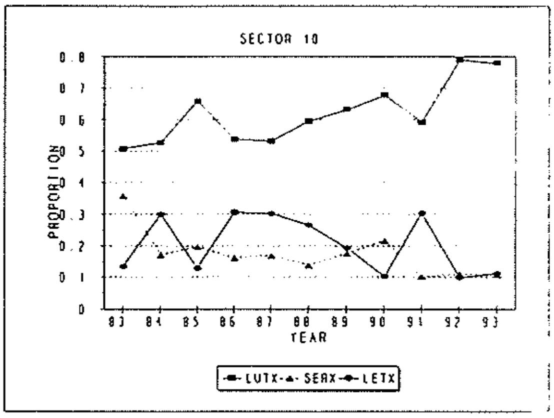


Fig. 17.

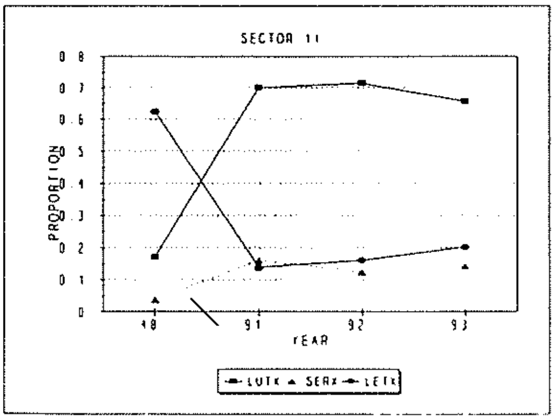


Fig. 18.

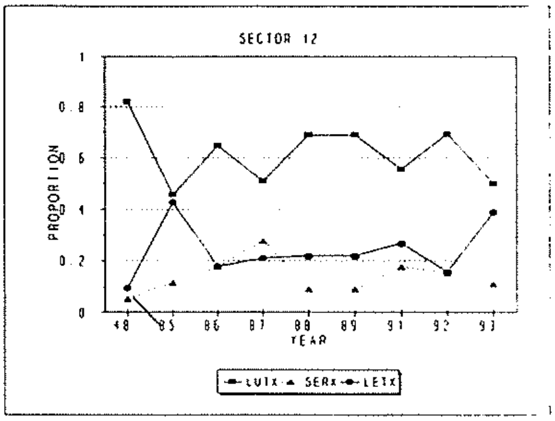


Fig. 19.

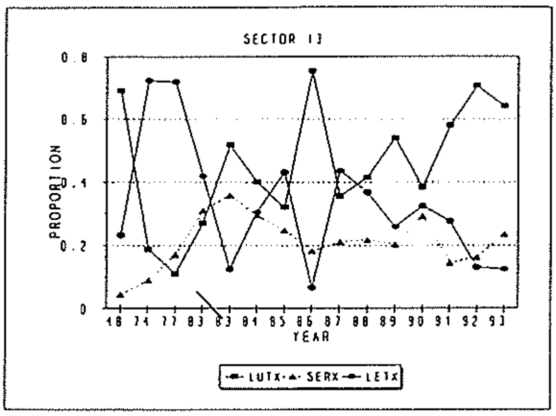


Fig. 20.

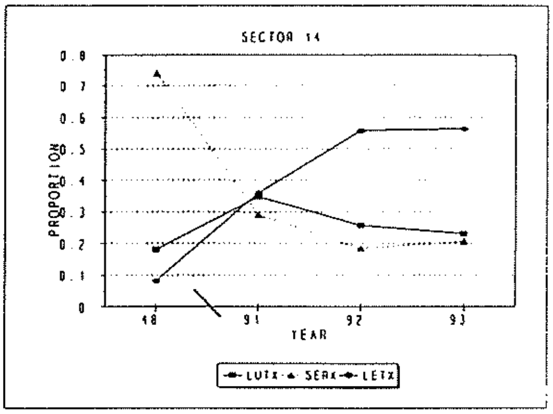
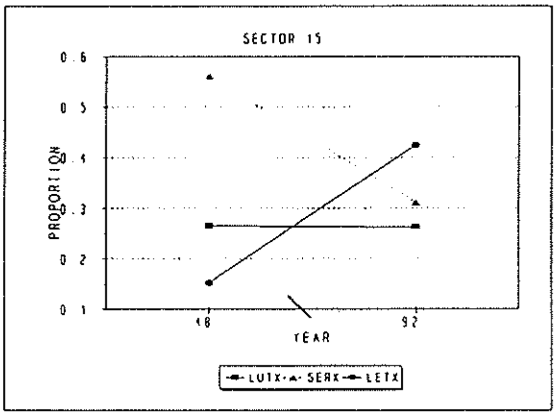


Fig. 21.



Apart from the historical data, the gross species composition at each location has remained almost stable with time although a decline in the proportion of serranids is apparent (eg Sectors 3-6). No firm conclusions may be drawn in relation to the historical data since depth fished and other factors may have been different. The locations where obvious changes have occurred are :

Sector 1 in recent years the proportion of lutjanids has decreased and lethrinids increased for which there is no obvious explanation. However, the proportions have fluctuated over time and are not presently very different from 1985.

Sector 3 : Lutjanids have increased and serranids decreased. Fishing by schooners at this location has decreased with time and that by whalers increased.

Sector 7 : Since 1990 there has been a dramatic decrease in lutjanids and increase in lethrinids and to a lesser extent, serranids. Catches by schooners have decreased (only 2 trips to this location were sampled in 1993) and those of whalers increased.

Sector 13 : Lethrinids have decreased and lutjanids increased - considerable fluctuation. Here precise location and depth fished may be important. In the latter years the mothership venture fished deeper water at the Amirantes

Whilst fishing pressure over time may have been responsible for such changes, it is necessary to consider a single representative boat category over the time period to eliminate variability arising from observations from a number of boat categories. (see 5.1.2)

5.1.2. Catch rate analyses.

Assuming constant catchability, catch rate is an index of the abundance of the resource. Thus a declining catch rate over time suggests that a resource is under pressure and the biomass is decreasing. Catch rates by boat category by location per annum have been computed (Annex 1 Table A1.22). However, within each boat category are a number of vessel types each with different relative fishing power (eg, Mees, 1990b). In this case, gross catch rate cannot be considered an index of abundance. It is necessary either to standardise effort for all boat types, or to consider only a representative boat type which has fished in the same way consistently throughout the history of the fishery. Factors other than boat type may also affect catch rates such as seasonality, depth range, and climate and these also need to be considered, and if possible standardised over the data period. Nevertheless, this 'gross catch rate' data is illustrated (Figs 22-36) to highlight, in conjunction with species composition changes observed above, which locations and boat categories could usefully be further investigated.

Fig. 22.

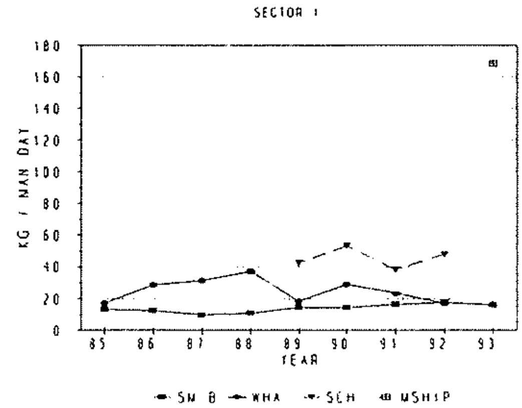


Fig. 23.

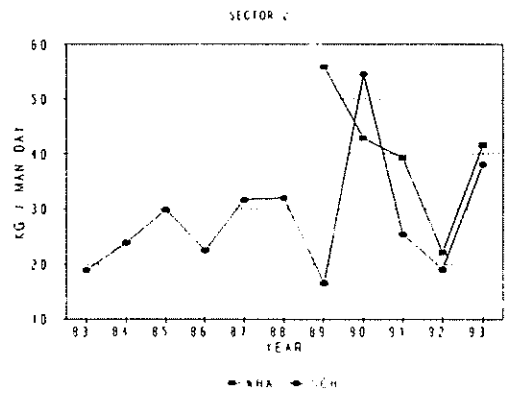


Fig. 24.

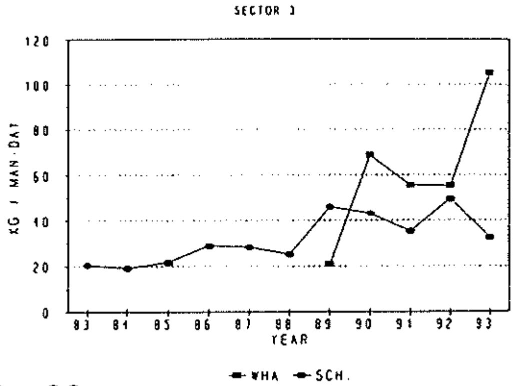


Fig. 26.

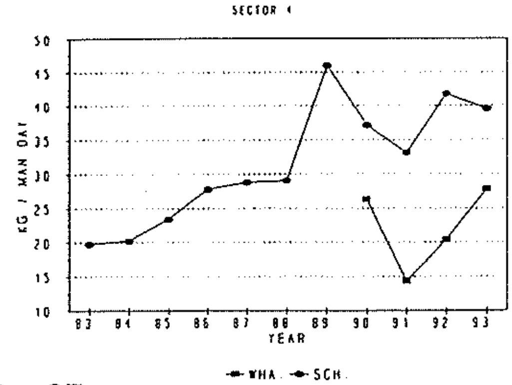


Fig. 26.

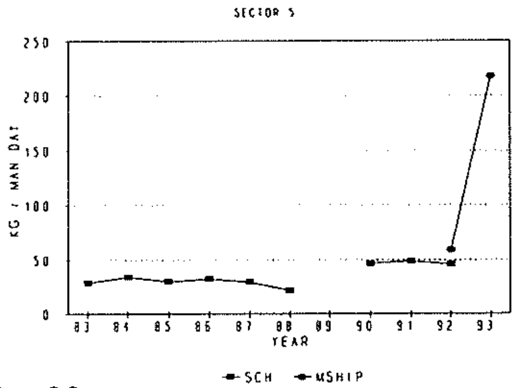


Fig. 27.

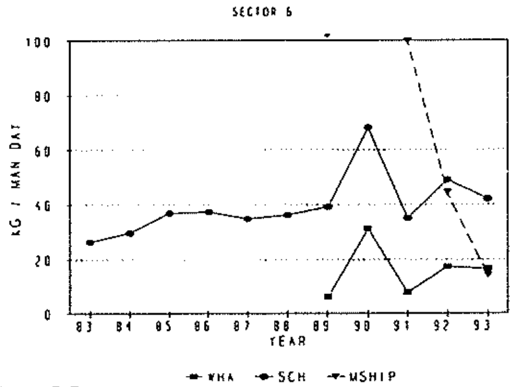


Fig. 28.

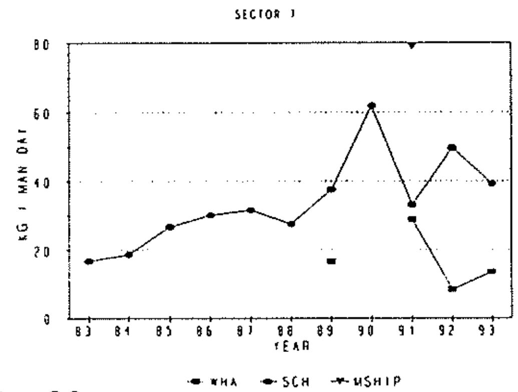


Fig. 29.

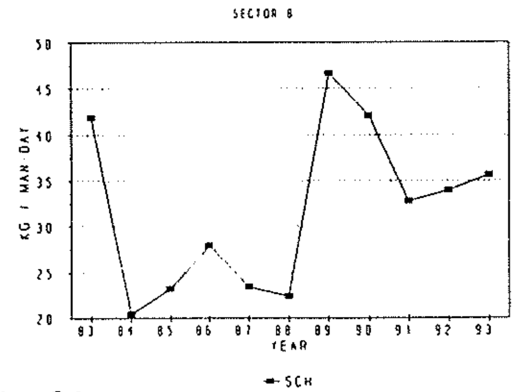


Fig. 30.

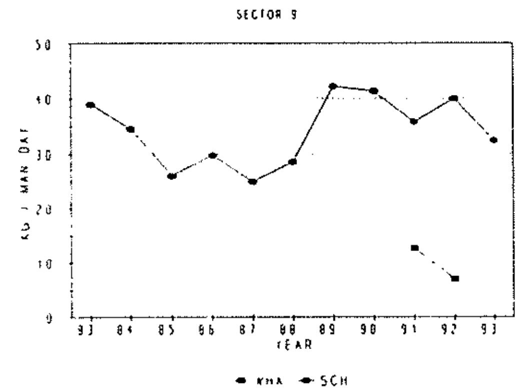


Fig. 31.

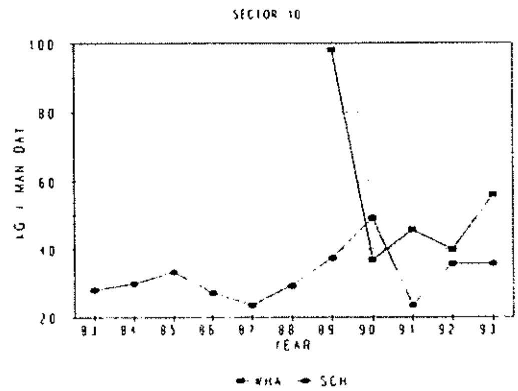


Fig. 32.

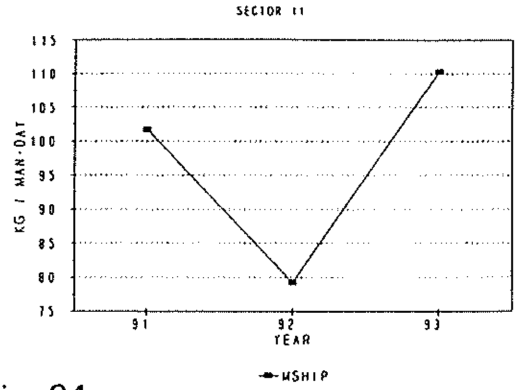


Fig. 33.

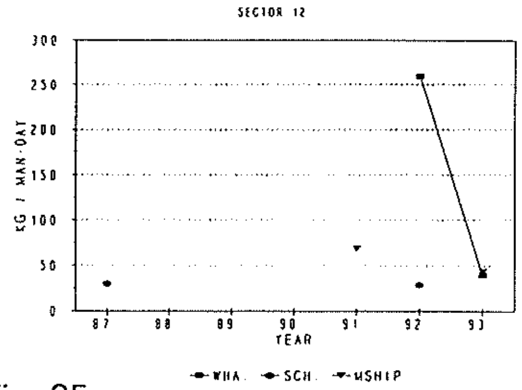


Fig. 34.

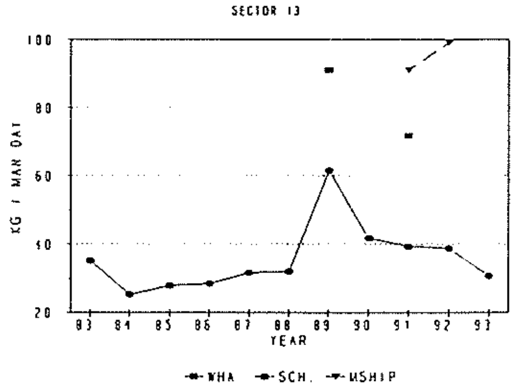


Fig. 35.

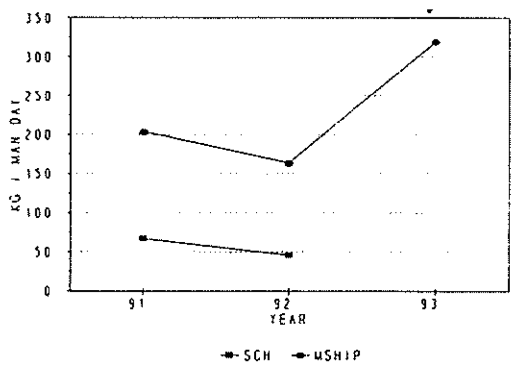
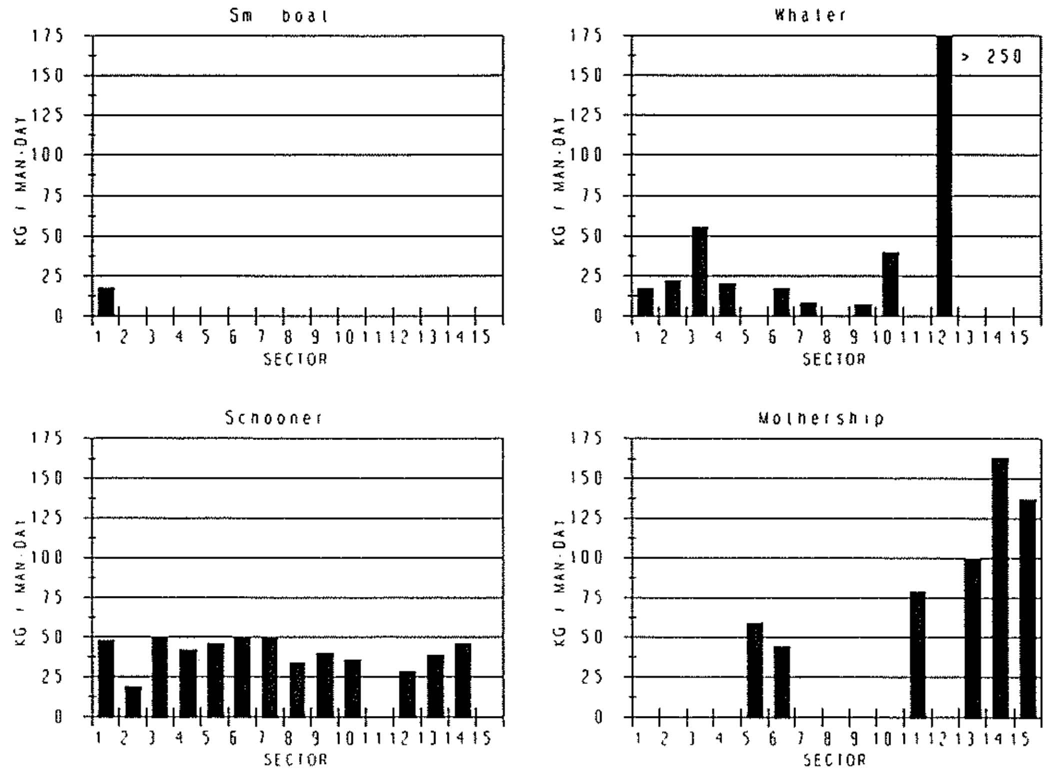


Fig. 36. Catch rates by boat category and location during 1992.



The fishing power of the different boat categories differed considerably and catch rates followed the order mothership > > schooner > whaler[2] > small boats, both within single locations and overall (Figs. 22 & 36). This related to a combination of factors including gear and fishing method, and time spent fishing (to compare boat categories a standard unit of effort was chosen : man-days). Between locations whalers achieved variable catch rates but apart from sector 1 the sample size was small. Schooners achieved similar catch rates at each location, whilst from the mothership venture it would appear that the greatest catch rates were achieved at the locations most distant from the Mahe plateau (Sectors 13-15, Fig. 36[3]).

Over time, catch rates fluctuated. Fishing effort was light and intermittent at most locations (see 5.1.1) with the exception of the 'inshore' sector 1. Locations and boat categories exhibiting catch rate trends that require further investigation are:

- Whalers, sector 1: catch rates declined since 1988 (Fig. 22) and species composition altered considerably since 1990 (Fig. 13). This may reflect changes in abundance induced by fishing pressure. Prior to 1990 the data collection procedure for whalers was different and demersal catches were believed to be under-estimated, so caution is required in consideration of the whole data set.

- Schooners, various locations. At sector 2 catch rates declined from 1989/90 but rose again in 1993 (n that year was only 2). However, over the period 1983-93 the elevated catch rates of 1989/90 appear abnormal and rather than indicating a long term decline in abundance, these data may indicate a strong recruitment during those years or technological[4] changes in the fishery. Such elevated catch rates are apparent at other locations for the same time period (eg. 4, 6, 7, 8, 9, 13).

- Mothership-dory venture, various locations. Annual decreases in catch rate were observed (eg. Sector 6, 12).

As previously stated, these gross catch rate data are inadequate to test whether depletion has occurred at different locations and it is necessary to consider standardised and / or stratified data sets. Furthermore, within fishing sectors fishing could have occurred at a number of locations, some of which may contain

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[2] The high catch rate achieved by whalers at Platte (sector 12) seems unlikely and is more likely to represent a data entry error.

[3] See Also Annex 4, Table 2. This shows, for example, that relative to the catch rates observed at the SE edge of the Mahe Plateau, those at Providence/Farquahar were 2.2 times greater.

[4] New vessel designs for schooners and the introduction of electric fishing reels. During 1989/90 deep water species were targeted elevating catch rates.

discrete populations. Catch rates for the mothership venture at discrete locations have been reported by Mees (1991b; 1992c; in press), but for the other boat categories such fine detail is not available. By boat category, the mothership venture is thus the most appropriate for further study, but covers a timescale of only 3 years. Data for schooners covers the longest period and data has been collected in a consistent manner, but the boats themselves have changed. By location, Sector 1 is the obvious choice for further study, but unfortunately the most important boat category at this location is whalers for which the quality of data is low and for which a change in technique was introduced in 1990. Detailed analyses by boat category and location follow.

- Stratified and standardised data for cpue analysis

For each of the boat categories small boats, whalers and schooners, there are a number of different boat designs, each with different relative fishing power. Different fishing gear are employed by different vessels (lines, droplines, gill nets) which will affect catch rates. A strong seasonal effect was shown for the schooner fishery (Mees, 1990b) and catch rates by species varied between the low (SE Trade Wind) season and high season. For whalers at sector 1 seasonality is less pronounced but evident (see Annex 2). Within fishing sectors, specific fishing location may affect catch rates and species composition. Fishing depth is another factor affecting catch rate and species composition.

In order to standardise annual catch rate data generalised linear interactive modelling (GLIM) was applied (Francis *et al*, 1993). This enabled both standardisation of annual data and estimation of the significance of factors contributing to variation in the catch rate. The process involves fitting a model to the data of the form:

eg. $1 + \text{year} + \text{season} + \text{location} + y.s + y.l + s.l + y.s.l$

Two (y.s; y.l; s.l) and three factor (y.s.l) interactions are tested and if not significant may be removed simplifying the model to single factors. Each factor is tested and only retained if significant. The GLIM output will be standardised annual catch rate. That is, variation attributable to season and location will have been taken account of in the model and annual standardised catch rates are then directly comparable.

For the purposes of standardisation, where month was not applicable, season was taken as : 1 (North-west monsoon), December, January and February; 2 (April inter-monsoon period), March-May; 3 (SE Trade Winds), June-August; 4 (October inter-monsoon period), September - November. Such a division was selected based on aggregated monthly catch rate data from several locations for different boat types (not shown) and was considered to provide better detail than the high / low season approach previously adopted (Mees, 1990b).

- The traditional whaler fishery, Sector 1. (Annex 2)

Traditional whalers catching at least 85% demersal species by weight from sector 1 of the Mahe Plateau were examined (Annex 2). Season (Fig. 37) and fishing area (Fig. 38) significantly affected species catch rates (Annex 2 Table A.2.4). The greatest catch rates occurred during the inter-monsoon period March-May when conditions are calm. This also coincides with the spawning period of many of the reef fish in Seychelles. The lowest catch rates occurred during the period of SE Trade winds. The species composition was similar during each season. By location, of the five areas selected : Mahe, Praslin, Mammelles, Silhouette and North Island, and Fregate and Recif (Table A.2.1), species composition was similar except for Mammelles which consisted of predominantly lethrinids and Job Gris. The total catch rate at Mammelles was also lower than elsewhere (Fig 38) and the difference in species composition may reflect the effects of fishing pressure. Catch rates by area were greater around Silhouette and Fregate which are lightly populated than around Mahe or Praslin.

Fig. 37. Observed species catch rates by season 1989-1993

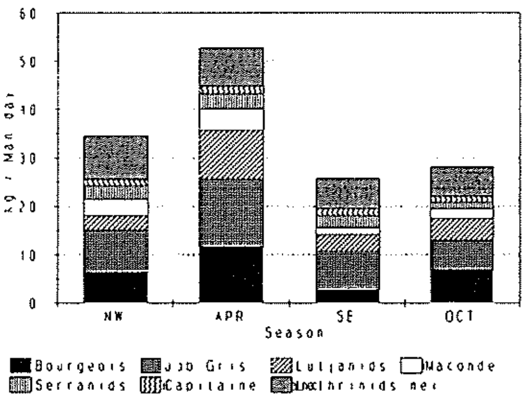
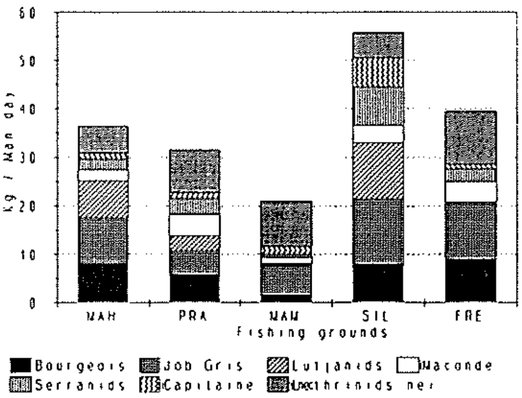


Fig. 38 : Observed species catch rates by fishing area, 1989-1993



Although spatial differences occurred, there was no biological reason to assume that the areas selected, which in some cases covered a large number of widely separated 'fishing grounds', contained discrete fish populations any more than sector 1 would. Of these areas, Mammelles was a single 'fishing ground', but catch rates remained stable over the period 1989-1993 (Fig A.2.2). Rather than stratify the data by location it was decided to examine the wider population contained in sector 1 by standardising annual catch rates for the observed seasonal and spatial differences (Annex 2).

GLIM was applied to catch rate data for Bourgeois, Job Gris, Maconde, and Capitaine Blanc, and aggregated data for other lutjanids, lethrinids, serranids and all demersal species (Fig 39). It was found that a model of the type (year*season*fishing area) resulted in a significant two factor interaction for year.fishing area. This indicated that the pattern of catch rates observed by fishing area was not consistent from year to year. As a result it is not strictly valid to reduce the model to single factors enabling standardisation of annual catch rates.

Excluding fishing area, standardised catch rates were derived allowing for monthly (Fig. 40) and seasonal variation (Fig. 41). However, since fishing area was significant this should be included in the model. The only way to do this is to overlook the year.area interaction and thereby derive standardised values (Fig. 42). Thus, whichever choice of standardised catch rate is made, it involves some compromise, which should be understood when the data is later employed in modelling of the fishery. It should also be noted that no single GLIM model could be applied successfully to all species. Whilst the standardised catch rate represents an index of abundance for the species or species groups examined, and data may be compared from year to year or between species when derived from the same model, values from different models may not be compared.

Fig. 39 : Observed species catch rates traditional whalers, sector 1

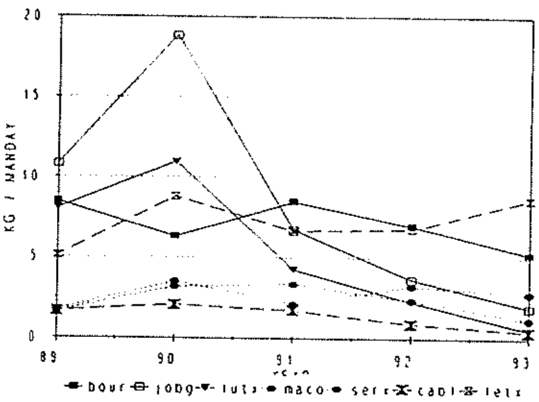


Fig. 40 : Species catch rates standardised for month, traditional whalers, sector 1

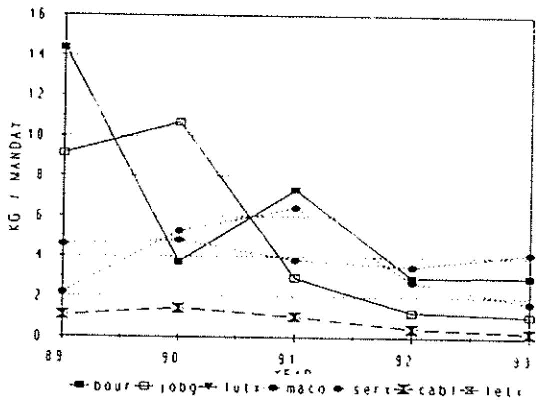


Fig. 41 : Species catch rates standardised for season, traditional whalers, sector 1

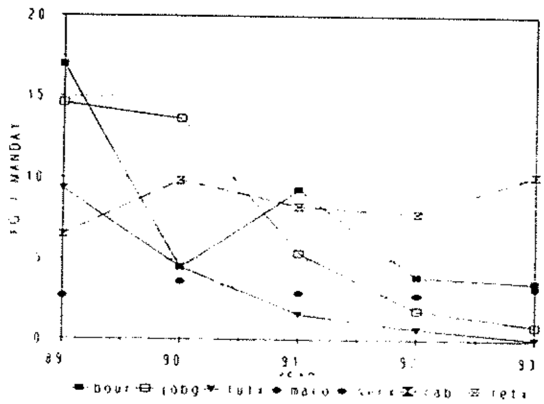
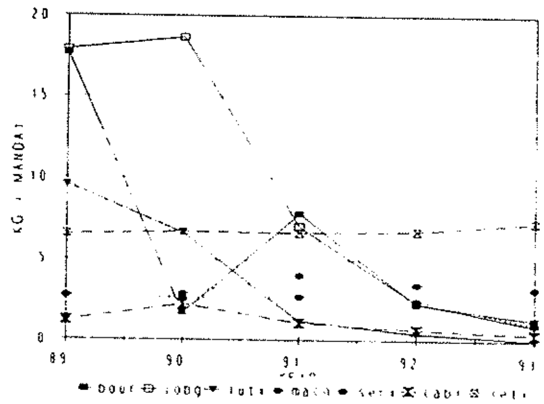


Fig. 42 : Species catch rates standardised for season and fishing area, traditional whalers, sector 1



The analyses suggest that in sector 1 the biomass of demersal species in 1993 was approximately one fifth that in 1989. Whilst 1990 *may* have represented a year of strong recruitment and high biomass across most of Seychelles (Figs. 22-35), there is no reason to believe that the catch rate by traditional whalers in sector 1 was unreasonably high that year compared to historical data (Fig A.2.8). The decrease in biomass is explained chiefly by significant decreases in lutjanids including bourgeois and Job Gris. The biomass of maconde did not change significantly with time whilst other serranids showed an increase followed by decrease in biomass. Lethrinids did not change significantly (when fishing area was considered), but the trend for the major lethrinid species, Capitaine Blanc, was to decline. The lutjanids, and particularly Bourgeois are commercially important and there is no reason to believe that target switching caused such dramatic changes in catch rate. It is thus concluded that the result of extremely high fishing pressure in sector 1 has been to deplete the stock of demersal species, in particular, members of the lutjanidae[5].

- The Schooner fishery (Annex 3)

Apart from sector 1 fishing pressure was light at most other locations and catch rates fluctuated but did not obviously indicate a decline (Figs 23-35). These locations were fished predominantly by schooners and more recently the mother-ship dory venture. For the schooner fishery, changes in vessel and gear technology resulted in increasing fishing power over time, thus potentially masking any decline in catch rate and probably causing the gross species composition changes reported in 5.1.1.

In order to examine for evidence of depletion and biomass change at the more distant fishing sectors, data stratified for the basic fleet of schooners using handlines only were employed. In fact, four categories of schooner were identified, but few data existed for three of the categories, particularly over the 10 year period for which data was available (Annex 3; Table A.3.1). The data indicated no evidence of depletion at the level of the fishing sector. Standardisation of the stratified boat category was not considered worthwhile (see Annex 3) and the conclusion drawn was that at the sectoral level effort was low and had little impact on demersal resources. The lack of definition in the fishing location data recorded meant that localised depletion which may have occurred was not observed (known to occur for the mothership venture). One danger of this is that within sectors catch rates may be maintained by sequentially fishing discrete areas. To avoid this improved data collection is recommended.

[5] It should be noted that sector 1 has been subject to fishing pressure for around 2 Centuries, thus the species composition in 1989 would already have been the result of prior fishing activity. The increasing number of whalers, however, has in recent years significantly increased fishing pressure in the near-shore locations, see 3.2.

- The Mothership-dory fishery (Annex 4)

This fishery operated for discrete periods each year and at number of different locations. Aggregated annual data (Figs 22-35) masks much of the detail contained in the information collected. Analyses examining daily catch rates by location and species within individual voyages were presented by Mees (1991b; 1992c). Mees (in press, reproduced in Annex 4) produced a comparison of standardised catch rates from locations visited more than once over the three year period during which the vessel operated.

Within voyages, daily catch rates were generally observed to decrease at any one location. Between voyages at the same locations, catch rates frequently remained depressed and continued to fall (Figs A.4.2-3). This was particularly true for smaller banks, but less so for larger locations such as Fortune Bank (Fig A.4.4). Frequently, apparent depletion could be attributed to changes in target species or depth (Fig A.4.10-19), and of 31 locations examined only two were suitable for comparing depletion between voyages.

- The application of catch rate data to production models

Stock assessments were derived from daily catch rate data for the mother-ship dory venture at various locations (Mees, 1992c[a]; 1993[b]; Annex 4[c]) by means of a simple Leslie depletion model (Table 10). The rate of recovery of depleted resources was assessed from locations visited on more than one occasion (see Annex 4).

Table 10. A summary of stock assessments derived from the mother-ship dory fishing ventures in Seychelles waters for *Pristipomoides filamentosus, Lethrinus nebulosus* and an aggregation of all demersal species in the shallow strata (0-75m).

SPECIES	LOCATION	SECTOR	KG KM^{-1}	KG KM^{-2}	BIOMASS (Kg)	SOURCE
P. filamentosus	Small Constant	11	382.5	1,531.0	21,266	b
	Correira Bank	11	855.4	3,419.3	28,483	b
	Correira Bank	11	717.8	2,869.3	23,903	c
	Correira Bank	11	743.7	2,972.9	24,766	c
	Sea mount 20	11	1,004.3	4,010.1	11,148	b
	Poivre	13	1,505.0	6,019.8	30,099	a
	Marie Louise	13	1,414.4	5,657.4	28,287	a
	African Banks	13	505.5	2,021.8	10,109	a
L. nebulosus	Cerf	14		121.3	24,268	a
	Farquhar	14		256.1	76,819	a
	Providence	14		842.7	252,806	a
All demersal spp	Farquhar (part)	14	-	1,756-7,128	121,177	c
(Shallow stratum)	Farquhar (part)	14	-	1,198-4,863	82,684	c

The resource of *L. nebulosus* in Sector 14 was considered to be under-estimated. Whilst the abundance of *P.filamentosus* in the Amirantes (sector 13) appeared greater than that at the banks south of the Mahe Plateau (sector 11), it should be understood that fishing area was inferred from the radius of activities of the dories at the Amirantes, whilst the total bank / mount area was used for sector 11. Greater detail relating to fishing radius and actual area exploited by the dories would be useful in refining these estimates. At Farquahar, the difference in biomass shown relates to depletion following voyage 2 and a lack of recovery by voyage 4.

Schooner data indicated no evidence of depletion and was not suitable for stock assessment.

Biomass dynamic production models (see Annex 5) were applied to annually aggregated catch data for all vessels fishing in sector 1 together with annual indices of abundance derived from the traditional whaler fleet (see Annex 2). These analyses indicated that current stock size is less than catch and questioned the input data : catch or catch rate. Prior to further analysis closer investigation of the data is required. Nevertheless, the dramatic decrease in cpue suggests that the demersal stocks in sector 1 are heavily exploited ..... (to be completed)

Table 11. Summary of biomass and yield estimates derived for sector 1 for individual species and a guild of all demersal species.

Fig 43. Biomass of demersal species 1989-1994 (fig agraph.cgm)

- The suitability of analysed catch and effort data for modelling with MIDAS

The schooner fishery data showed no depletion or multi-species effects not attributable to changes in gear technology and depth change, and is unsuitable for modelling. Multi-species effects were observed for the mother-ship venture (eg. overall catch rates remained constant whilst those of target species fell). However, the data relates to short term daily changes. Such short term depletion and changes are not directly comparable with potential long term effects of fishing, although subsequent voyages to the same location confirmed that recovery of the stocks had not always occurred. This data is too short term for sensible application to MIDAS. Whaler data for sector 1 was multi-species and displayed highly significant changes in species catch rates. This data set is suitable for multi-species modelling although the assumption that sector 1 encompasses a discrete population of each species should be remembered.

- Discussion of catch rate data

Catch rate information indicated that at the scale of the fishing sector, no depletion was apparent for any of the offshore locations. The inshore Mahe Plateau sector 1, however, indicated strong evidence of depletion and this sector is overfished. On a finer scale offshore, mothership dory information indicated that at large banks where mixing of the population may occur, no short term depletion was apparent. However, at smaller discrete locations local depletion occurred over both the short term and longer term. For pulse fishing events resources may recover between fishing trips and this is described in Annex 4. Tarbit (unpublished) described catch rates between 60-176 $kg.man^{-1}day^{-1}$ from a mothership dory fishing venture to the Providence Farquahar group in 1976, and concluded that overfishing had occurred. Present catch rates in 1992 were 117-181 $kg.man^{-1}day^{-1}$ indicating that recovery had occurred.

5.2. Length Frequency and Biometric Study Data

Length frequency and biometric study data were collected for *P. filamentosus, A. virescens,* and *L. nebulosus*, whilst only length frequency data were collected for *L. sebae* and *E. chlorostigma*. Most data was collected from schooners and none related to fishing sector 1 (see Annex 6). As a consequence demographic variables derived from these data will relate to lightly exploited stocks and could differ for the heavily exploited population in sector 1. This is significant in respect to application of MIDAS to the inshore fishery. Ideally steps should be taken to obtain biological data from sector 1 and from whalers. Furthermore, data collection procedures should be modified to relate biological details to specific vessel trips.

Annex 6 indicated that dissagregation of data was inappropriate in many cases due to the small sample size. Certain analyses (eg. estimation of growth) require dissagregated data, whilst others (eg. estimation of reproductive status) do not. In the following sections the data set employed is clearly defined. Where dissagregated data was required, in order to maintain as large a sample size as possible and to reasonably relate to sector 1, data from all other locations on the Mahe Plateau was pooled (Sectors 2 -10).

5.2.1. Population Structure

Annex 6 details all data collected during length frequency and biometric studies, summarised in Table 12. Sex ratio was that observed during biometric studies except for *L. sebae* for which this data was not available. Annex 6 and Table 13 indicate that length frequency and biometric data give different sex ratio values, and that for biometric data, based on whole fish, is considered more accurate. Whilst differences in these parameters may occur with respect to location, there was not a gradient of fishing pressure against which to compare any results and furthermore sample size was frequently small for any one location and gear. Sex ratio was thus investigated only for gear type aggregated over all locations.

Table 12 : A summary of Length parameters and sex ratio observed for study species.

	Fork length Lmin	Lmax	Lmean	Sex ratio M:F
P. filamentosus	21.5	87.8	48.73	1.02
A. virescens	21.0	96.3	61.90	1.24
L. nebulosus	18.5	79.0	48.30	0.62
L. sebae	14.1	98.3	57.03	1.07
E. chlorostigma	19.9	80.7	37.50	

Table 13 : Sex ratio observed for different gear types from length frequency and biometric study data.

Length frequency data

P. filamentosus

GEAR	N	M:F
Unknown	4835	1.32
Dropline	485	1.43
Gillnet	3994	1.24
Handline	8195	1.29
Reels	380	2.14
TOTAL	17889	1.30

A. virescens

GEAR	N	M:F
Unknown	5520	1.68
Dropline	19	1.11
Gillnet	77	2.08
Handline	3344	1.96
Reels	101	1.81
TOTAL	9061	1.78

L. nebulosus.

GEAR	N	M:F
Unknown	137	1.32
Gillnet	177	2.54
Handline	91	1.84
TOTAL	405	1.87

L. sebae

GEAR	N	M:F
Unknown	2583	1.09
Gillnet	48	2.20
Handline	12840	1.06
Reels	86	0.83
Traps	23	1.30
TOTAL	15580	1.07

Biometric study data

P. filamentosus

GEAR	N	M:F
Unknown	1654	1.03
Gill net	78	0.73
Handline	11	1.75
TOTAL	1743	1.02

A. virescens

GEAR	N	M:F
Unknown	797	1.25
Handline	115	1.21
TOTAL	912	1.24

L. nebulosus.

GEAR	N	M:F
Handline	50	0.62

5.2.2. Reproductive Biology (Annex 7)

Biometric study data was employed in order to determine the reproductive status of *P. filamentosus, A. virescens* and *L. nebulosus*. Information relating to maturity stage and sex was recorded from incompletely gutted fish during length frequency studies, but these results are not fully reported due to the possibility of mis-identification of maturity stage and under-estimation of the number of mature fish. For *L. sebae* only length frequency data was available and analyses based on these data are shown. Detailed analyses are indicated in Annex 7, summarised in Table 14.

Table 14 : Summary of reproductive parameters derived for key study species from Seychelles demersal fishery.

DETAILS		SPECIES		
	P. filamentosus	A. virescens	L.nebulosus	L. sebae
Min length at maturity, males GSI	31.0	34.0	38?	
Min length at maturity, females GSI	29.0	32.0	40?	
Min length at maturity, females =3+	36.6	38.0	39.8 / 69.3?	33.5
Lm25, females (biometric data)	45.0	38 or 63		60.0
Lm50, females (biometric data)	51.0	42 or 69	58?	64.0
Lm75, females (biometric data)	59.0	74.0		70.0
Spawning season, males	Feb-May & Nov	Oct -Feb & Apr - May		
Spawning season, females	All year, peak Feb-May & Oct -Dec	All year, peak Oct - Feb & Apr - May	Mar & Oct-Nov	All year

The minimum length at sexual maturity was smaller for length frequency study data than that for biometric data but is only indicated for *L. nebulosus* where the small sample size gave an unreasonably high result. The fact that maturity occurs at small sizes for a small number of individuals in the population is apparent from interpretation of the data relating to Gonadosomatic index. The lengths shown in Table 14 relate to those at which a large proportional increase in GSI was observed, indicating gonad development at that size.

The proportion of fish in the population which are mature increases with length (and age), and from examination of Figs A.7.1, A.7.6, A.7.12 and A.7.14 maturity ogive information was derived. Sufficient biometric data was only available to achieve this for *P. filamentosus* with confidence. For *A. virescens* it appeared that half of all fish were mature at quite small lengths, but the sample size at length was small (See Table A.7.6). A range of values are reported. For *L. nebulosus* and *L. sebae* only length frequency data was available, but Lm_{50} values reported in Table 14 may be over-estimates. Estimation of this parameter from length frequency data for *P. filamentosus* (Fig A.7.3, $Lm_{50}=63$ cm) and *A. virescens* (Fig A.7.8, $Lm_{50}=69$ cm) led to higher estimates than from biometric study data.

Spawning for all species occurred throughout the entire year, but peak periods coincided with the inter-monsoon periods of March-May and October-November.

(Literature values, and Moussac for maconde)

5.2.3. Gear Selectivity (Annex 8)

Different fishing gear may exploit different size classes of the same population of fish. This is of significant importance for management - one strategy would be to exploit fish above the size at sexual maturity; an alternative gaining favour is to exploit small fish leaving larger more fecund fish to continue spawning. In the modelling phase of this project the effect of gear selectivity and of different management strategies upon the optimisation of benefits from the resource will be investigated. For the present analyses, gear selectivity is not affected by year or location and data were pooled by gear type only for each species. Individual years were analysed separately where it appeared that different size classes had been exploited. For example, in 1992 smaller fish (*P. filamentosus*) were caught in gill nets than during 1991 and 1993 (Fig A.8.5). Annex 6 indicated the number of fish measured by gear type, species and location each year. Gear selectivity parameters (see Annex 8, Table 15) are based upon the data available, and in those cases with small sample size they may change as more data become available.

Table 15 : To indicate gear selectivity parameters (Lc, the first fully exploited length class, and ogive parameters Lc_{25}-Lc_{75}) and the minimum and maximum length classes caught by gear type for each species.

SPECIES	GEAR	YEAR	K	Linf	Lmin	Lmax	Lc	Lc25	Lc50	Lc75	Comments
P. filamentosus	Unknown	89, 91-93	0.288	81.7	20	86	41	31.6	36.2	39.9	
P. filamentosus	Handline	90-93	0.288	81.7	22	80	41	32.7	37.1	39.8	
P. filamentosus	Reels	92-93	0.288	81.7	24	76	43	34.9	38.6	40.6	
P. filamentosus	Dropline	91-92	0.288	81.7	24	74	45	39.2	42.4	44.5	
P. filamentosus	Gillnets	1991	0.288	81.7	20	86	49	40.4	47.0	49.7	
		1992	0.288	81.7			33	28.1	30.0	31.8	
		1993	0.288	81.7			39	37.4	38.9	40.4	Too few data
A. virescens	Unknown	91-93	0.260	104.0	20	96	67	62.1	65.2	67.3	Flat, cut off 41-67?
A. virescens	(Unknown	91-93	0.260	104.0			41	35.0	39.5	41.8	alternative cut off)
A. virescens	Handline	91-93	0.260	104.0	24	94	69	63.9	67.0	69.2	
A. virescens	Reels	91-92	0.260	104.0	40	88	69	66.3	68.0	69.9	
A. virescens	Droplines	91-92	0.260	104.0	50	78					Too few data
A. virescens	Gillnets	91-93	0.260	104.0	34	88	65	55.7	61.8	64.1	
A. virescens		91	0.260	104.0			63	51.5	60.1	62.2	Few data
A. virescens		92	0.260	104.0							Too few data
A. virescens		93	0.260	104.0			65	55.4	61.1	63.5	
L.sebae	Unknown	91-93	0.230	96.0	18	88	59	54.5	56.9	58.9	
L.sebae	Handlines	89-93	0.230	96.0	14	98	61	56.5	59.3	61.4	
L.sebae	Reels	93	0.230	96.0	32	82	61	50.7	53.7	58.7	
L.sebae	Gillnets	93	0.230	96.0	34	86	49	43.2	45.8	47.5	Flat, cut off 59?
L.sebae		(93	0.230	96.0			59	42.6	45.3	47.3	alternative cut off)
L.sebae	Traps	92	0.230	96.0	24	50	35	24.0	32.5	34.8	Few data
E. chlorostigma	Unknown	90-93	0.175	64.5	20	74	35	27.7	29.5	31.3	
E. chlorostigma	Handlines	91-93	0.175	64.5	18	80	35	27.8	29.7	31.5	
E. chlorostigma	Reels	91-93	0.175	64.5	24	62	35	28.2	29.7	31.4	
E. chlorostigma	Droplines	92-93	0.175	64.5	30	58	39	31.4	33.6	36.2	
E. chlorostigma	Gillnets	91-93	0.175	64.5	24	64	35	28.9	31.0	32.9	
E. chlorostigma	Traps	92-93	0.175	64.5	26	52	35	28.4	30.8	32.8	
L. nebulosus	Unknown	92	0.230	80.0	18	70	41	36.6	38.7	40.7	
L. nebulosus	Handlines	92	0.230	80.0	30	78	53	43.1	47.3	50.7	
L. nebulosus	Gillnets	92	0.230	80.0	24	62	37	30.5	34.6	37.4	

Lc_{50} for all gears is less than Lm_{50} for *P. filamentosus* suggesting that recruitment overfishing of this species is a potential danger. Particularly for small mesh gill nets (assumed from 1992 data), fish are caught before the onset of maturity. For *A. virescens* Lc_{50} and Lm_{50} are similar, and the different gears catch similar sizes of fish. Gear selectivities to *L. nebulosus* indicated that lines caught larger fish (Lc_{50} ~ 53-59cm), gillnets caught intermediate size fish (Lc_{50} ~ 45 cm) and traps caught small fish equivalent to the size at first sexual maturity (~ 33cm). Lm_{50} has not been accurately determined for this species but may be around 49 cm (0.5*Lmax, Grimes, 1987). Few data existed for *L. nebulosus*, but the evidence was that gillnets caught smaller fish than handlines and Lc50 was similar to Lm (39 cm, 0.5 Lmax). Large specimens of E. chlorostigma were not frequently captured except in gill nets, and Lc_{50} was similar for all gears.

The selectivities reported here agree with those from research cruises reported by Arthur (1993). In general, traps and gillnets exploited smaller fish than line fishing methods, and further research into mesh size and net selectivity is to be recommended given the recent developments in net fishing techniques. *P. filamentosus* appears to be the species under greatest threat since all gear types exploit this species below maturity.

5.2.4. Growth and Mortality

To be completed

5.2.5. Length - Weight Relationships

To be completed

BIBLIOGRAPHY OF SEYCHELLES LITERATURE RELEVANT TO THE DEMERSAL FISHERY

Anon, (1989) National Development Plan, 1990-1994. Chapter 11, Fisheries. pp 23-46

Bach, P. (in press) Croissance et Mortalite du Bourgeois, Lutjanus sebae (Cuvier,1828) Exploite par les Lignes a main aux Seychelles, version provisoire du 07/09/90, ORSTOM, Montpellier, France.

Bautil, B.P.R. (1988) Handline Fishing From Schooners in the Seychelles - an Analysis of the Increases in Catch Rates and Values from Outfitting the Schooner 'Chantal' with an Echo Sounder and Electrically Powered Fishing Reels, FAO/UNDP/RAF/87/008/WP/42/88/E : 22pp.

Birkett, L. (1979) Western Indian Ocean Fishery Resources Survey. Report on the Cruises of R/V "Proffesor Mesyatsev", December 1975 - June 1976 and July 1977 - December 1977. Rome, FAO/UNDP, Indian Ocean Programme, IOP/Tech. Rep. 26, 96p.

Chauvelon, P. (1990) Lecture Assistee par Ordinateur en Otolithometrie Application a l'Etude de L'Age de Lutjanus Sebae (Cuvier, 1828) aux Seychelles. Diplome d'Etude Approfondie, Oceanologie - Gestation des Resources Vivants, Academie Aix - Marseille, ORSTOM Montpellier, France, 42pp.

Harris, A. (1977) A Mothership Line Fishing Venture in Seychelles Waters (October 1977), Fisheries Bulletin No. 5, Fisheries Department, Seychelles: 18p

Intes, A. and P. Bach (1989) Campagne de Prospection des Crustaces at Poissons Profonds Sur Les Accores du Plateau Seychellois a Bord du N. O. Alis, Convention FRANCE/SEYCHELLES no. 87/206/01, 119p

Johnsen, T. (1985) Simulations of the Profit Potential for Different Boat Types Introduced as a Supplement to or Replacement for the Schooner Fleet of Seychelles, FAO SWIOP Document RAF/79/065/WP/25/85

Kunzell, T., U. Lowenberg and W. Weber (1983) Demersal Fish Resources of the

Mahe Plateau/Seychelles. Arch. FischWiss. 34(1):1-22.

Lablache, G. and G. Carrara (1984) Schooner Handlining in Seychelles, Victoria, Mahe, FAO Regional Project for the Development and Management of Fisheries in the South West Indian Ocean, RAF/79/065/14/84. SWIO Doc. (14)41p

Lablache, G. and G. de Moussac (1987) A review of the Artisanal Fisheries of the Seychelles, SFA, 29pp.

Lablache, G. and G. Carrara (1988) Population Dynamics of Emperor Red Snapper (Lutjanus sebae) With Notes on the Demersal Fishery of the Mahe Plateau, in : Venema, S.C., J. M. Christiansen and D. Pauly (eds., 1988) Contributions To Tropical Fisheries Biology. Papers Prepared by the Participants at the FAO / DANIDA Follow-up Training Courses on Fish Stock Assessment in the Tropics. Hirtshals, Denmark, 5 - 30 May 1986 and Manila, Philippines, 12 January - 6 February 1987 FAO Fish. Rep., (389): 519p, pp 171-192.

Lablache, G., Moussac, G. de and N. Jivan Shah (1988) A summary description of the Artisanal Fisheries and Resources for the Seychelles, in proceedings of the workshop on the Assessment of the Fishery Resources in the South West Indian Ocean, FAO/UNDP : RAF/79/065/WP/41/88/E : pp 116-141

Marchal, E., F. Varlet, B. Stequert and F. Conand (1981) Resources Pelagiques et Demersales des Iles Seychelles. Resultats de la Deuxieme Campagne du N/O Coriolis (Aout - Septembre 1980) ORSTOM Paris, Convention FAC 8032.30400 pag. var.

Mees, C.C. (1989a) The Artisanal Fishery of the Seychelles, SFA, 12pp.

Mees, C.C. (1989b) Seychelles Artisanal Fisheries Statistics - Annual Report for the Year Ended December 1988, SFA/R&D/009, 101pp.

Mees, C.C. (1989c) Artisanal Fishing Boats in the Seychelles - A Report of a Boat Census Conducted During March 1989 and Review of Historical Data, 1976-1989, SFA/R&D/011, 49pp.

Mees, C.C. (1989d) The Changing State of Seychelles Artisanal Fishing Fleet, Food and Agriculture Organisation, South West Indian Ocean Programme, Fisheries Bulletin RAF/87/008, October 1989.

Mees, C.C. (1990a) Seychelles Artisanal Fisheries Statistics - Annual Report for the Year Ended December 1989, SFA/R&D/012, 101pp.

Mees, C. C. (1990b) Seychelles Schooner Fishery - An Analysis of Data Collected During the Period January 1985 to July 1990, SFA/R&D/015, 144pp.

Mees, C.C. (1990c) The Fishermen of Seychelles - Results of a Socio - Economic Study of Seychelles Fishing Community, SFA/R&D/013, 68pp

Mees, C.C. (1990d) Results of a Socio - Economic Study of Seychelles Fishing Community - complete Tables of Results by Analytical Sub Stratum, SFA/R&D/DATA/001

Mees, C.C. (1990e) A Socio - Economic Study of Seychelles Fishing Community, Food and Agriculture Organisation, South West Indian Ocean Programme, Fisheries Bulletin RAF/87/008, 33, September 1990

Mees, C.C. (1990f) Seychelles Catch Assessment Survey for the local fishery - A description of the programmes employed to generate the analysis of data. SFA, 60 pp

Mees, C.C. (1991a) Seychelles Artisanal Fisheries Statistics for 1990, SFA/R&D/016, 94pp.

Mees, C.C. (1991b) A Mothership - Dory Fishing Operation in Seychelles (Results of the First Voyage of the Locally Registered Vessel Pecheur Breton, March - May 1991), SFA/R&D/018, 34pp

Mees, C. C. (1992a) A Brief Analysis of the Whaler Handline Fishery - internal SFA discussion document, Unpublished.

Mees, C.C. (1992b) Seychelles Demersal Fishery - An Analysis of Data Relating to Four Key Demersal Species: Pristipomoides filamentosus; Lutjanus sebae; Aprion virescens; Epinephelus chlorostigma. SFA/R&D/019 143pp.

Mees, C. C. (1992c) Pecheur Breton : An Analysis of Data Relating to a Mothership - Dory fishing Operation in Seychelles Waters From March 1991 - June 1992, SFA/R&D/023, 84pp.

Mees, C.C and E. Grandcourt (1992) Seychelles Artisanal Fisheries Statistics for 1991 SFA/R&D/022, 96pp.

Mees, C. C. (1993) Population biology and stock assessment of Pristipomoides filamentosus on the Mahe Plateau, Seychelles, Journal of Fish Biology 43: 695-708.

Mees, C.C. (in press) Demersal fish stock assessment in Seychelles - an analysis of a mothership - catcher boat fishery in : Procedings of the International .workshop on tropical groupers and snappers, 26-29 October 1993, Campeche Mexico, ICLARM/EPOMEX

Michaud, P. (1988) An Analysis of Management Options For The Schooner Fishery of The Seychelles, SFA, 19pp.

Michaud, P. (1990) Preliminary Guidelines on incentives for investors in industrial fishing, SFA, 3pp.

Moussac, G. de (1986) Mise en Evidence de L'Hermaphroditisme Protogyne D'Epinephelus chlorostigma (Valenciennes, 1828) aux Seychelles (Pisces, Serranidae), Cybium 10(3): 249-262.

Moussac, G. de (1987a) Seychelles Artisanal Fisheries Statistics for 1985, SFA/R&D/004, 32pp.

Moussac, G. de (1987b) Seychelles Artisanal Fisheries Statistics for 1986, SFA/R&D/003, 32pp.

Moussac, G. de (1988a) Seychelles Artisanal Fisheries Statistics for 1985, SFA/R&D/005, 43pp.

Moussac, G. de (1988b) Synthese des Donnees Sur la Peche Artisanale Aux Seychelles, Biologie-Resources-Exploitation. SFA/R&D/006, 64pp

Nageon de Lestang, J. (1989) Report on the Problems affecting the economic viability of the whaler fleet, SFA, 6pp.

Parker, D. (1988) The future of the Schooner Fishery, Problems of financial viability and recruitment of fishermen, SFA, 26pp.

Ratcliffe, C. (1974) Report on the Mascareign III Fishing Venture, Fisheries Department Manuscript.

Sanders, M. J., G. Carrara and G. Lablache (1988) Preliminary Assessment of the Brown spotted Grouper Epinephelus chlorostigma Occurring on the Mahe Plateau (Seychelles), in : Procedings of the Workshop on the Assessment of the Fishery Resources in the South West Indian Ocean. RAF/79/065/WP/41/88/E pp 347-357.

Seychelles Fishing Authority, (1986a) The fisheries policy of the Government of Seychelles - The management of marine resources for national development. SFA/86/P&E/001

Seychelles Fishing Authority, (1986b) Seychelles Fishing Fleet Development Strategy, SFA, 13pp

Seychelles Fishing Authority (1990) Seychelles Artisanal Catch Assessment Survey - Notes For Implementation. SFA, 39pp.

Tarbit, J. (1980) Demersal Trawling in Seychelles Waters. Fish. Bull. No 4, Fish. Div. Seychelles, 84pp.

Tarbit, J. (Unpublished) A Further Note on Mothership / Dory Operations in the Providence Group, Fisheries Department, January 1976

Tarbit, J. (1987) Demersal Fisheries Development in Seychelles and the Evaluation of New Fishing Vessel Designs and Operating Strategies, Consultancy Report, ODA.

REFERENCES

Allen, G. R. (1987) Synopsis of the circumtropical fish genus Lutjanus (Lutjanidae), in Polovina and Ralston (see below) pp 33 - 88.

Anderson, W. D. (1987) Systematics of the family Lutjanidae (Perciformes : Percoidei), the snappers, in Polovina and Ralston (see below), pp 1 -32.

Beddington, J. R. and J. G. Cooke (1983). The potential yield of fish stocks. FAO Fisheries Technical Paper. 242: 47pp.

Bertalanffy, L. von (1934). Untersuchungen uber die Gesetzlichkeiten des Wachstums. 1. Allgemeine Grundlagen der Theorie. Roux' Archiv fur Entwicklungsmechanik Organismen 131 : 613 - 653.

Bhattacharya, C. G., (1967) A Simple Method of Resolution of a Distribution into Gaussian Components. Biometrics, 23: 115 - 35.

Brouard, F. and R. Grandperrin (1985). Deep bottom fishes of the outer reef slope in Vanuatu. South Pacific Commission, Seventeenth Regional Technical Meeting on Fisheries, Noumea, New Caledonia 5 - 9 August 1985. SPC/Fisheries 17/WP.12., 127pp.

Dalzell, P. (1990) Deep Water Dropline Fishing Surveys in the South Pacific Region between 1975 to 1988 : A Preliminary Analysis of Data Collected by the SPC Master-fisherman Programme, presented at USAID/NMFS Workshop on Deep water Handline Fishing, 5 - 26/7/89, Honolulu, Hawaii, NOAA - TM - NMFS - SWFSC - 148.

Druzhinin, A. D. and N. A. Filatova (1981) Some Data on Lutjanidae from the Gulf of Aden Area. J. Ichthyology 20 (1): 8 -14.

Everson, A. R., H. A. Williams and B. M. Ito (1989) Maturation and Reproduction in Two Eteline Snappers, Uku, Aprion virescens, and Onaga, Etelis coruscans. Fishery Bulletin, U.S. 87: 877 - 888.

Gayanilo, F.C., M Soriano and D. Pauly (1988). A draft guide to the compleat ELEFAN. ICLARM Software 2, Contribution No. 435, 65pp..

Ghorab, H. M., A. R. Bayoumi, M.I. Bebars, and A.A. Hassan (1986) Age and Growth of the Grouper Epinephelus chlorostigma (Serranidae) From the Red Sea. Bull. Inst. Oceanogr. & Fish. ARE., 12: 1-12.

Grimes, C. B. (1987). Reproductive biology of the Lutjanidae : A review. In Tropical snappers and Groupers: Biology and Fisheries Management (Polovina, J. J. and S. Ralston, eds.), pp. 239 - 294. Boulder and London: Westview Press.

Gulland, J. A. and S. J. Holt (1959) Estimation of Growth Parameters for Data at Unequal Time Intervals. J. Cons. CIEM, 25 (1):47 -49.

Hampton, J. and J. Majkowski (1987). An examination of the reliability of the ELEFAN computer programs for length -based stock assessment. In Length-based methods in fisheries research. ICLARM conference proceedings 13 (Pauly, D. and G. R. Morgan, eds.), pp.203-216. Manila: ICLARM

Jones, R. (1984) Assessing the Effects of Changes in Exploitation Pattern Using Length Composition Data (With Notes on VPA and Cohort Analysis). FAO Fish. Tech. Pap., (256) : 118p.

Kami, H. T. (1973) The Pristipomoides (Pisces: Lutjanidae) of Guam with Notes on their Biology. Micronesia 9(1) : 97-118.

Kikkawa, B. S. (1984). Maturation, spawning, and fecundity of Opakapaka, Pristipomoides filamentosus, in the Northwestern Hawaiian Islands. In Proceedings of the Second Symposium on Resource Investigations in the Northwestern Hawaiian Islands, May 25-27, 1983, Vol. 2, UNIHI - SEAGRANT - MR - 84 -01 (Grigg R. W. and K. Y. Tanoue eds.), pp. 149 - 160. Honolulu: University of Hawaii.

Leis, J. M. (1987) Review of the Early Life History of Tropical Groupers (Serranidae) and Snappers (Lutjanidae), in Polovina and Ralston (see below) pp 189-238.

Loubens, G. (1980) Biologie de Quelques Especes de Poissons du Lagon Neo-Caledonien II. Sexualite et Reproduction. Cah. Indo-Pac. 2:41 - 72.

Mathews, C. P. and M. Samuel (1987) Growth, Mortality and Assessments for Groupers from Kuwait, Kuwait Bulletin of Marine Science 9: 173 - 191.

Min, T. S., T. Senta, and S. Supongpan (1977) Fisheries Biology of Pristipomoides Spp. (Family Lutjanidae) in the South China Sea and its Adjacent Waters. Singapore J. Pri. Ind. 5(2) : 96 - 115.

Munro, J. L. and D. Pauly, (1983) A Simple Method for Comparing Growth of Fishes and Invertebrates. ICLARM Fishbyte, 1(1) : 5-6.

Nzioka, R. M. (1979) Observations on the Spawning Seasons of Eašt African Reef Fishes. J. Fish. Biol. 14: 329 - 342.

Parrish, J. D. (1987) The Trophic Biology of Snappers and Groupers, in Polovina and Ralston (see below) pp 405-464.

Pauly, D. and N. David (1981) ELEFAN I, a Basic Programme for the Objective Extraction of Growth Parameters From Length Frequency Data. Meeresforshung, 28(4) :205 -211.

Pauly, D. (1980). On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. Journal du Conseil, Conseil International pour l'Exploration de la Mer. 39(3): 175-192

Polovina, J. J. (1986) A Variable Catchability Version of the Leslie Moel With application To an Intensive Fishing Experiment on a Multispecies Stock. Fishery Bulletin, 84 (2) : 423 - 428.

Polovina, J. J. and S. Ralston (1987) Tropical snappers and Groupers, Biology and Fisheries Management, Westview Press, Boulder and London, 659p. Polovina, J. J. (1986). A variable catchability version of the Leslie model with application to an intensive fishing experiment on a multispecies stock. Fishery Bulletin, 84 (2): 423 - 428.

Polovina, J. J. and S. Ralston (1987) Tropical snappers and Groupers, Biology and Fisheries Management, Westview Press, Boulder and London, 659p.

Polovina, J. J., R. Benco, A. Carlot, E. Cillauren, P. Dalzell, N. Howard, D. Kobayashi, T. Latu, P. Lokani, G. Nath, H. Pili, A. Sesewa, R. Shomura, T. Sua, G. Tiroba, and S. Tulua (1990). Summary of the methods and results from the tropical stock assessment workshop, Honolulu, HI, July 5-26, 1989. NOAA - Technical Memorandum - NMFS - SWFSC - 148: 8pp.

Radtke, R. L. (1987) Age and Growth Information Available From the Otoliths of the Hawaiian Snapper, Pristipomoides Filamentosus. Coral Reefs, 6(1) : 19 - 25.

Ralston, S. (1987) Mortality Rates of Snappers and Groupers. In Polovina, J.J. and S. Ralston (1987 see above), pp 375 - 404.

Ralston, S. and G. T. Miyamoto (1983) Analysing the Width of Daily Otolith Increments to Age the Hawaiian Snapper, Pristipomoides filamentosus. Fish. Bull., U.S. 81: 523 - 535.

Ralston, S. V. D. (1981). A study of the Hawaiian deep sea handline fishery with special reference to the population dynamics of Opakapaka, Pristipomoides Filamentosus (Pisces : Lutjanidae). Ph.D. Dissertation, University of Washington, Seattle, 204pp.

Ralston, S., R. M. Gooding, and G. M. Ludwig (1986). An ecological survey and comparison of bottom fish resource assessments (submersible versus handline fishing) at Johnston Atoll. Fishery Bulletin. 84(1): 141-156.

Ralston, S. and H. A. Williams (Unpub) Age, growth and mortality of Lutjanid and other deep slope fishes from the Mariana Archipelago. Quoted in Mortality rates of snappers and groupers (Ralston, S., 1987). In Tropical Snappers and Groupers: Biology and Fisheries Management (Polovina, J. J. and S. Ralston, eds.), pp. 239 - 294. Boulder and London: Westview Press.

Randall, J. E. (1987) A Preliminary Synopsis of the Groupers (Perciformes : Serranidae: Epinephelinae) of the Indo Pacific Region. In Polovina, J.J. and S. Ralston (1987 see above), pp 89 - 188.

Schaefer, M. (1954) Some Aspects of the Dynamics of Populations Important to the Management of the Commercial Marine Fisheries, Bull. I-ATCC, 1(12):27-55

Shapiro, D. Y. (1987) Reproduction in Groupers. In Polovina, J.J. and S. Ralston (1987 see above), pp 295 - 328

Sparre, P. (1987) Computer Programmes For Fish Stock Assessment. Length Based Fish Stock Assessment For Apple II Computers. FAO Fish. Tech. Pap. 101 Supl. 2, 218pp.

Stomatopoulos, C. and J. F. Caddy (1989) Estimation of Von Bertalanffy Growth Parameters : A Versatile Linear regression Approach. J. Cons. Int. Explor. Mer, 45: 200 - 208.

Talbot, F. H. (1960) Notes on the Biology of the Lutjanidae (pisces) of the East African Coast, With special Reference to L. Bohar (Forskal). Ann. S. Afr. Mus. 45: 549 - 579.

Valenciennes, A. (1830). In Histoire naturelle des poissons. 6. (Cuvier, G. and A. Valenciennes) Reprinted 1969, Amsterdam: A. Asher and Co.

Van der Knapp, M., Z. Waheed, H. Shareef and M. Rasheed (1991) Reef Fish Resources Survey in The Maldives. BOBP/WP/64 MDV/88/007, 61pp.

Weatherall, J. A., J. J. Polovina and S. Ralston, (1987) Estimating Growth and Mortality in Steady State Fish Stocks From Length Frequency Data. ICLARM Conf. Proc., (13) : 53 - 74.

ANNEX 1 : Estimation of total catch, effort and species composition by boat type and location per annum.

For small boats and whalers the proportion of trips in which demersal species were caught was determined from sampled data (Table A1.1; A1.2). Estimates of the total demersal fish catch and effort, aggregated for all fishing locations by boat category[6], are available from SFA annual statistical reports (5.1.1; Table 7). For small boats with no location specific data it was assumed that all fishing occurred inshore (Sector 1). For the other boat categories the number and proportion of fishing trips by location per annum was determined from sampled data (Table A1.3.). Assuming sampled data is representative of the fishery as a whole and that catch rates are the same at different locations[7], the total catch by boat category by location per annum (Table A1.4) was determined from total catch (Table 7) and the proportion of effort by location (Table A1.3.).

TABLE A1.1. : The number and proportion of small boat- and whalers trips sampled for which demersal species were caught (details for ARTFISH database)

BOATTYPE	DETAILS	85	86	87	88	89	90	91	92	93
Outboard	all trips	1091	1379	1601	1131	1347	1806	981	958	1257
Outboard	demersals caught	496	629	837	711	854	1191	653	574	878
Outboard	% demersal	45.5%	45.6%	52.3%	62.9%	63.4%	65.9%	66.6%	59.9%	69.8%
Pirogue	all trips	69	368	355	158	126	89	26	25	31
Pirogue	demersals caught	56	131	142	96	111	74	22	19	20
Pirogue	% demersal	81.2%	35.6%	40.0%	60.8%	88.1%	83.1%	84.6%	76.0%	64.5%
Sm. boats	demersals caught	552	760	979	807	965	1265	675	593	898
Whaler	all trips	277	548	1004	1087	1454				
Whaler	demersals caught	131	360	556	574	859				
Whaler	% demersal	47.3%	65.7%	55.4%	52.8%	59.1%				

[6] For whalers the number of trips relating to demersal species was estimated by applying the proportions derived in Table A1.2 to the total whaler trips per annum.

[7] Catch rate by location does in fact differ, so the estimates of catch by location will tend to be under-estimated for distant locations and over-estimated at nearer more heavily fished locations.

TABLE A1.2. : The number and proportion of whalers trips sampled by location for which demersal species were caught (details for WHALER database)

SECTOR	DETAILS	89	90	91	92	93	TOT
0	DEMERSALS CAUGHT	255	376	415	292	351	1689
0	ALL TRIPS	434	536	563	409	458	2400
	% TRIPS + DEMERSAL	58.8%	70.1%	73.7%	71.4%	76.6%	70.4%
1	DEMERSALS CAUGHT	247	515	488	301	294	1845
1	ALL TRIPS	419	802	862	483	407	2973
	% TRIPS + DEMERSAL	58.9%	64.2%	56.6%	62.3%	72.2%	62.1%
2	DEMERSALS CAUGHT	13	39	49	21	15	137
2	ALL TRIPS	13	39	49	23	18	142
	% TRIPS + DEMERSAL	100.0%	100.0%	100.0%	91.3%	83.3%	96.5%
3	DEMERSALS CAUGHT	1	4	3	6	4	18
3	ALL TRIPS	1	4	3	6	5	19
	% TRIPS + DEMERSAL	100.0%	100.0%	100.0%	100.0%	80.0%	94.7%
4	DEMERSALS CAUGHT	0	4	1	10	1	16
4	ALL TRIPS	0	4	1	10	1	16
	% TRIPS + DEMERSAL	0	100.0%	100.0%	100.0%	100.0%	100.0%
6	DEMERSALS CAUGHT	2	2	1	9	4	18
6	ALL TRIPS	2	2	1	9	4	18
	% TRIPS + DEMERSAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
7	DEMERSALS CAUGHT	2	0	2	12	7	23
7	ALL TRIPS	3	0	2	13	7	25
	% TRIPS + DEMERSAL	66.7%	0	100.0%	92.3%	100.0%	92.0%
9	DEMERSALS CAUGHT	0	0	1	3	0	4
9	ALL TRIPS	0	0	1	3	0	4
	% TRIPS + DEMERSAL	0	0	100.0%	100.0%	0	100.0%
10	DEMERSALS CAUGHT	1	2	1	8	6	18
10	ALL TRIPS	1	2	1	8	6	18
	% TRIPS + DEMERSAL	100.0%	100.0%	100.0%	100.0%	100.0%	100.0%
12	DEMERSALS CAUGHT	0	0	0	1	1	2
12	ALL TRIPS	0	0	0	1	1	2
	% TRIPS + DEMERSAL	0	0	0	100.0%	100.0%	100.0%
13	DEMERSALS CAUGHT	3	0	2	0	0	5
13	ALL TRIPS	3	0	2	0	0	5
	% TRIPS + DEMERSAL	100.0%	0	100.0%	0	0	100.0%
TOT	DEMERSALS CAUGHT	524	942	963	663	682	3775
TOT	ALL TRIPS	876	1389	1485	965	907	5622
	% TRIPS + DEMERSAL	59.8%	67.8%	64.8%	68.7%	75.2%	67.1%

TABLE A1.3. : The proportion of the total sampled effort by location per annum. Total sampled effort (trips) for all locations by boat category is shown

SECTOR	BOATTYPE	83	84	85	86	87	88	89	90	91	92	93
1	SMALL BOATS	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
1	WHALER	87%	87%	87%	87%	87%	87%	87%	91%	89%	81%	89%
1	SCHOONER		0%		1%			15%	12%	6%	9%	
1	MOTHERSHIP											9%
2	WHALER	7%	7%	7%	7%	7%	7%	7%	7%	9%	6%	5%
2	SCHOONER	5%	6%	3%	11%	9%	3%	1%	8%	7%	2%	1%
3	WHALER	1%	1%	1%	1%	1%	1%	1%	1%	1%	2%	1%
3	SCHOONER	19%	11%	13%	9%	11%	4%	2%	2%	4%	2%	1%
4	WHALER	1%	1%	1%	1%	1%	1%	1%	1%	0%	3%	0%
4	SCHOONER	4%	9%	12%	8%	7%	11%	7%	6%	9%	19%	34%
5	SCHOONER	4%	4%	8%	3%	5%	1%		2%	5%	6%	
5	MOTHERSHIP										1%	13%
6	WHALER	1%	1%	1%	1%	1%	1%	1%	0%	0%	2%	1%
6	SCHOONER	11%	11%	13%	3%	14%	15%	6%	28%	23%	16%	21%
6	MOTHERSHIP									33%	3%	1%
7	WHALER	1%	1%	1%	1%	1%	1%	1%		0%	3%	2%
7	SCHOONER	2%	7%	5%	9%	11%	9%	10%	11%	7%	10%	1%
7	MOTHERSHIP									1%		
8	SCHOONER	2%	3%	3%	2%	6%	2%	3%	2%	4%	2%	4%
9	WHALER	0%	0%	0%	0%	0%	0%	0%		0%	1%	
9	SCHOONER	36%	29%	16%	42%	15%	34%	41%	19%	20%	14%	27%
10	WHALER	1%	1%	1%	1%	1%	1%	1%	0%	0%	2%	2%
10	SCHOONER	4%	9%	8%	12%	12%	11%	9%	5%	8%	7%	4%
11	MOTHERSHIP									61%	15%	9%
12	WHALER	0%	0%	0%	0%	0%	0%	0%			0%	0%
12	SCHOONER		0%			1%					1%	
12	MOTHERSHIP									0%		1%
13	WHALER	0%	0%	0%	0%	0%	0%	0%		0%		
13	SCHOONER	13%	10%	18%	1%	9%	10%	5%	4%	7%	12%	6%
13	MOTHERSHIP									4%	20%	
14	SCHOONER									1%	1%	
14	MOTHERSHIP									10%	56%	10%
15	MOTHERSHIP										5%	
99	SCHOONER											2%
99	MOTHERSHIP											56%
TOTAL	WHALER TRIPS	NA	NA	NA	NA	NA	NA	NA	4236	3746	4745	4615
TOTAL	SCHOONER TRIPS	491	NA	365	518	628	504	371	349	456	596	170
TOTAL	MOTHERSHIP TRIPS									1354	1686	1052

Unknown locations assumed to be in same proportion as known.
Small-boats - the entire catch / effort is assumed to relate to sector 1
Whalers 1983-1989 : % by stratum calculated as average of that for 1990 -1992 (fishing location was not recorded prior to June 1989)
Schooners 1984 = average of all 1983,1985-1988 (ie 5 closest years) 1983 trips = Sept '92 - Aug '93 from Lablache and Carrara, 1984. No data available for 1994
Mothership = census not sample, only fished in years indicated

TABLE A1.4 : The estimated total demersal fish catch (mt) by boat category and location per annum (Note Mothership catch = actual landings by sector)

SECTOR	BOATTYPE	83	84	85	86	87	88	89	90	91	92	93
1	SPORTS BOATS	NA	NA				0.0	0.0		0.0		
1	SMALL BOATS	NA	NA	266.8	356.5	207.0	218.4	267.1	201.6	215.1	214.9	247.1
1	WHALER	NA	NA	258.2	717.8	585.5	522.7	585.2	1036.5	1049.4	733.3	852.0
1	SCHOONER		0.4		2.3			75.8	67.8	26.6	28.8	
1	MOTHERSHIP											16.0
1	TOTAL	NA	NA	525.0	1076.6	792.5	741.1	928.1	1305.9	1291.1	976.9	1115.1
2	WHALER	NA	NA	21.2	59.1	48.2	43.0	48.2	78.5	105.4	51.2	43.5
2	SCHOONER	20.1	21.6	9.2	40.5	46.3	13.1	5.6	48.4	33.3	5.4	2.3
2	TOTAL	NA	NA	30.4	99.6	94.4	56.1	53.8	126.9	138.6	56.6	45.8
3	WHALER	NA	NA	2.8	7.9	6.4	5.7	6.4	8.1	6.5	14.6	11.6
3	SCHOONER	77.4	38.4	35.0	32.7	56.3	14.6	11.2	12.9	20.0	7.2	1.2
3	TOTAL	NA	NA	37.8	40.6	62.7	20.3	17.7	21.0	26.4	21.8	12.8
4	WHALER	NA	NA	3.5	9.9	8.0	7.2	8.0	8.1	2.2	24.4	2.9
4	SCHOONER	17.2	30.1	34.0	30.4	37.5	46.6	36.5	35.5	41.6	64.7	62.0
4	TOTAL	NA	NA	37.6	40.3	45.5	53.7	44.5	43.6	43.7	89.1	64.9
5	SCHOONER	17.2	14.9	22.1	11.3	26.3	4.4		9.7	23.3	21.6	
5	MOTHERSHIP										3.6	31.0
5	TOTAL	17.2	14.9	22.1	11.3	26.3	4.4		9.7	23.3	25.1	31.0
6	WHALER	NA	NA	2.9	8.1	6.6	5.9	6.6	4.0	2.2	21.9	11.6
6	SCHOONER	43.0	39.2	35.0	12.4	76.3	61.1	30.9	158.3	109.8	52.1	37.4
6	MOTHERSHIP									127.2	5.3	0.2
6	TOTAL	NA	NA	37.9	20.5	82.9	67.0	37.5	162.3	239.1	79.4	49.2
7	WHALER	NA	NA	3.6	9.9	8.1	7.2	8.1		4.3	29.2	20.3
7	SCHOONER	8.6	26.7	14.7	34.9	60.0	36.4	53.4	64.6	33.3	34.2	2.3
7	MOTHERSHIP									4.1		
7	TOTAL	NA	NA	18.3	44.8	68.1	43.6	61.4	64.6	41.7	63.4	22.6
8	SCHOONER	8.6	11.3	9.2	6.8	33.8	10.2	16.8	12.9	16.6	5.4	7.0
9	WHALER	NA	NA	1.0	2.7	2.2	2.0	2.2		2.2	7.3	
9	SCHOONER	140.4	100.0	44.1	159.9	81.3	142.6	213.4	109.8	93.1	48.5	49.1
9	TOTAL	NA	NA	45.1	162.7	83.5	144.6	215.6	109.8	95.3	55.9	49.1
10	WHALER	NA	NA	2.7	7.4	6.0	5.4	6.0	4.0	2.2	19.5	17.4
10	SCHOONER	14.3	32.5	22.1	47.3	61.3	45.1	44.9	29.1	39.9	25.2	7.0
10	TOTAL	NA	NA	24.7	54.7	67.3	50.5	51.0	33.1	42.1	44.7	24.4
11	MOTHERSHIP									201.3	50.7	18.1
12	WHALER	NA	NA	0.3	0.7	0.6	0.5	0.6			2.4	2.9
12	SCHOONER		0.7			5.0					1.8	
12	MOTHERSHIP									0.7		1.1
12	TOTAL	NA	NA	0.3	0.7	5.6	0.5	0.6		0.7	4.2	4.0
13	WHALER	NA	NA	0.4	1.0	0.8	0.7	0.8		4.3		
13	SCHOONER	51.6	35.2	48.7	4.5	45.0	40.7	28.1	22.6	31.6	39.6	10.5
13	MOTHERSHIP									13.9	90.0	
13	TOTAL	NA	NA	49.1	5.5	45.8	41.5	28.9	22.6	49.8	129.5	10.5
14	SCHOONER									3.3	1.8	
14	MOTHERSHIP									71.8	370.1	32.2
14	TOTAL									75.2	371.9	32.2
15	MOTHERSHIP										21.6	
99	SCHOONER											3.5
99	MOTHERSHIP											228.9
99	TOTAL											232.4

SPECIES COMPOSITION

The species composition of the sampled catch for each boat category at each location each year was determined and applied to total catch derived in Table A1.4 to determine species catches by location (Tables A1.5 - A1.21). For whalers in 1989 catch was derived from ARTFISH but species composition from the new method applied from July - December 1989 when species records were improved.

NOTE : Sector 11 total catch and species catches are under-estimated since some schooners occaisionally fish there but the location reported is usually SE or S : ie the catch will be recorded in Sector 6 or 7.

TABLE A1.5 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 1

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SMALL BOATS	85	266.80				0.32	65.69			61.39	40.04				18.02							81.34
WHALERS	85	258.20				6.29	56.91			54.67	25.39				4.67							110.27
TOTAL	85	525.00				6.61	122.59			116.06	65.43				22.69							191.82
SMALL BOATS	86	356.50				1.69	60.56			74.94	66.26				19.67							133.39
WHALERS	86	717.80				38.40	161.83			264.13	48.63				77.86							126.95
SCHOONERS	86	2.30	0.07			0.23	0.21	0.26			0.27	0.03		0.22		0.04	0.08	0.32	0.05	0.13	0.39	
TOTAL	86	1076.60	0.07			40.32	222.59	0.26		339.07	115.16	0.03		0.22	97.53	0.04	0.08	0.32	0.05	0.13	0.39	260.34
SMALL BOATS	87	207.00				0.78	49.62			31.92	24.40				13.73							86.55
WHALERS	87	585.60				52.03	154.85			187.28	33.26				37.33							120.76
TOTAL	87	792.60				52.81	204.47			219.20	57.66				51.06							207.31
SMALL BOATS	88	218.40				0.70	71.16			32.02	24.74				14.70							75.09
WHALERS	88	522.70				67.34	205.44			87.27	22.18				25.71							114.75
TOTAL	88	741.10				68.04	276.60			119.29	46.92				40.41							189.84
SMALL BOATS	89	267.10				1.08	49.73			64.63	40.24				18.68							92.74
WHALERS	89	585.20	116.23	43.46	0.05	31.42	183.07		16.15	13.86	38.13	13.50		1.79	16.58	21.51	16.00	0.59	6.95	7.57		59.34
SCHOONERS	89	75.80	25.46	2.22		7.26	5.67	12.62			2.85	5.09		2.01	1.96	1.28	0.27	6.06	0.17	2.64	0.23	
TOTAL	89	928.10	141.69	45.68	0.05	39.76	238.47	12.62	16.15	78.49	81.22	18.59		3.81	37.22	22.79	16.27	6.65	7.11	10.21	0.23	152.08
SMALL BOATS	90	201.60				30.53	48.40			10.09	29.70				12.39							70.50
WHALERS	90	1036.50	150.44	43.39	2.80	69.02	484.54		48.12	3.04	40.61	25.73		6.38	13.39	33.28	16.51	9.41	7.30	15.32		67.22
SCHOONERS	90	67.80	23.67	1.51		2.67	6.38	0.75	13.84		3.26	4.80	0.92	1.06	3.04	1.71	0.42	1.46		2.26	0.06	
TOTAL	90	1305.90	174.11	44.90	2.80	102.21	539.31	0.75	61.96	13.13	73.57	30.54	0.92	7.44	28.81	34.99	16.94	10.87	7.30	17.58	0.06	137.72
SMALL BOATS	91	215.10	41.70				50.37			2.59	29.11				13.96							77.37
WHALERS	91	1049.40	291.22	32.33	8.88	62.44	295.96		1.17	0.47	50.36	29.39		19.01	13.43	33.19	51.68	4.69	17.76	49.00		88.42
SCHOONERS	91	26.60	8.07	0.85		2.08	1.63	0.61	2.31		1.80	1.86		0.33	1.00	0.25		3.69	0.91	1.07	0.14	
TOTAL	91	1291.10	340.98	33.18	8.88	64.52	347.96	0.61	3.48	3.06	81.27	31.25		19.34	28.40	33.44	51.68	8.38	18.67	50.07	0.14	165.78
SMALL BOATS	92	214.90	34.10				36.82			4.98	35.05				17.17							86.78
WHALERS	92	733.30	199.95	29.50	3.93	23.70	153.21		2.57	0.10	70.37	12.70		9.62	27.36	29.91	34.62	4.09	16.83	8.28		106.56
SCHOONERS	92	28.80	6.63	0.51		0.85	2.41	0.03	12.16		1.55	1.68		0.07	1.09	0.76	0.02		0.04	0.88	0.11	
TOTAL	92	977.00	240.68	30.01	3.93	24.55	192.43	0.03	14.73	5.09	106.97	14.38		9.69	45.62	30.67	34.64	4.09	16.87	9.16	0.11	193.34
SMALL BOATS	93	247.10	34.62				72.43			4.69	34.95				16.45							83.96
WHALERS	93	852.00	171.05	26.69	5.79	28.32	231.08		0.95		82.27	4.86		4.86	26.37	20.25	49.25	2.42	25.13	10.70		162.02
MOTHERSHIP	93	16.05	2.31	1.41		0.20	4.79			1.21	0.73	0.63	0.17	0.08	0.26	0.75				0.26		3.27
TOTAL	93	1115.15	207.98	28.10	5.79	28.52	308.30		0.95	5.90	117.95	5.49	0.17	4.92	43.07	21.00	49.25	2.42	25.13	10.96		249.25

TABLE A1.6 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 2

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	20.10	5.66	2.17		2.38	2.71	0.29			3.17	2.03			0.93	0.50	0.06	0.03			0.27	
SCHOONERS	84	21.60	10.41	0.55		1.17	1.33	0.81			3.97	1.98		0.06	0.32	0.52		0.28		0.20		
WHALERS	86	21.20				0.52	4.67			4.49	2.08				0.38							9.05
SCHOONERS	85	9.20	2.36	1.80		0.25	1.41	1.37			0.75	0.63				0.43	0.03			0.28		
TOTAL	86	30.40	2.36	1.80		0.77	6.08	1.37		4.49	2.83	0.63			0.38	0.43	0.03			0.28		9.05
WHALERS	86	59.10				3.16	13.32			21.75	4.00				6.41							10.46
SCHOONERS	86	40.50	5.74	1.93		4.94	10.44	0.67			3.23	2.04		1.49	0.55	1.20	0.84	3.82	0.33	0.72	2.57	
TOTAL	86	99.60	5.74	1.93		8.11	23.76	0.67		21.75	7.23	2.04		1.49	6.96	1.20	0.84	3.82	0.33	0.72	2.57	10.46
WHALERS	87	48.20				4.28	12.75			15.42	2.74				3.07							9.94
SCHOONERS	87	46.30	5.75	1.11		5.17	5.35	7.57			2.71	1.81		2.45	0.98	1.52	0.15	9.68	0.56	0.86	0.63	
TOTAL	87	94.50	5.75	1.11		9.45	18.10	7.57		15.42	5.45	1.81		2.45	4.05	1.52	0.15	9.68	0.56	0.86	0.63	9.94
WHALERS	88	43.00				5.54	16.90			7.18	1.82				2.11							9.44
SCHOONERS	88	13.10	3.43	0.36		0.44	1.79	3.64			1.08	0.56		0.23	0.62	0.40	0.15	0.40		0.01		
TOTAL	88	56.10	3.43	0.36		5.98	18.69	3.64		7.18	2.90	0.56		0.23	2.73	0.40	0.15	0.40		0.01		9.44

SECTOR 2 CONTINUED

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
WHALERS	89	48.20	9.89	6.96	0.62	5.41	12.88		1.36	0.16	2.47	0.64		1.53	0.76	2.14	0.47	0.01	0.60	0.32		1.99
SCHOONERS	89	5.60	0.95	0.84		0.19	1.44	0.76			0.26	0.70		0.06	0.16	0.06	0.03	0.10	0.05		0.01	
TOTAL	89	53.80	10.84	7.80	0.62	5.60	14.33	0.76	1.36	0.16	2.71	1.34		1.59	0.90	2.21	0.60	0.11	0.65	0.32	0.01	1.99
WHALERS	90	78.50	16.15	2.37	0.47	6.94	27.30		2.62	0.07	5.21	3.37		0.32	0.90	3.39	1.60	1.66	0.32	1.32		4.49
SCHOONERS	90	48.40	13.43	1.61		0.57	13.24	1.82	10.70		2.11	2.47		0.03	1.19	1.23						
TOTAL	90	126.90	29.58	3.98	0.47	7.51	40.54	1.82	13.32	0.07	7.32	5.84		0.34	2.09	4.62	1.60	1.66	0.32	1.32		4.49
WHALERS	91	105.40	16.01	3.18	3.70	18.42	35.85		0.85		1.55	3.49		1.93	0.88	2.30	4.86	5.07	2.65	1.52		3.13
SCHOONERS	91	33.30	5.40	4.27		2.65	5.61	0.05	1.64		1.68	1.86		0.92	0.72	1.88	0.05	4.12	0.67	1.02	0.76	
TOTAL	91	138.70	21.42	7.45	3.70	21.06	41.46	0.05	2.49		3.23	5.35		2.85	1.60	4.19	4.91	9.19	3.32	2.54	0.76	3.13
WHALERS	92	51.20	11.96		0.22	4.99	19.68				5.22	2.50		0.29	2.09	1.07	1.05	0.24				1.90
SCHOONERS	92	5.40	0.76	0.16		0.05	1.05		1.81		0.34	0.14		0.02	0.41	0.13	0.05	0.38	0.01	0.07		
TOTAL	92	56.60	12.72	0.16	0.22	5.05	20.73		1.81		5.56	2.64		0.31	2.51	1.20	1.10	0.63	0.01	0.07		1.90
WHALERS	93	43.50	4.88	1.61	1.67	6.61	14.82				0.66	0.35		1.23	0.13	0.90	3.74	0.35	3.43	0.53		2.59
SCHOONERS	93	2.30	1.49	0.03		0.07	0.20				0.11	0.19		0.00	0.05	0.12				0.04		
TOTAL	93	45.80	6.37	1.63	1.67	6.68	16.02				0.77	0.54		1.24	0.18	1.02	3.74	0.35	3.43	0.57		2.59

TABLE A1.7 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 3

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	77.40	18.09	3.69		2.12	4.62	6.46			5.72	7.03			22.08	3.97	0.98	0.65		0.41	1.59	
SCHOONERS	84	38.40	10.56	2.29		1.80	4.24	1.84			9.53	4.80		0.02		1.65	0.50	1.06		0.10		
WHALERS	85	2.80				0.07	0.62			0.59	0.28				0.05							1.20
SCHOONERS	85	35.00	11.56	2.50		1.86	3.71	0.62	0.02		5.83	4.24		0.81	0.01	1.47	0.06	2.02		0.26	0.04	
TOTAL	85	37.80	11.56	2.50		1.93	4.32	0.62	0.02	0.59	6.10	4.24		0.81	0.06	1.47	0.06	2.02		0.26	0.04	1.20
WHALERS	86	7.90				0.42	1.78			2.91	0.54				0.86							1.40
SCHOONERS	86	32.70	11.63	1.62		1.90	6.89	0.31			2.59	3.32		0.58	0.17	0.98	0.13	1.00	0.04	0.46	1.06	
TOTAL	86	40.60	11.63	1.62		2.32	8.67	0.31		2.91	3.13	3.32		0.58	1.03	0.98	0.13	1.00	0.04	0.46	1.06	1.40
WHALERS	87	6.40				0.57	1.69			2.05	0.36				0.41							1.32
SCHOONERS	87	56.30	10.61	1.80		2.29	4.56	17.43	0.01		5.99	3.76	0.01	1.21	2.70	1.50	0.69	2.11	0.20	1.14	0.29	
TOTAL	87	62.70	10.61	1.80		2.86	6.25	17.43	0.01	2.05	6.35	3.76	0.01	1.21	3.11	1.50	0.69	2.11	0.20	1.14	0.29	1.32
WHALERS	88	5.70				0.73	2.24			0.95	0.24				0.28							1.25
SCHOONERS	88	14.60	2.66	0.76		0.62	1.56	1.33			1.26	0.85		0.52	0.46	0.83	0.80	2.06	0.36	0.44	0.07	
TOTAL	88	20.30	2.66	0.76		1.35	3.80	1.33		0.95	1.50	0.85		0.52	0.74	0.83	0.80	2.06	0.36	0.44	0.07	1.25
WHALERS	89	6.40									4.43						1.97					
SCHOONERS	89	11.20	3.35	1.31		0.29	3.02	0.14			0.65	1.47		0.08	0.21	0.66		0.03				
TOTAL	89	17.60	3.35	1.31		0.29	3.02	0.14			5.07	1.47		0.08	0.21	0.66	1.97	0.03				
WHALERS	90	8.10	0.37	0.26		0.04	6.47				0.09	0.18		0.01	0.02	0.05	0.32					0.28
SCHOONERS	90	12.90	5.54	1.12		0.40	3.47	0.35			0.32	0.18		0.01	0.12	0.30	0.15			0.90	0.04	
TOTAL	90	21.00	5.91	1.38		0.44	9.94	0.35			0.42	0.36		0.02	0.13	0.35	0.47			0.90	0.04	0.28
WHALERS	91	6.50	1.08	0.42		0.08	4.03				0.05	0.30			0.01	0.12	0.22					0.19
SCHOONERS	91	20.00	5.48	0.07		2.39	5.30	0.03	0.16		1.17	0.74		0.18	0.58	0.20	0.45	1.81	0.57	0.88		
TOTAL	91	26.50	6.56	0.49		2.47	9.33	0.03	0.16		1.22	1.04		0.18	0.59	0.31	0.67	1.81	0.57	0.88		0.19
WHALERS	92	14.60	0.68	0.03		0.06	12.41				0.12	0.72			0.01	0.02	0.25					0.29
SCHOONERS	92	7.20	1.44	1.43		0.22	1.70		0.16		0.40	0.55		0.04	0.30	0.49	0.08		0.05	0.21	0.13	
TOTAL	92	21.80	2.12	1.46		0.29	14.11		0.16		0.52	1.27		0.04	0.31	0.52	0.33		0.05	0.21	0.13	0.29
WHALERS	93	11.60	0.61	0.11		0.09	10.18				0.09	0.12			0.03	0.08	0.20		0.03			0.06
SCHOONERS	93	1.20	0.80	0.11			0.04		0.05		0.11	0.05				0.03						
TOTAL	93	12.80	1.41	0.22		0.09	10.22		0.05		0.21	0.17			0.03	0.11	0.20		0.03			0.06

TABLE A1.8 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 4

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	17.20	6.52	0.19		0.37	0.13	0.74			1.76	1.40			6.13	0.32	0.32				0.32	
SCHOONERS	84	30.10	6.60	2.60		1.59	2.75	3.58			7.42	2.04		0.92		1.74		1.02			0.08	
WHALERS	85	3.50				0.09	0.77			0.74	0.34				0.06							1.49
SCHOONERS	85	34.00	8.39	2.46		2.75	6.46	0.69	1.48		4.06	2.63	0.01	0.45	0.35	1.58	0.88	0.19	0.03	0.74	0.86	
TOTAL	85	37.60	8.39	2.45		2.84	7.24	0.69	1.48	0.74	4.40	2.63	0.01	0.45	0.42	1.58	0.88	0.19	0.03	0.74	0.86	1.49
WHALERS	86	9.80				0.53	2.23			3.64	0.67				1.07							1.75
SCHOONERS	86	30.40	12.78	1.18		1.55	3.16	1.41			2.58	3.44		0.46	0.43	0.82	0.36	0.91	0.07	0.90	0.33	
TOTAL	86	40.30	12.78	1.18		2.08	5.40	1.41		3.64	3.25	3.44		0.46	1.51	0.82	0.36	0.91	0.07	0.90	0.33	1.75
WHALERS	87	8.00				0.71	2.12			2.56	0.45				0.51							1.65
SCHOONERS	87	37.50	14.54	1.09		1.06	2.61	5.88			3.48	3.01		0.49	1.55	1.65	0.98	0.29	0.04	0.50	0.32	
TOTAL	87	45.50	14.54	1.09		1.77	4.73	5.88		2.56	3.94	3.01		0.49	2.06	1.65	0.98	0.29	0.04	0.50	0.32	1.65
WHALERS	88	7.20				0.93	2.83			1.20	0.31				0.36							1.58
SCHOONERS	88	46.60	12.22	1.74		1.87	3.10	11.60			4.60	4.28		0.78	2.21	1.84	0.28	1.60	0.20	0.28		
TOTAL	88	53.80	12.22	1.74		2.80	5.93	11.60		1.20	4.90	4.28		0.78	2.57	1.84	0.28	1.60	0.20	0.28		1.58
WHALERS	89	8.00				1.03	3.14			1.34	0.34				0.39							1.76
SCHOONERS	89	36.50	18.69	2.10		0.63	1.60	0.94			2.58	4.70		0.65	0.68	0.63		2.58		0.66	0.05	
TOTAL	89	44.50	18.69	2.10		1.66	4.74	0.94		1.34	2.92	4.70		0.65	1.08	0.63		2.58		0.66	0.05	1.76
WHALERS	90	8.10	3.45	0.02		0.18	1.15				1.23	0.27		0.07	0.10	0.57	0.62					0.64
SCHOONERS	90	35.50	16.64	1.50		0.31	5.21	0.14	1.79		1.98	3.57		0.18	0.66	1.10	0.20	2.23		0.01		
TOTAL	90	43.60	20.10	1.52		0.48	6.36	0.14	1.79		3.20	3.84		0.25	0.76	1.68	0.72	2.23		0.01		0.64
WHALERS	91	2.20	0.20				1.43				0.14				0.08	0.35						
SCHOONERS	91	41.60	16.10	0.14		2.02	1.83	0.69	9.23		2.99	2.91		0.37	1.21	0.92		0.46	0.17	3.56		
TOTAL	91	43.80	15.29	0.14		2.02	3.26	0.69	9.23		3.13	2.91		0.37	1.29	1.27		0.46	0.17	3.56		
WHALERS	92	24.40	3.70		0.11	0.58	7.80				4.11			0.09	0.46	0.32	2.37	0.21				4.64
SCHOONERS	92	64.70	34.60	1.44		0.71	4.76	0.32	7.14		5.00	3.26		0.16	1.86	2.18	1.24	1.25	0.09	0.58	0.12	
TOTAL	92	89.10	38.30	1.44	0.11	1.29	12.55	0.32	7.14		9.11	3.26		0.25	2.33	2.50	3.62	1.46	0.09	0.58	0.12	4.64
WHALERS	93	2.90	2.59								0.31											
SCHOONERS	93	62.00	30.98	1.13		1.04	4.30		7.96		4.53	5.17		0.31	1.48	1.49	0.38	2.16	0.12	0.60	0.38	
TOTAL	93	64.80	33.56	1.13		1.04	4.30		7.95		4.84	5.17		0.31	1.48	1.49	0.38	2.16	0.12	0.60	0.38	

TABLE A1.9 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 5

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	17.20	7.52	0.01		0.48	1.03	0.75			2.05	4.45			0.32	0.28		0.06		0.26		
SCHOONERS	84	14.90	5.22	0.31		0.84	0.80	1.93			3.14	2.05		0.22		0.28	0.07	0.03				
SCHOONERS	85	22.10	9.60	1.61		1.01	1.68	0.07	0.06		2.23	3.76		0.08	0.08	1.38	0.19	0.23		0.13		
SCHOONERS	86	11.30	4.65	0.57		0.86	0.76	0.14			1.10	1.81		0.20	0.32	0.27	0.44	0.10	0.02	0.06		
SCHOONERS	87	26.30	16.84	0.44		0.66	1.04	1.62			1.52	2.66		0.21	0.76	0.45	0.66	0.11	0.02	0.22		
SCHOONERS	88	4.40	1.62	0.18		0.03	0.11	0.12			0.68	1.04		0.03	0.31	0.06	0.21			0.01		
SCHOONERS	90	9.70	4.72	1.28		0.01	0.38		2.12		0.32	0.53			0.21	0.14						
SCHOONERS	91	23.30	5.48	0.05		0.34	1.43	0.62	10.19		1.66	0.81		0.05	1.23	1.20	0.21			0.03		
SCHOONERS	92	21.60	3.23	0.03		0.14	1.00	0.21	13.50		0.91	0.89		0.01	1.16	0.39	0.07	0.01	0.02	0.00	0.03	
MOTHERSHIP	92	3.60	0.38		0.03	0.98	0.75		0.25	0.00	0.08	0.13	0.06	0.06	0.06	0.04	0.01	0.70		0.05		0.02
TOTAL	92	25.20	3.62	0.03	0.03	1.13	1.75	0.21	13.75	0.00	0.99	1.02	0.06	0.08	1.22	0.42	0.08	0.71	0.02	0.05	0.03	0.02
MOTHERSHIP	93	31.00	4.31	1.13	0.02	0.65	5.16			4.84	0.97	4.05	0.36	0.25	0.45	1.40				1.68		5.85

TABLE A1.10 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 6

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	43.00	17.87	1.35		1.06	1.26	2.90			2.99	6.22			6.68	1.41	0.18	0.36		0.61	0.33	
SCHOONERS	84	39.20	15.49	1.52		2.32	1.48	1.92			9.49	4.48		0.09	0.27	1.04	0.58	0.07		0.43	0.04	
WHALERS	85	2.90				0.07	0.64			0.61	0.29				0.05							1.24
SCHOONERS	85	35.00	18.26	0.76		1.27	2.00	0.30	0.36		4.29	4.93		0.19		1.18	0.71	0.17		0.55	0.02	
TOTAL	85	37.90	18.26	0.76		1.34	2.64	0.30	0.36	0.61	4.57	4.93		0.19	0.05	1.18	0.71	0.17		0.55	0.02	1.24
WHALERS	86	8.10				0.43	1.83			2.98	0.55				0.88							1.43
SCHOONERS	86	12.40	3.80	0.53		0.27	1.09	3.42			0.82	1.39		0.09	0.42	0.34		0.03		0.20		
TOTAL	86	20.50	3.80	0.53		0.70	2.92	3.42		2.98	1.37	1.39		0.09	1.30	0.34		0.03		0.20		1.43
WHALERS	87	6.60				0.59	1.75			2.11	0.37				0.42							1.36
SCHOONERS	87	76.30	37.20	3.61		1.27	4.96	9.12			4.81	8.23		0.59	2.01	1.52	1.20	0.80	0.01	0.90	0.08	
TOTAL	87	82.90	37.20	3.61		1.86	6.70	9.12		2.11	5.19	8.23		0.59	2.43	1.52	1.20	0.80	0.01	0.90	0.08	1.36
WHALERS	88	5.90				0.76	2.32			0.99	0.25				0.29							1.30
SCHOONERS	88	61.10	20.81	3.60		1.71	4.99	11.92			3.56	5.42		0.84	1.80	1.88	0.35	2.83	0.46	0.73	0.32	
TOTAL	88	67.00	20.81	3.60		2.47	7.30	11.92		0.99	3.81	5.42		0.84	2.09	1.88	0.35	2.83	0.46	0.73	0.32	1.30
WHALERS	89	6.60									3.52				1.17	0.73	1.17					
SCHOONERS	89	30.90	8.61	0.14		1.52	1.82	12.91			1.91	2.22		0.15	0.63	0.38	0.35			0.04	0.22	
TOTAL	89	37.50	8.61	0.14		1.52	1.82	12.91			5.43	2.22		0.15	1.80	1.11	1.53			0.04	0.22	
WHALERS	90	4.00	1.42	0.37		0.10					0.16						0.29		0.25			1.41
SCHOONERS	90	158.30	10.02	1.01		14.35	10.91	6.14	97.79		6.72	4.69		0.26	3.76	0.85	0.03	0.26	0.03	1.43	0.05	
TOTAL	90	162.30	11.44	1.38		14.45	10.91	6.14	97.79		6.88	4.69		0.26	3.76	0.85	0.32	0.26	0.27	1.43	0.05	1.41
WHALERS	91	2.20	0.53				0.90				0.77											
SCHOONERS	91	109.80	16.89	1.60		10.28	9.28	4.72	35.46		7.33	7.52		0.84	5.73	1.93	0.22	3.07	0.78	2.53	1.62	
MOTHERSHIP	91	127.20	14.03	1.02	0.45	5.18	14.62		59.10	1.03	3.92	3.52	4.06	1.67	0.81	2.40	2.30	4.11	0.32	8.55		0.11
TOTAL	91	239.20	31.45	2.62	0.45	15.47	24.80	4.72	94.56	1.03	12.02	11.03	4.06	2.51	6.54	4.33	2.52	7.17	1.10	11.08	1.62	0.11
WHALERS	92	21.90	4.30			0.58	3.61				1.70	0.06			0.02	0.15	1.01	3.17				7.29
SCHOONERS	92	52.10	11.33	0.40		0.55	2.63	0.09	30.75		1.89	1.38		0.05	1.23	0.49	0.30	0.03	0.02	0.80	0.15	
MOTHERSHIP	92	5.30	0.73	0.20		0.07	0.53		1.42		0.13	0.06	0.08	0.07	0.02	0.34	0.15		0.00	1.36		0.14
TOTAL	92	79.30	16.37	0.60		1.19	6.77	0.09	32.18		3.72	1.49	0.08	0.12	1.27	0.98	1.47	3.21	0.02	2.16	0.15	7.43
WHALERS	93	11.60	1.56			0.90	3.71				1.48	1.17			0.27	0.04	1.49	0.20	0.12			0.67
SCHOONERS	93	37.40	4.66	0.87		0.62	2.80	0.00	22.50		1.50	1.12		0.19	1.69	0.83	0.06	0.02	0.01	0.60	0.02	
MOTHERSHIP	93	0.20	0.03				0.02		0.06	0.01	0.01	0.02	0.03		0.01	0.01	0.00			0.00		0.00
TOTAL	93	49.20	6.25	0.87		1.52	6.53	0.00	22.56	0.01	3.00	2.31	0.03	0.19	1.98	0.88	1.54	0.21	0.13	0.60	0.02	0.67

TABLE A1.11 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 7

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	8.60	2.56	0.88		0.05	0.69	0.67			0.59	0.54			1.35	0.64	0.17	0.22	0.12		0.23	
SCHOONERS	84	25.70	9.69	1.01		1.75	1.29	0.89			4.10	2.06		0.61	0.06	1.50		1.36		1.38		
WHALERS	85	3.60				0.09	0.79			0.76	0.35				0.07							1.64
SCHOONERS	85	14.70	6.76	0.63		0.34	1.72	0.85			1.58	1.56		0.07		0.34	0.26	0.21		0.28	0.10	
TOTAL	85	18.30	6.76	0.63		0.43	2.51	0.85		0.76	1.93	1.56		0.07	0.07	0.34	0.26	0.21		0.28	0.10	1.64
WHALERS	86	9.90				0.53	2.23			3.64	0.67				1.07							1.76
SCHOONERS	86	34.90	16.46	0.60		1.29	3.21	2.22	0.06		3.62	5.68		0.20	0.46	0.64	0.29			0.16	0.03	
TOTAL	86	44.80	16.46	0.60		1.82	5.44	2.22	0.06	3.64	4.29	5.68		0.20	1.53	0.64	0.29			0.16	0.03	1.76
WHALERS	87	8.10				0.72	2.14			2.59	0.46				0.52							1.67
SCHOONERS	87	60.00	32.74	1.81		1.66	3.35	5.06			4.01	6.76		0.62	1.55	0.98	0.82	0.06	0.00	0.57	0.02	
TOTAL	87	68.10	32.74	1.81		2.38	5.49	5.06		2.59	4.47	6.76		0.62	2.07	0.98	0.82	0.06	0.00	0.57	0.02	1.67
WHALERS	88	7.20				0.93	2.83			1.20	0.31				0.35							1.58
SCHOONERS	88	36.40	9.48	0.87		2.23	2.72	5.79			2.89	2.85		1.33	1.39	1.14	0.28	3.03	0.18	2.22	0.01	
TOTAL	88	43.60	9.48	0.87		3.16	5.55	5.79		1.20	3.20	2.85		1.33	1.74	1.14	0.28	3.03	0.18	2.22	0.01	1.58

SECTOR 7 CONTINUED.

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
WHALERS	89	8.10	0.32								1.62					0.02	0.89					5.25
SCHOONERS	89	53.40	16.26	1.93		3.34	4.04	7.17			3.34	2.86		1.53	3.69	1.11	0.12	7.07	0.13	0.73	0.07	
TOTAL	89	61.50	16.69	1.93		3.34	4.04	7.17			4.96	2.86		1.53	3.69	1.13	1.01	7.07	0.13	0.73	0.07	5.26
SCHOONERS	90	64.60	9.41	0.61		6.22	5.98	0.61	26.45		1.89	3.90		0.33	3.58	1.12		0.15		4.17	0.16	
WHALERS	91	4.30	0.35			0.13	0.24				0.81				0.10	0.05	0.81	0.04	0.02			1.75
SCHOONERS	91	33.30	15.15	0.71		2.27	2.43		4.69		1.83	1.31		0.38	1.61	1.62	0.06	0.54	0.08	0.61		
MOTHERSHIP	91	4.10	1.18		0.04	0.55	0.49		0.87	0.00	0.17	0.11	0.14	0.05	0.06	0.04	0.12	0.09		0.17		
TOTAL	91	41.70	16.69	0.71	0.04	2.95	3.16		5.56	0.00	2.81	1.42	0.14	0.43	1.78	1.71	0.99	0.67	0.10	0.79		1.75
WHALERS	92	29.20	5.18	0.37			2.41				6.28				0.35	0.23	1.16	0.56				12.66
SCHOONERS	92	34.20	5.01	0.42		0.85	2.15	0.09	20.32		1.93	1.08	0.01	0.09	1.06	0.52	0.15	0.06	0.01	0.29	0.14	
TOTAL	92	63.40	10.20	0.78		0.85	4.66	0.09	20.32		8.22	1.08	0.01	0.09	1.41	0.75	1.31	0.63	0.01	0.29	0.14	12.66
WHALERS	93	20.30	0.62				2.76				5.51			0.28	0.75	1.76	0.62	0.20				7.80
SCHOONERS	93	2.30	0.82	0.06			0.12		0.61		0.23	0.20		0.02	0.11	0.08	0.02		0.01		0.02	
TOTAL	93	22.60	1.44	0.06			2.89		0.61		5.75	0.20		0.29	0.86	1.84	0.63	0.20	0.01		0.02	7.80

TABLE A1.12 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 8

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	8.60	2.82	1.66		0.07	0.07	1.22				0.98			1.62	0.21		0.04				
SCHOONERS	84	11.30	2.76			1.33	0.65	0.21			3.23	1.07						1.69		0.35		
SCHOONERS	85	9.20	3.24	0.20		1.02	0.63	0.13			0.86	1.24		0.20		1.37	0.09	0.19		0.14		
SCHOONERS	86	6.80	2.04	0.74		0.58	0.71	0.27			0.36	0.39		0.23	0.33	0.60		0.41	0.03	0.12		
SCHOONERS	87	33.80	12.92	1.06		4.02	2.70	0.96			1.71	2.44		1.28	0.66	0.69	0.16	4.54	0.41	0.17	0.11	
SCHOONERS	88	10.20	2.37	0.11		1.45	1.73	0.15			0.70	0.46		0.97	0.25	0.40		0.88	0.19	0.49	0.04	
SCHOONERS	89	16.80	3.09	0.29		0.22	0.89	10.44			0.39	0.62		0.08	0.60	0.15				0.01		
SCHOONERS	90	12.90	3.43	3.52		0.31	1.16	0.21	0.10		0.97	0.79		0.04	0.35	1.16	0.27		0.02	0.40	0.17	
SCHOONERS	91	16.60	1.75			1.08	1.60	0.09	2.61		1.62	0.54		0.81	2.29	0.04		2.96	0.29	0.62	0.29	
SCHOONERS	92	5.40	1.52	0.29		0.66	1.99		0.08		0.18	0.23		0.01	0.11	0.26	0.01			0.06		
SCHOONERS	93	7.00	1.34	0.24		0.42	1.03	0.07	0.74		0.27	0.16		0.16	0.17	0.64	0.01	1.60	0.09	0.03	0.04	

TABLE A1.13 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 9

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	140.40	20.90	9.04		21.03	16.95	22.06			13.82	5.96		0.58	6.40	8.52	0.44	8.34		6.22	0.15	
SCHOONERS	84	100.00	27.98	4.54		12.64	10.40	3.68			9.94	7.69		2.91	0.03	3.59	3.44	8.66	0.30	4.05	0.16	
WHALERS	85	1.00				0.02	0.22			0.21	0.10				0.02							0.43
SCHOONERS	85	44.10	14.48	2.40		3.22	7.85	0.58	0.14		4.16	4.74		0.64	0.06	2.46	0.47	1.70		1.17	0.02	
TOTAL	85	45.10	14.48	2.40		3.26	8.07	0.58	0.14	0.21	4.26	4.74		0.64	0.08	2.46	0.47	1.70		1.17	0.02	0.43
WHALERS	86	2.70				0.14	0.61			0.99	0.18				0.29							0.48
SCHOONERS	86	159.90	56.89	9.01		10.20	20.99	7.32			11.11	10.96		3.69	3.99	4.80	1.55	10.77	1.50	5.74	1.40	
TOTAL	86	162.60	56.89	9.01		10.34	21.59	7.32		0.99	11.29	10.96		3.69	4.28	4.80	1.55	10.77	1.50	5.74	1.40	0.48
WHALERS	87	2.20				0.20	0.58			0.70	0.12				0.14							0.46
SCHOONERS	87	81.30	14.74	3.54		8.75	9.05	6.98	0.04		4.11	4.47		4.41	3.27	2.19	1.51	15.19	1.10	1.23	0.72	
TOTAL	87	83.50	14.74	3.54		8.94	9.63	6.98	0.04	0.70	4.23	4.47		4.41	3.41	2.19	1.51	15.19	1.10	1.23	0.72	0.46

TABLE A1.14 : SECTOR 9 CONTINUED.

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
WHALERS	88	2.00				0.26	0.79			0.33	0.08				0.10							0.44
SCHOONERS	88	142.60	33.96	6.11		12.01	20.78	10.71			6.14	7.25		7.97	3.62	5.70	0.98	21.75	1.45	3.42	0.74	
TOTAL	88	144.60	33.96	6.11		12.27	21.57	10.71		0.33	6.23	7.25		7.97	3.72	5.70	0.98	21.75	1.45	3.42	0.74	0.44
WHALERS	89	2.20				0.28	0.86			0.37	0.09				0.11							0.48
SCHOONERS	89	213.40	36.18	7.21		16.69	34.49	43.33			7.90	10.37		7.63	8.38	4.46	0.95	30.84	0.75	3.88	0.34	
TOTAL	89	215.60	36.18	7.21		16.98	35.35	43.33		0.37	8.00	10.37		7.63	8.48	4.46	0.95	30.84	0.75	3.88	0.34	0.48
SCHOONERS	90	109.80	34.17	5.98		6.69	23.42	0.36	4.32		3.94	7.48		1.90	2.93	6.88	0.23	6.97	0.14	4.41		
WHALERS	91	2.20					0.17				0.23				0.06	0.49						1.24
SCHOONERS	91	93.10	23.39	2.91		6.11	9.20	1.55	4.05		6.56	3.43		3.26	3.83	3.05	0.63	18.51	1.21	2.94	2.46	
TOTAL	91	95.30	23.39	2.91		6.11	9.37	1.55	4.05		6.80	3.43		3.26	3.89	3.54	0.63	18.51	1.21	2.94	2.46	1.24
WHALERS	92	7.30	0.45				1.72				1.66											3.48
SCHOONERS	92	48.50	11.39	2.12		3.10	10.10	0.73	7.80		2.53	2.84		0.38	1.47	1.73	0.60	1.15	0.11	1.53	0.92	
TOTAL	92	55.80	11.84	2.12		3.10	11.82	0.73	7.80		4.17	2.84		0.38	1.47	1.73	0.60	1.15	0.11	1.53	0.92	3.48
SCHOONERS	93	49.10	22.68	2.32		0.54	5.48		4.84		2.98	3.44		0.30	1.24	1.82	0.18	2.46	0.03	0.77	0.05	

TABLE A1.15 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 10

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	14.30	3.97	1.25		0.17	0.89	0.96			2.28	0.35			2.50	1.19	0.22	0.11		0.40		
SCHOONERS	84	32.50	7.51	3.14		1.12	3.90	1.47			3.36	1.74		0.49		5.96	1.74	0.33		1.54	0.21	
WHALERS	85	2.70				0.07	0.60			0.57	0.27				0.06							1.15
SCHOONERS	85	22.10	6.45	0.78		1.60	5.66	0.66	0.13		2.03	2.45		0.12		0.86	0.14	0.34	0.05	0.77	0.07	
TOTAL	85	24.80	6.45	0.78		1.66	6.25	0.66	0.13	0.57	2.30	2.45		0.12	0.06	0.86	0.14	0.34	0.05	0.77	0.07	1.15
WHALERS	86	7.40				0.40	1.67			2.72	0.50				0.80							1.31
SCHOONERS	86	47.30	11.14	0.82		3.78	6.98	1.69			2.19	2.09		2.24	0.96	0.99	0.30	11.76	0.34	0.69	1.33	
TOTAL	86	54.70	11.14	0.82		4.18	8.65	1.69		2.72	2.69	2.09		2.24	1.76	0.99	0.30	11.76	0.34	0.69	1.33	1.31
WHALERS	87	6.00				0.53	1.59			1.92	0.34				0.38							1.24
SCHOONERS	87	61.30	8.50	1.69		6.18	9.44	5.73			2.81	2.33		4.31	1.19	2.48	0.49	13.30	0.92	1.32	0.61	
TOTAL	87	67.30	8.50	1.69		6.72	11.03	5.73		1.92	3.15	2.33		4.31	1.57	2.48	0.49	13.30	0.92	1.32	0.61	1.24
WHALERS	88	5.40				0.70	2.12			0.90	0.23				0.27							1.19
SCHOONERS	88	45.10	11.20	1.87		3.07	9.20	0.96			1.52	1.53		2.75	0.73	1.19	0.24	8.78	0.49	1.20	0.35	
TOTAL	88	50.50	11.20	1.87		3.77	11.32	0.96		0.90	1.75	1.53		2.75	1.00	1.19	0.24	8.78	0.49	1.20	0.35	1.19
WHALERS	89	6.00	1.07	0.08		0.04	1.26				0.36	0.36		0.07	0.08	0.29	2.36			0.02		0.01
SCHOONERS	89	44.90	16.65	1.39		2.08	8.42	1.13			1.87	2.60		0.72	2.85	2.45	0.30	2.94	0.08	1.18	0.23	
TOTAL	89	50.90	17.72	1.47		2.12	9.68	1.13			2.23	2.96		0.79	2.93	2.74	2.66	2.94	0.08	1.20	0.23	0.01
WHALERS	90	4.00	0.28			0.53	1.47					0.88		0.09		0.20				0.34		0.21
SCHOONERS	90	29.10	8.65	0.39		3.08	3.71	0.37	3.98		1.95	1.49		0.52	2.29	1.20	0.05	0.83	0.16	0.44	0.01	
TOTAL	90	33.10	8.93	0.39		3.60	5.18	0.37	3.98		1.95	2.37		0.61	2.29	1.40	0.05	0.83	0.16	0.77	0.01	0.21
WHALERS	91	2.20	0.28	0.20		0.56	0.87				0.03			0.04		0.06		0.13	0.04			
SCHOONERS	91	39.90	4.27	1.80		7.92	6.59	0.08	2.39		1.52	1.09		0.85	0.75	2.60		8.87	0.33	0.37	0.48	
TOTAL	91	42.10	4.55	2.00		8.48	7.46	0.08	2.39		1.55	1.09		0.88	0.75	2.66		9.00	0.37	0.37	0.48	
WHALERS	92	19.50	2.99	0.63		0.07	12.06				0.79	0.59		0.07	0.08	0.16	0.45		0.03			1.57
SCHOONERS	92	25.20	6.93	0.81		0.99	3.53	1.91	5.41		1.62	1.10		0.05	0.66	0.53	0.13	1.27	0.07	0.08	0.10	
TOTAL	92	44.70	9.92	1.44		1.06	15.59	1.91	5.41		2.41	1.69		0.13	0.75	0.70	0.57	1.27	0.10	0.08	0.10	1.57
WHALERS	93	17.40	1.55	0.18		1.36	9.64		1.28		0.40	0.73			0.03	0.97	0.17			0.33		0.75
SCHOONERS	93	7.00	3.64	0.14		0.62	0.59		0.02		0.37	0.78		0.13	0.20	0.13	0.02	0.17	0.00	0.18	0.00	
TOTAL	93	24.40	5.19	0.32		1.98	10.23		1.31		0.77	1.51		0.13	0.24	1.11	0.19	0.17	0.00	0.52	0.00	0.75

TABLE A1.16 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 11

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
MOTHERSHIP	91	201.26	4.13		0.67	28.65	27.36		78.47	1.98	12.11	8.90	5.76	3.51	2.08	0.46	0.06	10.42	0.83	16.30		0.67
MOTHERSHIP	92	60.66	0.31	0.14	0.04	4.53	14.44		14.14	2.63	1.95	1.72	1.63	0.57	0.44	0.18		4.61	0.14	2.40		0.80
MOTHERSHIP	93	18.09	0.84	0.10	0.00	0.08	2.20		6.77	2.88	1.08	0.44	0.66	0.18	0.20	0.30		0.39		1.76		1.21

TABLE A1.17 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 12

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
WHALERS	85	0.30				0.01	0.07			0.06	0.03				0.01							0.13
WHALERS	86	0.70				0.04	0.16			0.26	0.06				0.08							0.12
WHALERS	87	0.60				0.06	0.16			0.19	0.03				0.04							0.12
SCHOONERS	87	5.00		0.06		1.47	0.82	0.09			0.19	0.02		0.43	0.86			0.42	0.35	0.29		
TOTAL	87	5.60		0.06		1.53	0.98	0.09		0.19	0.22	0.02		0.43	0.89			0.42	0.35	0.29		0.12
WHALERS	88	0.60				0.06	0.20			0.08	0.02				0.02							0.11
WHALERS	89	0.60				0.08	0.24			0.10	0.03				0.03							0.13
MOTHERSHIP	91	0.70			0.01	0.00	0.24		0.14		0.07	0.01	0.00	0.02	0.02	0.01		0.14		0.04		
WHALERS	92	2.40	0.01			1.67	0.48									0.07				0.27		
SCHOONERS	92	2.40				0.74	0.39		0.14		0.03	0.03		0.26	0.42	0.01		0.29		0.10		
TOTAL	92	4.80	0.01			2.30	0.87		0.14		0.03	0.03		0.26	0.42	0.08		0.29		0.38		
WHALERS	93	2.90	0.20				1.28				0.08			0.04		0.06						1.26
MOTHERSHIP	93	1.10					0.28		0.23	0.01	0.18	0.01	0.06	0.02	0.06	0.00		0.07		0.16		0.03
TOTAL	93	4.00	0.20				1.56		0.23	0.01	0.26	0.01	0.06	0.06	0.06	0.06		0.07		0.16		1.27

TABLE A1.18 . ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 13

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	83	51.60	1.38			19.22	3.35	2.74			9.71	3.96		2.21	2.62	0.13	0.07	5.21		1.01		
SCHOONERS	84	35.20	1.16	0.12		5.94	2.93	3.96	0.02		5.42	2.29		2.33	0.33	0.26	0.01	9.23	0.01	1.00	0.19	
WHALERS	85	0.40				0.01	0.09			0.08	0.04				0.01							0.17
SCHOONERS	85	48.70	0.72			7.82	6.06	0.64	0.30		1.74	1.66		7.38	1.30	0.23		20.13	0.12	0.62		
TOTAL	85	49.10	0.72			7.83	6.14	0.64	0.30	0.08	1.78	1.66		7.38	1.31	0.23		20.13	0.12	0.62		0.17
WHALERS	86	1.00				0.05	0.23			0.37	0.07				0.11							0.18
SCHOONERS	86	4.50	0.03			2.29	1.14	0.03			0.06	0.08		0.47	0.24	0.01		0.06		0.11		
TOTAL	86	5.50	0.03			2.34	1.37	0.03		0.37	0.11	0.08		0.47	0.34	0.01		0.06		0.11		0.18
WHALERS	87	0.80				0.07	0.21			0.26	0.05				0.05							0.16
SCHOONERS	87	45.00	0.16			11.59	3.24	0.63	0.03		0.72	0.83		4.97	3.00	0.04		18.61	0.75	0.27	0.17	
TOTAL	87	45.80	0.16			11.66	3.45	0.63	0.03	0.26	0.76	0.83		4.97	3.05	0.04		18.61	0.75	0.27	0.17	0.16
WHALERS	88	0.70				0.09	0.28			0.12	0.03				0.03							0.15
SCHOONERS	88	40.70	0.06			11.73	4.45	0.43			0.08	0.39		4.52	3.95	0.01		14.95	0.01	0.12		
TOTAL	88	41.40	0.06			11.82	4.73	0.43		0.12	0.11	0.39		4.52	3.98	0.01		14.95	0.01	0.12		0.15
WHALERS	89	0.80	0.06	0.00	0.01	0.10	0.06				0.00	0.02		0.21	0.04	0.02		0.11	0.05	0.01		0.08
SCHOONERS	89	28.10	0.12	0.53		6.09	0.91	7.73			0.90	1.32		0.59	2.76	0.01		1.04	0.03	6.07	0.01	
TOTAL	89	28.90	0.18	0.53	0.01	6.20	0.97	7.73			0.90	1.34		0.81	2.79	0.03		1.16	0.08	6.08	0.01	0.08
SCHOONERS	90	22.60	3.12	0.18		3.43	0.90	0.14	0.90		0.68	1.03		2.32	2.55	0.24	0.44	5.63		1.03		
WHALERS	91	4.30				3.13	0.84					0.03		0.12		0.07		0.07	0.04			
SCHOONERS	91	31.60	0.41			8.10	2.50	0.98	3.47		0.39	3.13		0.41	1.46	0.23		1.65	0.24	8.54	0.11	
MOTHERSHIP	91	13.94	0.14		0.09	1.87	1.17		6.22		0.82	0.34	0.25	0.20	0.06	0.11	0.01	0.50	0.02	2.07		0.09
TOTAL	91	49.84	0.54		0.09	13.10	4.51	0.98	9.69		1.21	3.50	0.25	0.72	1.51	0.41	0.01	2.21	0.30	10.61	0.11	0.09
SCHOONERS	92	39.60	2.29	1.71		6.31	7.56	0.71	10.72		1.64	1.80		0.16	1.73	0.73	0.09	0.67	0.06	3.36	0.10	
MOTHERSHIP	92	89.99	1.71	0.10	0.16	8.18	6.12		45.61	0.40	7.20	2.56	3.31	0.81	1.87	0.94	0.01	0.97	0.03	6.85		3.27
TOTAL	92	129.69	4.00	1.81	0.16	14.49	13.67	0.71	56.22	0.40	8.84	4.36	3.31	0.96	3.59	1.67	0.09	1.64	0.09	10.20	0.10	3.27
SCHOONERS	93	10.60	1.66	0.77		1.52	1.28	0.66	0.84		0.35	0.78		0.42	0.92	0.47	0.01	0.07	0.02	0.73	0.01	

TABLE A1.19 · ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 14

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	91	3.30		0.08		0.69	0.03	0.01			0.05				0.38				0.00	2.06	0.01	
MOTHERSHIP	91	71.85			0.08	15.15	3.72		6.37	0.06	2.88	9.82	0.03	2.43	6.26	0.78	0.13	4.67		19.55		0.05
TOTAL	91	75.15		0.08	0.08	15.84	3.74	0.01	6.37	0.06	2.92	9.82	0.03	2.43	6.64	0.78	0.13	4.67	0.00	21.60	0.01	0.05
SCHOONERS	92	1.80				0.42	0.02		0.06		0.00	0.04		0.02	0.26		0.01	0.01	0.00	0.95		
MOTHERSHIP	92	370.08			0.08	17.32	19.79		38.46	19.40	16.66	33.87	1.24	4.67	12.13	0.11	1.13	18.57	1.06	170.41		15.18
TOTAL	92	371.88			0.08	17.74	19.81		38.52	19.40	16.66	33.91	1.24	4.69	12.40	0.11	1.14	18.58	1.07	171.35		15.18
MOTHERSHIP	93	32.23			0.00	2.64	1.53			3.26	1.31	2.67	0.04	0.59	2.05					14.85		3.27

TABLE A1.20 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 15

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
MOTHERSHIP	92	21.59			0.04		0.70		4.89	0.05	2.16	2.06	0.01	0.29	2.20	0.00	0.00	0.01		7.89		1.29

TABLE A1.21 : ESTIMATED SPECIES CATCHES (MT) PER YEAR BY BOAT-TYPE IN SECTOR 99 (BY SEYCHELLOIS BOATS ONLY)

BOAT-TYPE	YEAR	TOTAL	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTX	MACO	V.PL	TIOF	CROI	SERX	C.BL	G.LO	LASC	D.BE	C.RO	BACS	LETX
SCHOONERS	93	3.50	0.16	0.03		0.41	0.19		1.80		0.11	0.32		0.02	0.33	0.00				0.10	0.02	
MOTHERSHIP	93	228.86	0.29				6.23		185.98	0.77	6.79	12.21	7.93	0.60	2.63		1.07	2.92		0.08		1.37
TOTAL	93	232.36	0.45	0.03		0.41	6.42		187.78	0.77	6.90	12.54	7.93	0.62	2.96	0.00	1.07	2.92		0.18	0.02	1.37

ESTIMATION OF CATCH RATES.

Catch rates by location and boat category per annum are indicated in Table A1.22. These data have not been standardised to account for changes in vessel design or gear over time within boat category, and also are not adjusted for seasonal variations. They illustrate, together with Figs (22-35) locations and boat categories where catch rate changes may be evident thus warranting more detailed examination (5.1.1) for further detail.

Table A1.22 Average annual catch rates by boat type and location.

Boattype	Sector	Catch Rates : kg/man-day 83	84	85	86	87	88	89	90	91	92	93
small boats	1			13.23	12.36	9.63	10.91	14.39	14.64	16.56	17.77	16.01
whaler	1			17.16	28.64	31.36	37.26	18.25	29.06	23.46	17.29	16.42
Schooner	1				12.38			42.36	53.31	38.36	47.94	
Mother-ship	1											168.49
whaler	2							55.89	42.79	39.22	22.14	41.57
Schooner	2	18.89	23.97	29.88	22.68	31.72	31.87	16.59	54.64	25.49	19.08	38.07
whaler	3							20.78	68.85	55.47	55.35	105.28
Schooner	3	20.55	19.20	21.82	29.15	28.44	25.38	46.04	43.23	35.64	49.59	32.70
whaler	4								26.29	14.31	20.41	27.78
Schooner	4	19.78	20.28	23.43	27.65	28.81	29.06	46.03	37.15	33.12	41.77	39.58
Schooner	5	28.86	34.23	30.18	32.32	29.61	21.76		46.51	48.81	46.81	
Mother-ship	5										59.33	218.27
whaler	6							6.18	31.31	7.86	17.21	16.50
Schooner	6	26.42	29.82	36.98	37.48	34.87	36.27	39.37	68.30	35.18	49.10	42.14
Mother-ship	6									99.83	44.50	14.00
whaler	7							16.73		28.80	8.43	13.59
Schooner	7	16.93	18.68	26.80	30.10	31.57	27.63	37.69	61.92	33.22	49.86	39.31
Mother-ship	7									79.00		
Schooner	8	41.91	20.44	23.25	27.96	23.45	22.36	46.68	42.07	32.78	33.99	35.61
whaler	9									12.67	6.96	
Schooner	9	39.03	34.56	26.02	29.71	24.98	28.59	42.21	41.42	35.81	40.04	32.41
whaler	10							98.08	36.81	45.71	39.82	55.94
Schooner	10	28.16	29.89	33.28	27.22	23.66	29.30	37.52	49.21	23.56	35.80	36.76
Mother-ship	11									101.70	79.26	110.30
whaler	12										259.70	39.70
Schooner	12					30.26					28.80	
Mother-ship	12									68.70		44.04
whaler	13							91.11		71.70		
Schooner	13	35.29	25.26	27.91	28.47	31.60	32.07	61.54	41.76	39.42	38.72	30.68
Mother-ship	13									91.08	99.10	
Schooner	14									67.69	46.15	
Mother-ship	14									203.54	163.39	319.14
Mother-ship	15										136.65	
Schooner	99											34.89
Mother-ship	99											192.81

ANNEX 2 : CATCH AND EFFORT DATA FOR TRADITIONAL WHALERS IN SECTOR 1 AND SELECTION OF DATA SET.

Sector 1, the inshore area of Mahe Plateau, was subject to the greatest fishing pressure. Schooners rarely fished in this location except during rough weather during the SE Trade Winds and consistent data was only available for small boats and whalers. Unfortunately these data sets were the least good in terms of data quality, lacking much species definition, location specific-, depth- and other details. During July 1989 an improved data collection system was introduced for the whalers, and this was incorporated fully into the SFA data collection programme in 1990. It is this data set which offers the most scope for examination of multi-species fisheries problems within sector 1.

Reporting of location by whalers was poor and a large number of data have been excluded from the analysis for lack of this information. Specific locations reported relate to the nearest island, or a direction from an island within sector 1. Catch rates by specific location are indicated in Figs. A.2.1-5, and for aggregated data for all of sector 1 in Fig. A.2.6. The data relate to traditional whalers only catching 85% or more demersal species by weight.

Whalers traditionally target carangidae, but are able easily to switch target species. In order to be confident that the fishing effort applied was targeted at demersal fish, only the sub set of data for which 85% or more of the catch consisted of these species was considered. This cut off point was selected since the schooners and mothership venture, known to target specifically demersal species land approximately 85% demersal species and 15% others. This, however, reduces the sample size examined (Fig. A.2.7).

The following data has not been standardised for seasonal effects (known to be significant, see below). Since the 1989 data relates only to a 6 month period, standardisation may result in a different pattern than that shown in Fig.A.2.6.

Figs. A.2.1-5 : Catch rates (kg / man-day for all demersal species) by reported fishing location within sector 1 for traditional whalers landing a catch of which 85% was demersal species.

Fig. A.2.1.

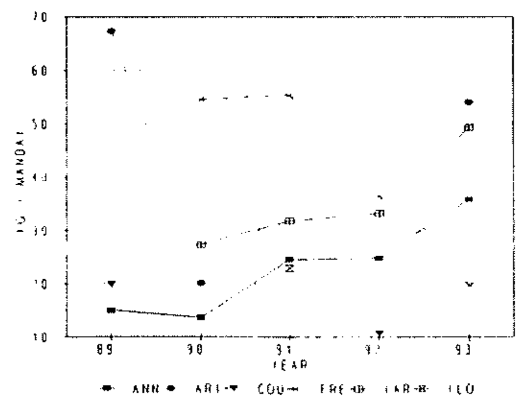


Fig. A.2.2.

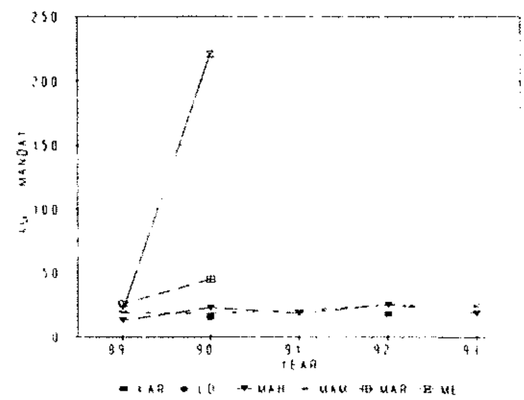


Fig A.2.3.

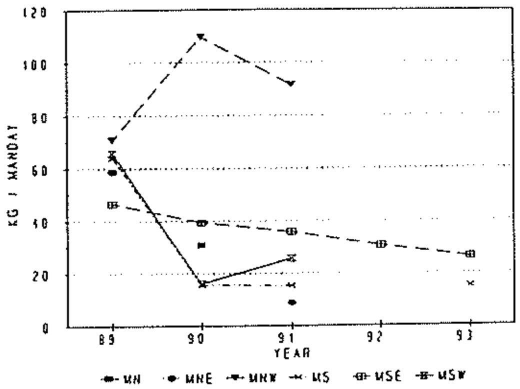


Fig. A.2.4.

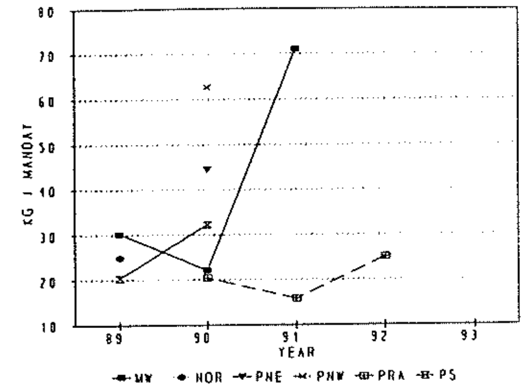


Fig. A.2.5.

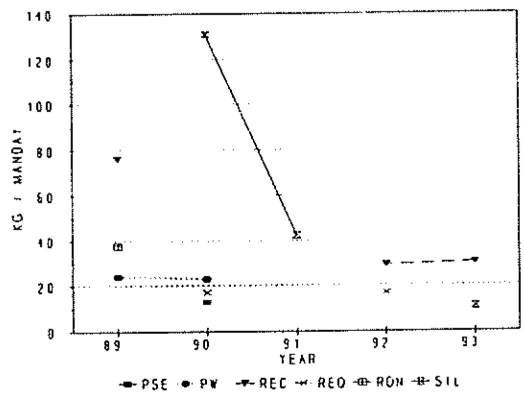


Fig. A.2.6. : Aggregated data for sector 1, traditional whalers, showing cpue where demersal species form 1-100% of the catch.

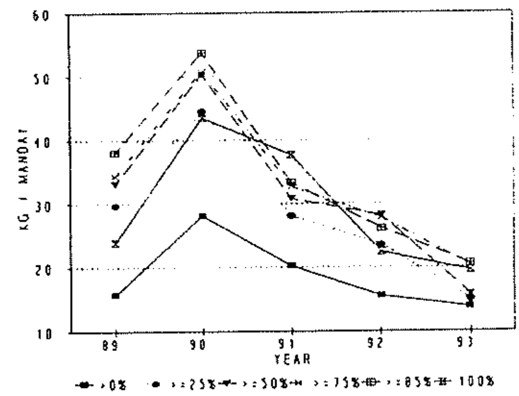


Fig. A.2.7. The number of traditional whalers sampled each year from sector 1 where demersal species form 1-100% of the catch.

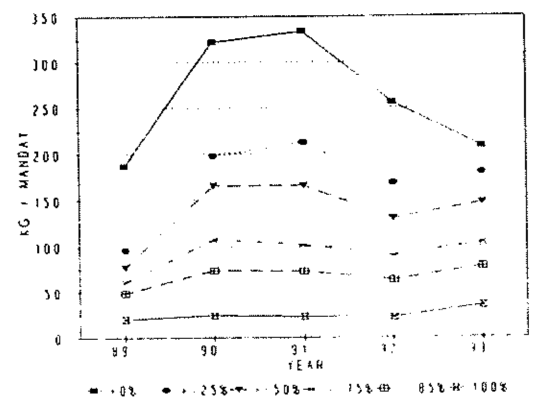


Fig. A.2.8 : Catch rate data from 1985-1989 from the ARTFISH database for all trips during which demersal species were caught, and data from WHALER since 1989

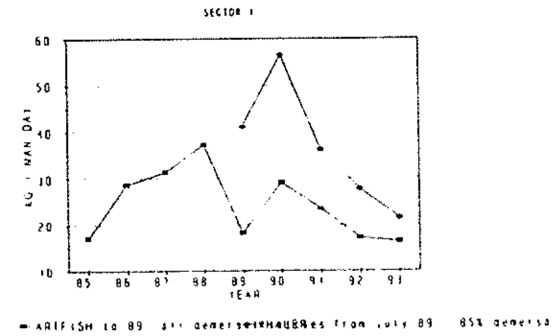


TABLE A.2.1 The number of trips sampled by fishing ground per annum for traditional whalers catching 85% or more demersal species within sector 1.

F_GROUND	89	90	91	92	93	TOTAL
AREA : UNCERTAIN						
IAR	0	1	4	1	1	7
KAR	0	0	0	1	0	1
REQ	0	1	0	4	0	5
TOT 0	0	2	4	6	1	13
AREA : MAHE						
ANN	6	4	8	4	4	26
ILO	0	0	1	0	0	1
MAH	4	3	4	25	38	74
ME	1	1	0	0	0	2
MN	0	1	0	0	0	1
MNE	2	0	1	0	0	3
MNW	1	2	2	0	0	5
MS	4	1	3	0	5	13
MSE	5	4	15	1	4	29
MSW	1	1	1	0	0	3
MW	8	2	1	0	0	11
RON	1	0	0	0	0	1
TOT MAHE	33	19	36	30	51	169
AREA : PRASLIN						
ARI	1	1	0	0	2	4
COU	1	0	0	1	0	2
LD	0	1	0	0	0	1
MAR	1	1	0	0	0	2
PNE	0	3	0	0	0	3
PNW	0	2	0	0	0	2
PRA	0	2	4	2	0	8
PS	2	2	0	0	0	4
PSE	0	1	0	0	0	1
PW	1	3	0	0	0	4
TOT PRASLIN	6	16	4	3	2	31
MAMMELLES	7	20	21	14	6	68
AREA : NORTH ISLAND AND SILHOUETTE						
NOR	2	0	0	0	0	2
SIL	0	1	3	0	1	5
TOT NOR/SIL	2	1	3	0	1	7
AREA : FREGATE AND RECIF						
FRE	0	16	5	4	14	39
REC	1	0	0	6	3	10
TOT FRE/REC	1	16	5	10	17	49
TOTAL	49	74	73	63	78	337

The new WHALER data set examined indicated a dramatic decrease in catch rates in sector 1 since 1990. Whilst the previous ARTFISH database had no location specific details it may be assumed that most of the fishing occurred in this sector. This data indicates that for all trips during which demersal species were caught, catch rates increased up to 1988, but dropped suddenly in 1989. From 1990 catch rates are derived from the WHALER database. These are compared with the present data set for traditional whalers only catching at least 85% demersal species (Fig. A.2.8). The gradual rise in catch rate may indicate the shift in importance of demersal species to the whaler fishery from the traditional carangid species targeted. 1988 data is not incompatible with that seen in 1990 from the revised data collection method and would suggest that the observed effects are not anomalous. Unfortunately, due to the lack of location specific detail the information prior to July 1989 cannot be included in the analysis.

For unstandardised data from the WHALER database, few individual locations indicated a decline in catch rate (Figs. A.2.1-2.5). At the level of individual 'fishing grounds' there are few sampled data each year (frequently 1-5, Table A.2.1) which may skew the results. Also, whilst analyses relating to specific locations are the ideal, those reported by whalers are vague and the area fished cannot be calculated. It is necessary to assume that within sector 1 full mixing of demersal species occurs and that they may be treated as a single populations (see 3.3). Aggregated data may then be used for further analysis.

Species catch rates for data aggregated over all of Sector 1 for traditional whalers catching at least 85% demersal species indicate that the most important species were bourgeois and Job Gris for lutjanids, Maconde for serranids and Capitaine Blanc for lethrinids (Table A.2.2). A dramatic decline in catch rate for lutjanids is indicated since 1989 (Figs. A.2.8, A.2.9).

Monthly data aggregated over the period 1989-1993 indicated a seasonal pattern of catch rates for demersal species (Fig A.2.11) which may be related to the prevailing wind patterns (see 2.2). The pattern was most prominent for lutjanids (Fig A.2.12).

Fig. A.2.11. Monthly catch rates for the total and demersal catch (1989-93)

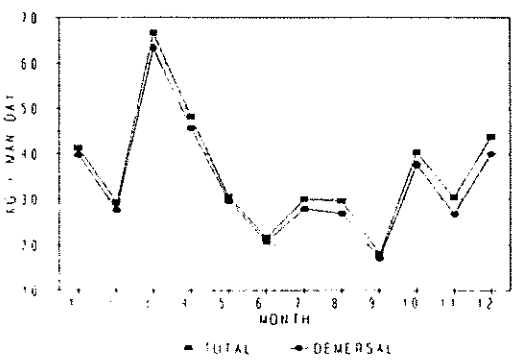


Fig. A.2.12 : Monthly catch rates by family (1989-1993)

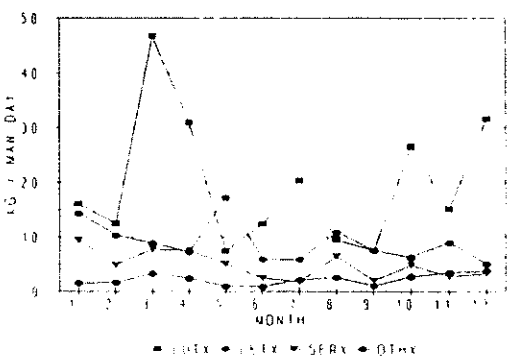


Table A.2.2. Non standardised catch rates (kg / man-day) by species for traditional whalers catching at least 85% demersal species

YEAR	BOUR	BORD	THER	VARA	JOBG	JOBJ	BATR	LUTJ	MACO	V_PL	TIOF	CROI	SERR	C_BL	G_LO	LASC	D_BE	C_RO	BACS	LETH	LUTX	LETX	SERX	OTHX	DEME
89	8.50	3.71	0.00	3.22	11.28	0.00	0.21	0.91	1.76	1.08	0.00	0.11	0.46	1.68	0.81	0.00	0.36	0.26	0.00	3.67	27.84	6.79	3.41	2.97	38.04
90	6.33	1.37	0.23	3.64	18.85	0.00	5.73	0.00	3.53	1.72	0.00	0.44	1.02	2.08	1.12	0.38	0.38	1.64	0.00	5.29	36.15	10.89	6.72	2.78	53.76
91	8.51	1.99	0.27	1.98	6.78	0.00	0.02	0.01	2.11	1.08	0.00	1.71	0.56	1.73	1.65	0.14	0.51	0.24	0.00	4.10	19.56	8.38	5.45	2.80	33.40
92	6.99	1.83	0.03	0.22	3.66	0.00	0.20	0.00	3.26	0.46	0.00	0.50	1.36	0.90	1.24	0.34	0.35	0.18	0.00	4.66	12.92	7.68	5.57	1.65	26.18
93	5.22	0.42	0.02	0.04	1.84	0.00	0.03	0.00	2.81	0.04	0.00	0.09	1.03	0.43	1.32	0.04	1.09	0.26	0.00	6.94	7.56	9.07	3.98	0.93	20.61

Fig. A.2.9. Species composition (%) by family.

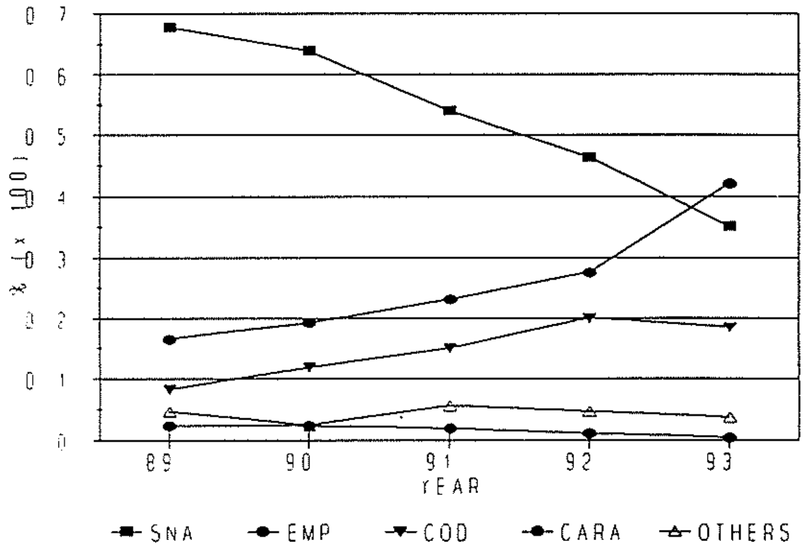
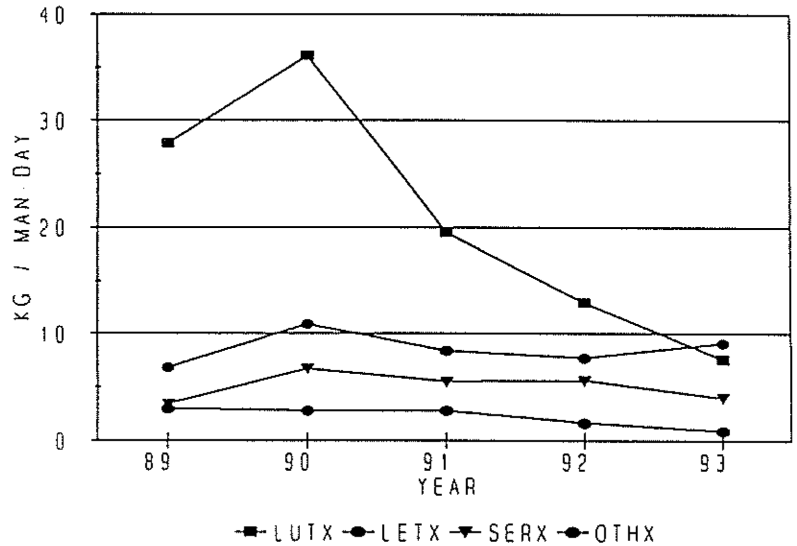


Fig. A.2.10. Family catch rates (kg/man-day)



Standardisation of catch rate data

Within sector 1 variation in catch rate may be attributed to seasonality, boat type, and specific fishing location. Depth and fishing method are constant. GLIM (Francis *et al*) was applied in order to derive standardised annual catch rates (see 5.1.2) for the major species indicated above and for family groupings for the remainder. Initially, based on the premise that sector 1 encompasses single populations of the demersal species studied, analyses tested only month and year interactions, standardising the annual data for the monthly variation observed. This model did not fit all the species data, so season was substituted for month (see 5.1.2. and Figs 40 & 41). There were still some data which could not be fitted to the model and also standardised catch rates for certain species showed unusual trends. Fishing ground could not be included owing to the large number of locations and small number of data points. Fishing areas (1-5) were selected (Table A.2.1) based on proximity to various island groups. Differences in catch rate by species occurred between these areas (see 5.1.2, Fig. 38)

In an attempt to increase sample size, boat type was originally included in the GLIM analysis. However, a significant year.boat interaction was found to occur ($F=3.2$, $df1=5$, $df2=407$, $p=0.0074$). Subsequent analyses examined only traditional whalers (> =85%D) in sector 1 (TRAW1).

For all of sector 1 the model :

1 + year + month + year.month (summarised as year*month)

was fitted (Table A.2.3.).

Table A.2.3. Results of GLIM analysis for the model year*month, TRAW1.

SPECIES	FACTOR	F	df1	DF2	p	SIGNIFICANT
Demersal	year.month	0.93	38	283	0.5874	no
	month	12.15	11	321	0.0000	highly
	year	28.40	4	321	0.0000	highly
Bourgeois	year.month	0.65	38	283	0.9434	no
	month	7.51	11	321	0.0000	highly
	year	8.87	4	321	0.0000	highly
Job Gris	year.month	1.01	38	283	0.4546	no
	month	11.71	11	321	0.0000	highly
	year	31.60	4	321	0.0000	highly
Lutjanids	year.month	no fit - floating point error				
Maconde	year.month	1.16	38	283	0.2535	no
	month	3.82	11	321	0.0000	highly
	year	0.71	4	321	0.5830	no
Serranids	year.month	0.38	38	283	0.9997	no
	month	8.59	11	321	0.0000	highly
	year	11.72	4	321	0.0000	highly
Cap. Blanc	year.month	2.27	38	283	0.0001	Yes : cannot simplify model to (y + m)
	month	3.80	11	321	0.0000	Yes : ignores year.month interaction
	year	7.55	4	321	0.0000	Yes : ignores year.month interaction
Lethrinids	year.month	2.13	38	283	0.0003	Yes : cannot simplify model to (y + m)

With the exception of the guilds other lutjanids, other lethrinids, and the species Capitaine Blanc, no year.month interaction occurred and it was possible to determine standardised annual catch rates which accounted for the significant monthly variation (Table A.2.3). Annual catch rate changes were also shown to be significant. However, for the species maconde, neither month nor year was significant implying that no change in the abundance of this species occurred with time.

In an attempt to fit a model to lutjanids, lethrinids and Capitaine Blanc the model year*season was tried, and for Capitaine Blanc year.*hilo (high and low seasons, Table A.2.4.). A simplified model permitting assessment of standardised catch rates was possible for all species except Serranids and Capitaine Blanc. No model could be fitted to Capitaine Blanc (including hilo) and the monthly model was fitted ignoring the 2 factor interaction observed (Table A.2.3).

Table A.2.4. Results of GLIM analysis for the model year*season, TRAW1.

SPECIES	FACTOR	F	df1	DF2	p	SIGNIFICANT
Demersal	year.season	1.08	11	318	0.3771	no
	season	30.48	3	329	0.0000	highly
	year	25.83	4	329	0.0000	highly
Bourgeois	year.season	0.67	11	318	0.7629	no
	season	17.13	3	329	0.0000	highly
	year	7.45	4	329	0.0000	highly
Job Gris	year.season	0.38	11	318	0.9651	no
	season	16.77	3	329	0.0000	highly
	year	25.78	4	329	0.0000	highly
Lutjanids	year.season	0.16	11	318	0.9992	no
	season	11.83	3	329	0.0000	highly
	year	11.44	4	329	0.0000	highly
Maconde	year.season	1.55	11	318	0.1124	no
	season	10.80	3	329	0.0000	highly
	year	0.71	4	329	0.5878	no
Serranids	year.season	4.40	11	318	0.0000	Yes : cannot simplify model to (y + s)
Cap. Blanc	year.season	3.28	11	318	0.0003	Yes : cannot simplify model to (y + s)
	year.hilo	5.58	4	327	0.0002	Yes : cannot simplify model to (y + h)
Lethrinids	year.season	1.37	11	318	0.1837	no
	season	0.75	3	329	0.5245	no
	year	0.98	4	329	0.4170	no

Annual catch rates for bourgeois, for example, altered significantly but suggested that the biomass was fluctuating. It was thought that this effect could be a result of changing location so the factor fishing area was next included in the model (year*season*fgrnd, Table A.2.5.). Two and three factor interactions were significant for all species / species groups, except for Job Gris. A simple model of the form (1 + year + season + fishing area) was thus not justified except in the latter case. If these interactions are ignored however, and a simple model fitted to the data, fishing area is found to significantly affect catch rates in every case, and annual changes in catch rate are significant also except for maconde and other lethrinids.

Table A.2.5. Results of GLIM analysis for the model year*season*fgrnd, TRAW1

SPECIES	FACTOR	F	df1	DF2	p	SIGNIFICANT
Demersal	year.season.fgrnd	0.64	17	259	0.8609	no
	year.season	1.20	11	276	0.2904	no
	year.fgrnd	2.23	15	276	0.0060	yes
	season.fgrnd	1.75	10	276	0.0696	no
	season	37.37	3	312	0.0000	highly (ignores year.fgrnd interaction)
	fgrnd	15.33	4	312	0.0000	highly (ignores year.fgrnd interaction)
	year	34.52	4	312	0.0000	highly (ignores year.fgrnd interaction)
Bourgeois	(Y.S + Y.F + S.F)	1.87	36	276	0.0029	yes
	season	26.69	3	312	0.0000	highly (ignores 2 factor interactions)
	fgrnd	9.98	4	312	0.0000	highly (ignores 2 factor interactions)
	year	12.65	4	312	0.0000	highly (ignores 2 factor interactions)
Job Gris	(Y.S + Y.F + S.F)	0.76	36	276	0.8392	no
	season	15.06	3	312	0.0000	highly
	fgrnd	8.63	4	312	0.0000	highly
	year	32.67	4	312	0.0000	highly
Lutjanids	(Y.S + Y.F + S.F)	no fit for full model				
	season	52.13	3	312	0.0000	highly (only simple model fitted)
	fgrnd	45.07	4	312	0.0000	highly (only simple model fitted)
	year	51.23	4	312	0.0000	highly (only simple model fitted)
Maconde	(Y.S + Y.F + S.F)	1.60	36	276	0.0208	yes
	season	14.01	3	312	0.0000	highly (ignores 2 factor interactions)
	fgrnd	8.39	4	312	0.0000	highly (ignores 2 factor interactions)
	year	0.58	4	312	0.6783	no
Serranids	(Y.S + Y.F + S.F)	6.69	35	277	0.0000	highly
	season	5.09	3	312	0.0019	yes (ignores 2 factor interactions)
	fgrnd	18.09	4	312	0.0000	highly (ignores 2 factor interactions)
	year	9.76	4	312	0.0000	highly (ignores 2 factor interactions)
Cap. Blanc	(Y.S + Y.F + S.F)	no fit for full model				
	season	2.70	3	312	0.0461	yes (only simple model fitted)
	fgrnd	34.34	4	312	0.0000	highly (only simple model fitted)
	year	13.94	4	312	0.0000	highly (only simple model fitted)
Lethrinids	(Y.S + Y.F + S.F)	2.42	36	276	0.0000	highly
	season	1.12	3	312	0.3427	no
	fgrnd	3.69	4	312	0.0060	yes (ignores 2 factor interactions)
	year	0.06	4	312	0.9930	no

Standardised annual catch rates derived from these models are indicated in Table A.2.5 and compared with the observed catch rates in Figures A.2.13-20 (see also Figs 40-42), but those standardised for fishing area should be viewed with caution since they over-look the interactions found to be significant. They represent indices of abundance for each species over time. Standardised catch rates derived for different species using the same model are directly comparable, but it is not valid to compare indices from different models. Unfortunately no single model fitted all species.

TABLE A.2.5. Standardised annual catch rates for the data set TRAW1 accounting for variation arising monthly, seasonally and by fishing area.

SPECIES	MODEL	1989	1990	1991	1992	1993	COMMENT
Dems	month	51.88	46.15	31.53	13.42	13.53	
	season	49.40	43.16	30.81	15.69	14.60	
	f.ground	54.65	57.69	35.16	17.06	16.05	ignores interactions
bour	month	14.38	3.72	7.34	2.96	2.99	
	season	16.98	4.50	9.27	3.92	3.60	
	f.ground	17.69	1.68	7.83	2.26	1.30	ignores interactions
jobg	month	9.12	10.69	2.95	1.24	1.08	
	season	14.61	13.65	5.39	1.86	0.90	
	f.ground	17.90	18.67	7.03	2.37	0.91	
lutx	month	NA	NA	NA	NA	NA	
	season	9.31	4.53	1.61	0.66	0.08	
	f.ground	9.56	6.63	1.18	0.45	0.03	ignores interactions
maco	month	4.62	4.84	3.83	3.52	4.18	
	season	2.73	3.64	2.92	2.82	3.26	
	f.ground	2.78	2.64	2.72	3.46	3.25	ignores interactions
serx	month	2.19	5.28	6.45	2.74	1.73	
	season	NA	NA	NA	NA	NA	
	f.ground	1.34	2.87	4.05	2.49	1.06	ignores interactions
cabl	month	1.07	1.43	1.03	0.43	0.25	ignores interactions
	season	1.21	1.48	1.20	0.45	0.22	ignores interactions
	f.ground	1.22	2.22	1.09	0.68	0.40	ignores interactions
letx	month	NA	NA	NA	NA	NA	
	season	6.50	9.85	8.24	7.83	10.18	
	f.ground	6.56	6.71	6.65	6.73	7.32	ignores interactions

Fig A.2.13 : standardised and observed catch rates : demersal species

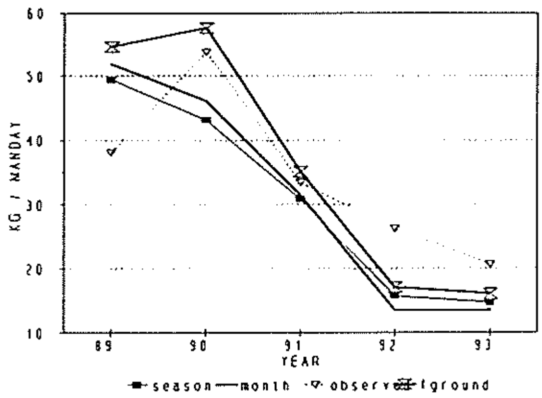


Fig A.2.14 : standardised and observed catch rates : Bourgeois

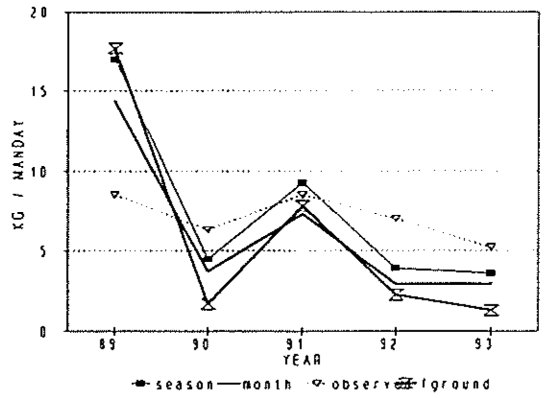


Fig A.2.15 : standardised and observed catch rates : Job Gris

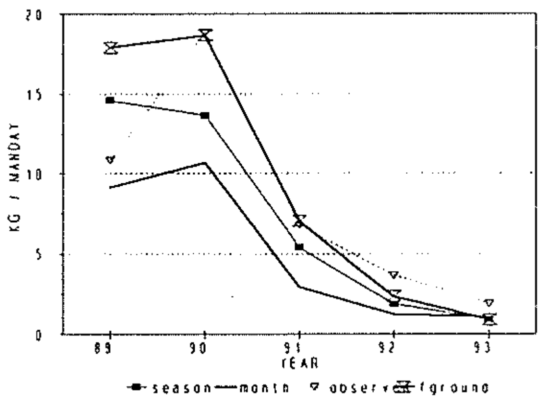


Fig A.2.16 : standardised and observed catch rates : other lutjanid species

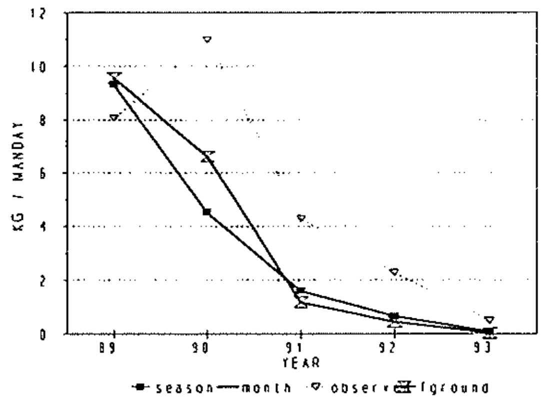


Fig A.2.17 : standardised and observed catch rates : Maconde

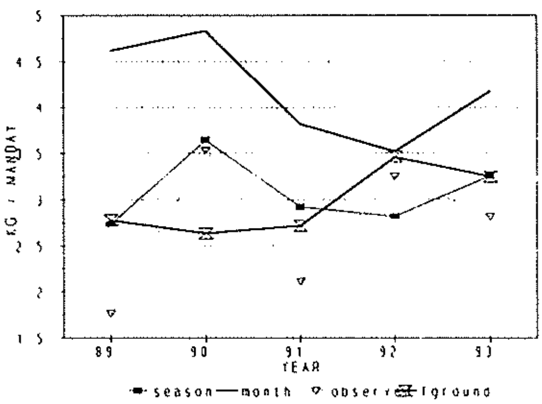


Fig A.2.18 : standardised and observed catch rates : other serranid species

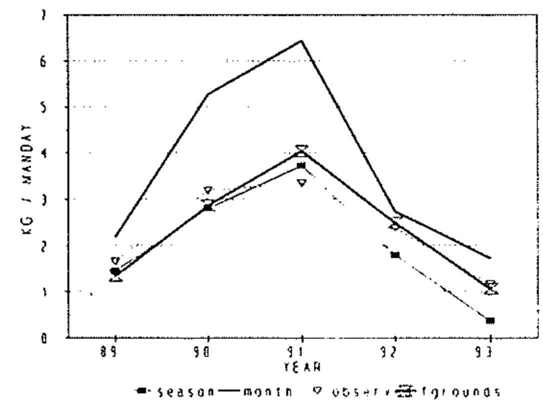


Fig A.2.19 : standardised and observed catch rates : Capitaine Blanc

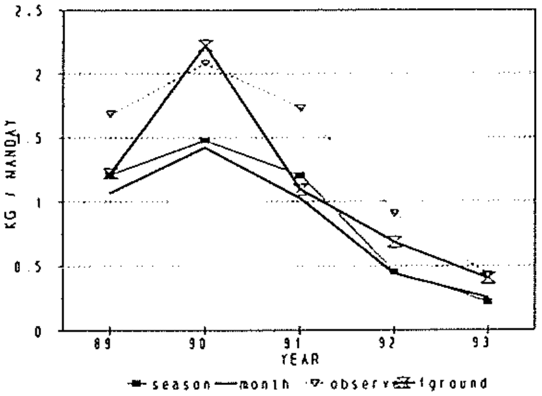
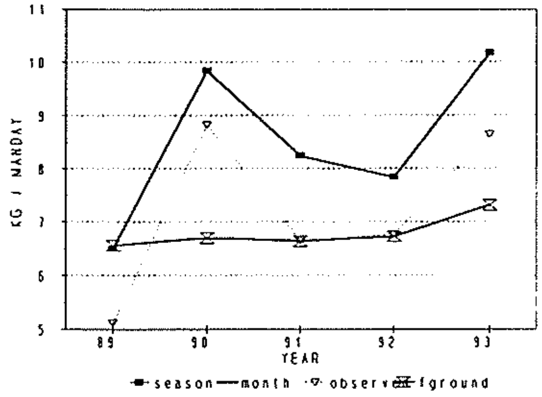


Fig A.2.20 : standardised and observed catch rates : other lethrinid species



ANNEX 3 : SCHOONER CATCH AND EFFORT DATA

Data from the schooner fishery were available from 1983 to the present, and potentially offered the greatest scope for assessment of the impact of fishing on multi-species demersal resources. Unfortunately however, this proved not to be the case : fishing effort was relatively low at any one location; few boats fished consistently throughout the entire 10 year period; adequate data on the use of echo-sounders, gear, and depth were not collected until 1990.

Mees, 1990b examined the schooner fishery in detail, and the same fleet stratification is employed in the present report (Table A.3.1). Only vessels for which complete catch details were recorded are included in the analyses.

Table A.3.1 : The number of schooner fishing trips sampled each year by boat, and stratification of the fleet. Mean catch rate aggregated over all data for each boat is indicated

BOAT	HP	YEAR											TOT	KG/
		83	84	85	86	87	88	89	90	91	92	93		MH
BASIC FLEET OF SCHOONERS (1)														
ANNA BELLE									5	33	2	5	45	46.3
AQUARIUS								1					1	64.5
BENOIT FANCHETTE							5						5	18.0
CLAYVERGE									1				1	11.3
ETOILE							1						1	10.2
KAPRISLETAN									1	7	1	1	10	52.9
LA BELLE DAYO								1	7	29	7	4	48	37.9
LA PROVIDENCE									1	3	2	3	9	27.9
LILLY									4				4	32.2
MALBAR				1		5							6	22.4
MIRELLA		6	10										16	26.7
RAYMOND BONTE								1					1	35.6
REX					1								1	19.1
SORENE							1						1	11.0
SOUMARIN II		11	8										19	20.6
STANLEY AH-KON							3						3	27.6
ST MARC		10	10										20	29.1
SZ 066								1					1	16.8
TOKOS		11	23										34	24.9
PIPON	27				1								1	38.0
SAGITAIRE	27	2			11	14	3						30	36.9
SOUMARIN I	27	9	24	19	31	35	26	17	3				164	31.7
ALERT	37	9	16	22	15	28	23	7					120	29.6
BOUDEUSE	37			2	18	12							32	18.4
CANCER (Dick)	37							5	20	40	5		70	35.4
DICK	37	9	27	17	24	24	20	9					130	26.1
FRANCOIS BONNE	37			1		11	2						14	24.7
HOPE	37			6	14	21	25						66	20.5
INNOCENT	37	3	14		16	27	19	13	10	21	4	6	133	29.2
JEFFERY DURUP I	37				3	3		2	2				10	37.3
JEFFERY DURUP II	37			3		10	10	8					31	29.8
KOUSOUPA	37			1									1	14.3
LA BELLE VIOLITA	37					4	18	20	16	28	12	14	112	42.7
LANINA	37	9	19	11									39	26.6
MAMI	37	9	12	9	12	22	14						78	30.2
PAILLE EN QUEUE	37			11	18	25	20	16	13	20	8	20	151	35.0

Table A.3.1 Continued

BOAT	HP	83	84	85	86	87	88	89	90	91	92	93	TOT	KG/ MH
BASIC FLEET OF SCHOONERS (1) CONTINUED.														
QUEEN	37	7	29	15	25	20	19	2					117	26.5
REEFER	37			12	18	21	18	4	8	35	12	6	134	36.3
REGIS AH-KON I	37			15	30	17	21						83	31.9
REGIS AH-KON II	37			1	24	27	2						54	38.3
REINE DES ANGES	37			8	16	12	4						40	18.1
SERRE	37	12	32	27	11	21	11	23	18	15			170	27.0
SILENCE	37			8	25	17	21		1			1	73	26.4
ST. ANDRE	37				17	29	15						61	32.0
TOUSSAINY	37	11	26	23	22	18	8						108	23.9
VALENCIA	37						6	1					7	26.1
VIGILANT	37	11	26	9	12	1							59	26.0
EDELBERT AH-KON	48			14	19	19	22	2	1				77	35.1
?	56	1		37	7						1		46	50.4
CHANTAL	56	10	29	19	23	30	26	4					141	35.7
DRAGON JAW	56			7	16	23	23	1					70	31.3
VENUS	56			3	2	25	11	1					42	28.6
LA DIGUE 12.5M SCHOONERS (2)														
ANDIAMO	76						5	1					6	14.3
DENEB	76						12	14	27	11	2	6	72	54.6
DOLPHIN (Andiamo)	76									36	14	19	69	36.7
VARIOLA	76						12	17	15	40	11		95	44.9
LA DIGUE 22.5M SCHOONERS (3)														
SCORPIO	150				3	6	5	11	17				42	50.4
TAURUS	150									17	11	7	35	44.5
VERSEAU	150									26	13	8	47	40.3
OTHER LARGE SCHOONERS (4)														
SEA GLEANER	120	5	8	3	1	8	14	13	7				59	23.0
ST MICHEL	120								4	25	13	5	47	22.8
CLARTE	150					1		3			1		5	52.6
NEW SCHOONERS ENTERING THE FISHERY SINCE 1990, EQUIVALENT TO BASIC FLEET (5)														
DE KOUZEN										9	18	9	36	50.4
DISKISYON											3		3	21.2
FAITH									2	20	7		29	25.9
LA BRINE											5	20	25	43.5
LA CYNTHIA										23	2		25	40.5
NAVAJO											7	3	10	31.2
NORTH STAR										4	3	2	9	35.1
PASYAN											4		4	37.7
REJETTA											2	4	6	36.6
ST. CROIX										24	3		27	24.5
ST GEORGES									2	30	4		36	21.1
VAINQUER										6	12	13	31	39.0
VOLOULOU										12			12	25.0
OTHERS CLASSED AS SCHOONERS, (6)														
SEYCHELLES NAVY				2									2	17.4
SWEDISH	20			1	15								16	16.8
TOTAL		145	313	307	450	536	445	198	185	514	189	156	3438	

The schooner fleet encompasses a wide variety of vessels, which have been stratified according to size and vessel design. Traditionally schooners fished with handlines. In 1986 electric fishing reels were introduced. Drop lines and gill nets were introduced in 1991/2 but have only been deployed on the large La Digue schooners (4). Echo sounders have commonly been used, but since 1992/3 GPS (global positioning satellite navigation) and fish finders have increasingly been used. Since that time some schooners have additionally fished with dories (some of the larger schooners also did this in the past). In 1990 data collection was improved to record fishing method and use of echo sounder. However, the more recent advances (GPS, fish finders, dories) have not been incorporated into the data collection programme and this needs to be addressed urgently. Furthermore, although it is known that Verseau and Taurus have fished with drop lines and gill nets, this information does not appear on the database[8]. Thus either none of these trips were sampled, or the data forms have been completed incorrectly.

Vessel-trips sampled where electric reels were used are indicated in Table A.3.2. Data prior to 1990 is assumed from knowledge of the dates on which electric fishing reels were fitted to the boats. Reported use of echo sounders is indicated in Table A.3.3. Surprisingly, only 68 vessel trips were recorded in which both electric reels and echo sounders were used. There is a possibility of mis-reporting.

Table A.3.2. Vessel trips sampled during which electric fishing reels were used

BOAT	86	87	88	89	90	91	92	93	TOT
CHANTAL	9	30	26	4	0	0	0	0	69
DE KOUZEN	0	0	0	0	0	6	17	9	32
DENEB	0	0	0	7	27	11	2	6	53
LA BELLE DAYO	0	0	0	0	0	0	0	1	1
LA BELLE VIOLITA	0	0	0	0	16	24	12	14	66
LA BRINE	0	0	0	0	0	0	0	6	6
REJETTA	0	0	0	0	0	0	0	2	2
SCORPIO	0	0	0	11	17	0	0	0	28
SEA GLEANER	0	0	0	0	1	0	0	0	1
ST MICHEL	0	0	0	0	0	3	9	4	16
TAURUS	0	0	0	0	0	0	10	7	17
VARIOLA	0	0	12	17	15	40	11	0	95
VERSEAU	0	0	0	0	0	26	12	8	46
TOTAL	9	30	38	39	76	110	73	57	432

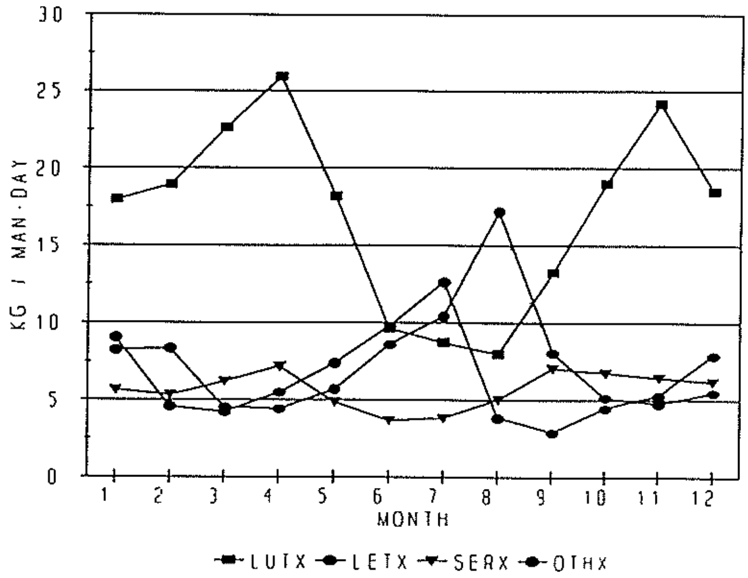
[8] These gear types occur on the length frequency data base. Unfortunately this data base is not linked to the catch and effort data : presently biological and catch- effort data are collected and treated separately. It is recommended that the computerisation of Seychelles CAS is upgraded to provide a fully integrated relational fisheries information system. Certain technical problems exist however ie. way that fish are handled through SMB meaning that biological data cannot always be related back to a particular vessel.

Table A.3.3. Vessel trips sampled during which echo sounders were used.

BOAT	90	91	92	93	TOT
	0	0	1	0	1
ANNA BELLE	5	33	2	5	45
CANCER	11	3	1	0	15
CLARTE	0	0	1	0	1
DE KOUZEN	0	9	18	9	36
DENEB	27	11	2	6	46
DISKÍSYON	0	0	3	0	3
DOLPHIN	0	36	14	19	69
FAITH	2	16	6	0	24
INNOCENT	3	21	4	5	33
JEFFERY DURUP I	1	0	0	0	1
KAPRISLETAN	0	4	0	1	5
LA BELLE DAYO	7	0	0	4	11
LA BELLE VIOLITA	16	28	12	14	70
LA BRINE	0	0	5	20	25
LA CYNTHIA	0	23	2	0	25
LA PROVIDENCE	1	3	2	3	9
NAVAJO	0	0	7	3	10
NORTH STAR	0	4	3	2	9
PAILLE EN QUEUE	13	16	8	19	56
PASYAN	0	0	3	0	3
REEFER	6	35	9	5	55
REJETTA	0	0	2	4	6
SCORPIO	17	0	0	0	17
SEA GLEANER	7	0	0	0	7
SERRE	1	0	0	0	1
SILENCE	0	0	0	1	1
ST MICHEL	4	25	12	5	46
ST. CROIX	0	3	1	0	4
TAURUS	0	17	10	7	34
VAINQUER	0	6	11	12	29
VARIOLA	15	40	11	0	66
VERSEAU	0	26	13	8	47
VOLOULOU	0	12	0	0	12
TOTAL	136	371	163	152	822

In order to examine schooner data for evidence of depletion or species composition changes due to fishing pressure, it is necessary to either stratify or standardise the available information (or a combination of both). Initially stratified data was examined in order to identify locations at which such effects may be observed. The basic schooner fleet utilising handlines only was examined. As reported for whalers, a strong seasonal effect was observed (eg. sector 9, Fig. A.3.1). Fishing sectors 2, 4, 6, 7, 9, and 10 were examined for evidence of depletion (Figs A.3.2-A.3.13). The La Digue 12 m schooners with electric reels were examined for sector 9 (Figs A.3.14-A.3.15). Other boat-gear-location combinations had limited data and were not investigated.

Fig. A.3.1. Monthly catch rate data aggregated over the period 1983-1993 for the family groups lutjanids, lethrinids, serranids and all others caught by basic fleet schooners using handlines only in sector 9 (Owen, Thor, Roberts Banks).



Figures A.3.2-A.3.13 : Observed catch rates for all species, demersal species and species groups lutjanidae, lethrinidae, serranidae and others for basic fleet schooners fishing with handlines only (The number of trips sampled is indicated).

Fig. A.3.2 Sector 2

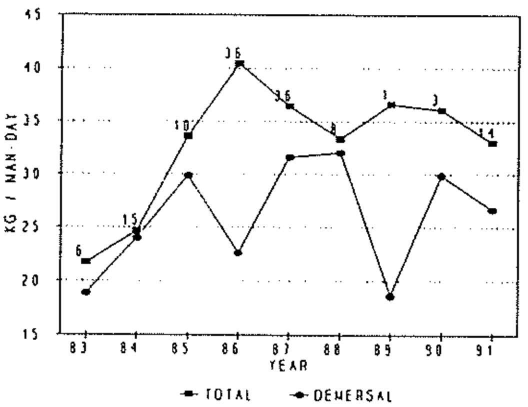


Fig. A.3.3 Sector 2

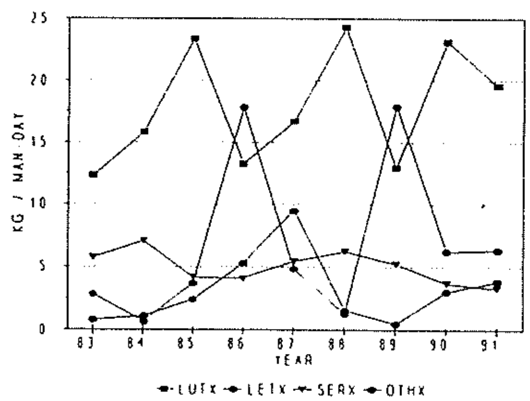


Fig. A.3.4. Sector 4

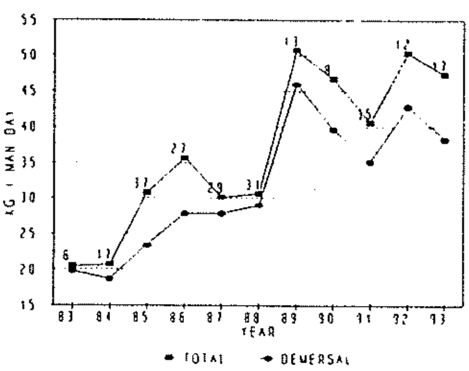


Fig. A.3.5. Sector 4

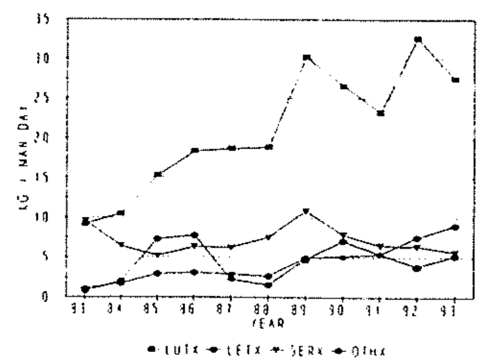


Fig. A.3.6. Sector 6

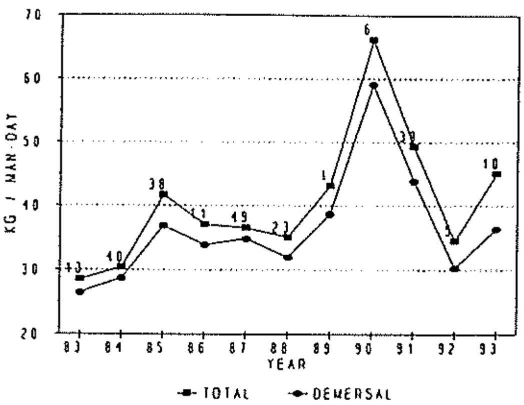


Fig A.3.7 : Sector 6

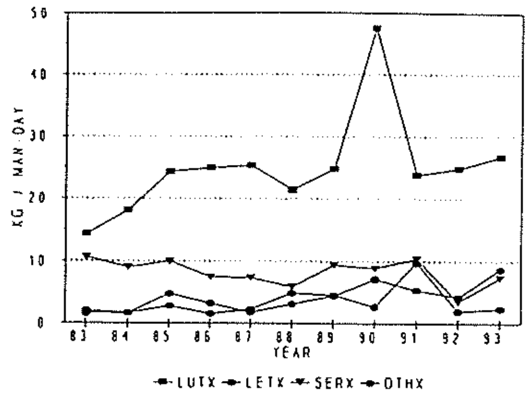


Fig A.3.8 : Sector 7

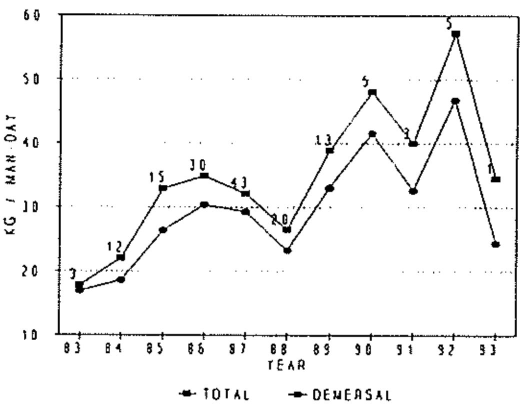


Fig A.3.9. : Sector 7

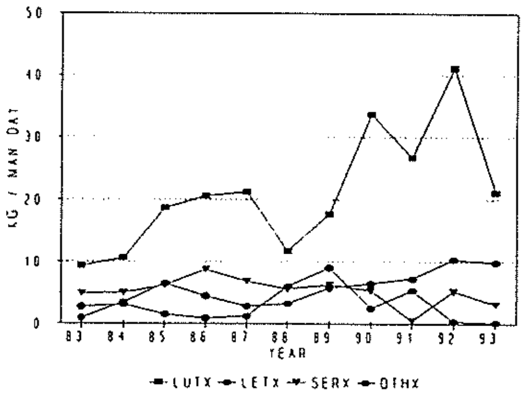


Fig A.3.10 : Sector 9

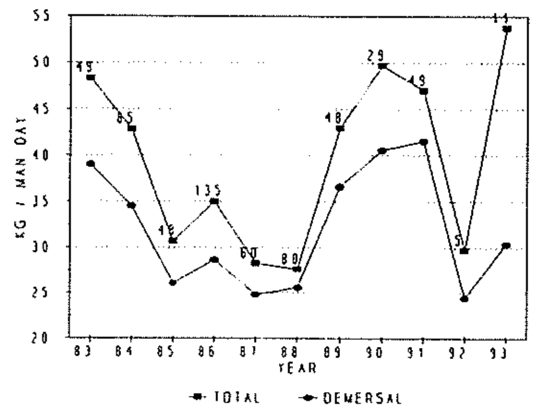


Fig A.3.11 : Sector 9

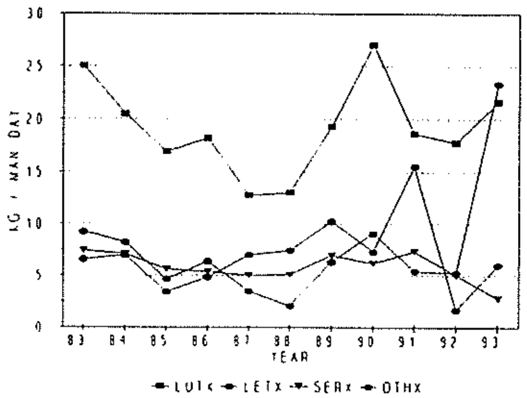


Fig A.3.12 : Sector 10

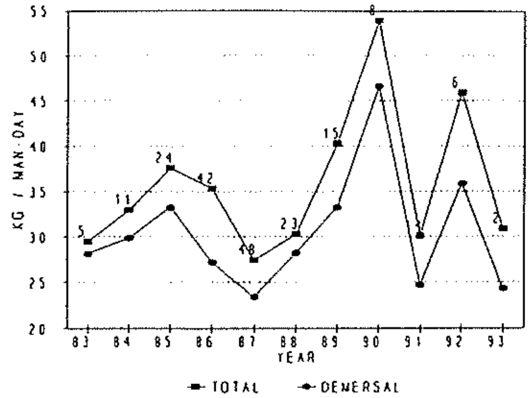
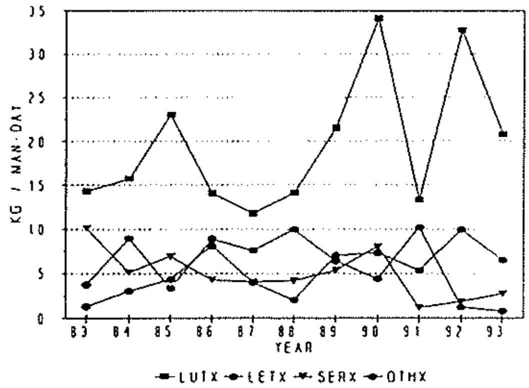


Fig A.3.13 : Sector 10



Figures A.3.14-A.3.15 : Observed catch rates for all species, demersal species and species groups lutjanidae, lethrinidae, serranidae and others for La Digue 12m schooners fishing with electric reels only, sector 9 (sample number indicated).

Fig. A.3.14

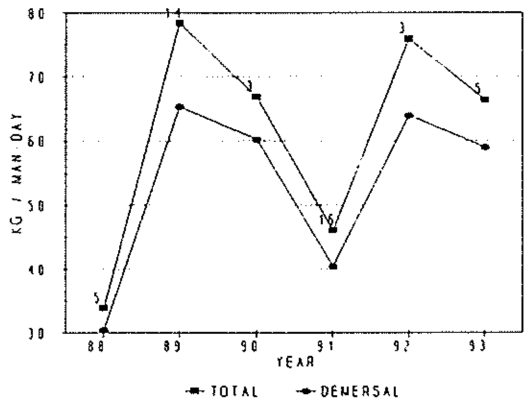
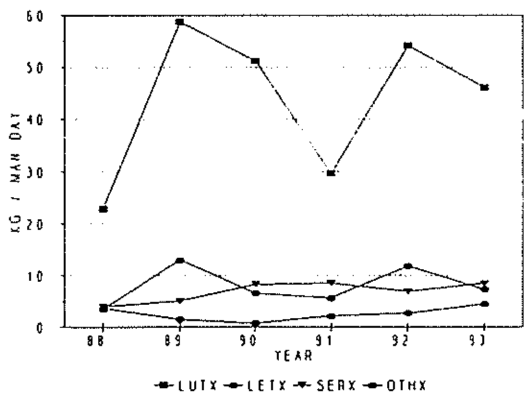


Fig A.3.15



Stratified data (Figs A.3.2-A.3.15) did not indicate evidence of depletion at any location, and catch rates apparently increased at Sector 4 and Sector 7. Increases in catch rates occurring in 1990 related to a shift of effort to deeper water, and presumably the basic fleet followed the trend adopted by vessels equipped with electric reels that year. Individual species catch rates also failed to indicate any consistent pattern, although maconde did decrease at most locations over the period.

A failure to observe depletion indicates that indeed fishing effort is low relative to the stock available and that biomass has remained relatively unchanged in the sectors examined. This could be slightly misleading in that within sectors, localised areas may have been depleted, but the definition of the data is inadequate to detect this. Furthermore, few vessels remained throughout the 10 year period, and only the better boats may have been left in 1993. Newer boats entering around 1989 may also have achieved better catch rates than some of the older boats - in particular this may explain the increases observed. At sector 9 the La Digue boats fishing with electric reels also indicated no depletion.

Stratified data thus did not indicate any location which warranted closer investigation through standardisation of catch rates. Standardisation was also not practical for most of the data set since parameters against which the catch rates should be standardised were not available until 1990 (depth, fishing gear, echo-sounder used). Within a stratified data set standardisation by season and individual boat -, and within locations standardisation by boat-type and season, is in theory possible. However, due to the small number of vessels fishing consistently throughout the 10 year period, and the large number of variables, sample size is small or data is lacking for most parameter combinations with the result that standardisation could not be achieved.

The conclusion to draw from these analyses is that at the level of the fishing sector, schooner fishing effort has been low and has had little impact on the demersal fishery resources. Locally (eg. within Sector 11 at a particular bank such as Small Constant) there may have been significant impact. However, the definition of the data is inadequate to detect this. Schooners simply report a general direction rather than a specific fishing location. Now that many schooners are equipped with GPS such a data collection system requires updating and latitude and longitude should be recorded. Furthermore, with the introduction of new vessels (eg. the Cygnus vessels) which fall into the statistical classification of 'Schooners' it is necessary to assess whether the schooner data collection form is adequate or whether new procedures should be devised.

ANNEX 4: Details of a paper presented at an EPOMEX/ICLARM workshop on tropical groupers and snappers, with additional details appended.

DEMERSAL FISH STOCK ASSESSMENT IN SEYCHELLES - AN ANALYSIS OF A MOTHERSHIP - CATCHER BOAT FISHERY.

A b s t r a c t

Stock assessments for certain important tropical demersal species are presented based on the analysis of commercial line fishing data collected from a mothership / catcher boat operation targeting snappers, groupers and emperors in Seychelles waters. Six fishing trips were conducted over the period March 1991 - March 1993 at a number of 'virgin' or lightly fished banks and sea mounts of varying size distant from the main centres of population.

Depletion estimates of initial population size (Biomass, B_0) are derived from daily information within single fishing voyages at specific locations. An attempt to determine production is presented utilising biomass estimates from subsequent voyages to the same locations. The limited duration spent at any one fishing location and variability in catch rates resulting from changes in fishing depth (target species) restrict the number of comparisons of site specific analyses from the present data set, but the method will be of increasing value as more information becomes available. The implications for management purposes are great: inferences may be made to the rate of recovery of depleted areas, useful in what is essentially a 'hit and run' fishery.

It is suggested that providing that adequate care is taken to account for variability in catch rates not directly attributable to fishing pressure, the application of this type of analysis to commercial data offers a cheap alternative to intensive fishing experiments during research cruises.

Introduction

The large number of fish species and information intensive requirements of most multi-species stock assessment models (for reviews see : Gulland and Garcia, 1984; Kerr and Ryder, 1989; Polovina, 1992) mean that data collection requirements for adequate stock assessment are beyond the means of many small fishery departments in tropical countries. Depletion methods of stock assessment, however, can be substantially cheaper and more effective than others (Hilborn and Walters, 1992). Polovina (1986) applied this approach to data collected during an intensive fishing experiment in the Marianas. Where commercial data can be utilized, substantial cost savings may be gained over the application of experimental fishing during planned research cruises, although at the expense of experimental design.

In this paper stock assessments are based on the analysis of commercial line fishing data collected from a mothership / catcher boat operation targeting snappers, groupers and emperors in Seychelles waters. Mees (1993) estimated the biomass of *Pristipomoides filamentosus* (Valenciennes, 1830) from data collected during a single voyage of this vessel. Here, subsequent voyages to a number of locations are presented, and enable estimates of stock production.

The study area.

Seychelles consists of four island groups in the Western Indian Ocean between 5° and 10°S and 45° and 56°E (Fig. 1). The majority of the population live on the granitic islands Mahe, Praslin and La Digue within the Mahe Plateau, whilst the coralline Amirantes, Providence / Farquhar and Aldabra / Cosmoledo groups are sparsely inhabited.

Demersal fishing effort by the artisanal fleet (mostly wooden vessels, 12 m length or smaller) is largely confined to the Mahe Plateau and its periphery, but in periods of good weather a few vessels may venture to the Amirantes group. The Providence / Farquhar and Aldabra / Cosmoledo groups may be regarded as un-fished excepting some exploitation during the 1970's by mothership - catcher boat ventures at the former group. Fishing activity at these locations, and at lightly fished banks and sea mounts south of the Mahe Plateau is examined.

Climatic conditions during the South East Trade Winds, which average 12 knots, frequently limit fishing activity from the end of May to October. It may also be affected by the north-west Monsoon between mid November and mid March. During the two inter-monsoon periods light variable winds and frequent calms occur.

Materials and methods

Between March 1991 and March 1993 an 88.4 m refrigerated cargo ship deployed up to twelve 7 m fibre-glass catcher boats during six fishing voyages to remote banks and island groups in the Seychelles. Each voyage lasted between 46 and 71 fishing days (Table 1).

Catcher boats were equipped with echo sounder and compass and usually fished within 10 miles of the mothership. Hand lines were used during the first voyage. Electric fishing reels were fitted subsequently although frequently a combination of electric reels and hand lines were used by the three man crew. One trip per boat per day was usual, although occasionally two trips were made.

Detailed catch and effort data were recorded for each catcher boat trip by an observer from the Seychelles Fishing Authority. Factors which could potentially affect catch rates and / or species composition were also recorded on the catch and effort log : depth fished, bait type, climatic conditions. These latter data are not available for all voyages and reported details for voyage 4 were considered unreliable. This information is utilised tentatively in interpretation of the results.

Total daily catch and effort data were generated by gear type (lines, reels or both) and location. In order to enable intra voyage comparisons relative fishing power was determined for gear type, month and fishing location by application of the following model to standardise fishing effort :

$$U_{tik}=U_{111}\cdot\alpha_t\cdot\beta_i\cdot\gamma_k\cdot\epsilon_{tik} \qquad (1)$$

where U is the catch rate, subscript t refers to time, i to gear type and k to fishing location. U_{111} is the catch rate obtained by the first gear type in the first time period at the first location, α_t is a factor that is the abundance in month t relative to month 1, β_i is the efficiency of gear type i relative to gear type 1, γ_k is the average abundance differential in area k relative to location 1, and ϵ_{tik} is a factor explaining the deviation between the observed U_{tik} and the expected value for t, i and k (see Hilborn and Walters, 1992).

Taking the logarithms of both sides of equation 1, a linear statistical model is derived :

$$\log(U_{tik})=\log(U_{111})+\log(\alpha_t)+\log(\beta_i)+\log(\gamma_k)+\log(\epsilon_{tik}) \qquad (2)$$

from which the parameters α, β, ad γ may be estimated by multiple linear regression.

Fishing effort of the original catcher - boat data was standardised relative to hand-lines and to the month of January. Total daily catch and effort data were recalculated by location. These data were employed in a modification of the Leslie depletion model (Leslie and Davis, 1939) in order to determine original biomass at the start of subsequent fishing occasions (B_{01} and B_{02}), as follows :

Since each fishing occasion lasts only a few days natural mortality, growth, recruitment and immigration will be negligible and may be disregarded. B_{ti}, the biomass remaining on day t of voyage i may be expressed :

$$B_{ti}=B_{0_i}-\sum_{s<t} C_{si} \qquad (3)$$
$$=B_{0_i}-D_{ti}$$

where C_{si} is the catch taken during day s of voyage i, and D_{ti} is the total catch taken on that voyage before day t.

The catch rate U_{ti} on day t of voyage i will be related to the biomass, B_{ti} by :
where q is the catchability, and ω_{ti} explains random variability.

Whilst biomass (B_0) changes between fishing voyages due to mortality, recruitment, growth

$$U_{ti} = q.B_{ti} + \omega_{ti}$$
$$= q.B_{0_i} - q.D_{ti} + \omega_{ti} \quad (4)$$

and immigration, the catchability (q) is expected to remain constant. To ensure the same estimate of q for all voyages, and to reduce estimation 'noise' due to short data series, equation 4 may be rewritten enabling simultaneous estimation of q and the B_{0i}'s by multiple regression. First, indicator variables I_{2ti} I_{3ti}....... are defined for all voyages except the first, so that $I_{2ti}=1$ for all data from voyage 2 and 0 for all other data, $I_{3ti}=1$ for all data from voyage 3, and 0 for all other data, and so on.

Consider the example of three voyages to one location. Using equation 4 we set for voyage 1 :

$$U_{t1} = q.B_{0_1} - q.D_{t1} + \omega_{t1}$$
$$= q.B_{0_1} + I_{2t1}.(q.B_{0_2} - q.B_{0_1}) + I_{3t1}.(q.B_{0_3} - q.B_{0_1}) - q.D_{t1} + \omega_{t1} \quad (5)$$

noting that for all observations in voyage 1 $I_{2t1} = I_{3t1} = 0$.
For voyage 2 ($I_{2t2} = 1$, $I_{3t2} = 0$):

$$U_{t2} = q.B_{0_2} - q.D_{t2} + \omega_{t2}$$
$$= q.B_{0_1} + I_{2t2}.(q.B_{0_2} - q.B_{0_1}) + I_{3t2}.(q.B_{0_3} - q.B_{0_1}) - q.D_{t2} + \omega_{t2} \quad (6)$$

and voyage 3 ($I_{2t3} = 0$ $I_{3t3} = 1$) :

$$U_{t3} = q.B_{0_3} - q.D_{t3} + \omega_{t3}$$
$$= q.B_{0_1} + I_{2t3}.(q.B_{0_2} - q.B_{0_1}) + I_{3t3}.(q.B_{0_3} - q.B_{0_1}) - q.D_{t3} + \omega_{t3} \quad (7)$$

This may be written in general form as:

$$U_{ti} = \alpha + \sum_{j=1}^{v} I_{jti}.\beta_j - q.D_{ti} + \omega_{ti} \quad (8)$$

where v is the total number of voyages undertaken,

$$\alpha = q.B_{0_1} \quad (9)$$

$$\beta_j = (q.B_{0_j} - \alpha) \quad (10)$$

for $j = 1$ to v. The variables q, α and β_j may be estimated by multiple linear regression. The biomass at the start of the first voyage may then be estimated from (9):

$$\hat{B}_{0_1} = \frac{\hat{\alpha}}{\hat{q}} \quad (11)$$

and subsequent voyages for j = 1 to v from (10)

Production (P) between voyages i and ($i+1$) to the same location can be estimated from

$$\hat{B}_{0_j} = \frac{\hat{\alpha} + \hat{\beta}_j}{\hat{q}} \qquad (12)$$

:

$$\hat{P}_{i \to (i+1)} = \frac{\hat{B}_{0_{i+1}} - (\hat{B}_{0_i} - C_i)}{d_{i \to (i+1)}} \qquad (13)$$

where C_i is the total catch removed at the end of voyage *i*, and $d_{i \to (i+1)}$ is the time interval, in days, between fishing occasions. Production is equivalent to all gains due to growth, recruitment and immigration, less losses due to natural mortality.

Results

Factors applied to standardise the original data by month and gear type are indicated in Table 2. Throughout the six voyages fishing took place at a total of 31 different banks, sea mounts or islands. At any one location fishing duration varied between 1 and 8 days and the prevalent pattern observed was that of decreasing daily catch rates. Results relate to those locations fished during two or more voyages for greater than one day (Table 3 and Figs. 2 and 3).

In general, mean catch rates are observed to decrease from one voyage to the next. This was true for small banks and sea mounts, but not for the large banks (Constant Bank). Daily catch rates at Fortune Bank, like Constant Bank, indicate no evidence of depletion between voyages (Figure 4). For small banks, exceptions were Bulldog Bank and Sea Mount '25' in the Providence / Farquhar group : during voyage 4 strong currents depressed catch rates, not the case during voyage 5 to these locations.

Eliminating those locations at which changes in depth and target species were significant (Sea Mount '20', Wizard Reef) only 3 locations of the original 31 are suitable for the present depletion study: Correira Bank, Small Constant Bank and Farquhar (Table 4 and Figs 5-7 respectively). Small Constant Bank was eliminated from the analysis : inconsistent results which were considered unreliable (only two data points for each of voyages 2 and 3); this bank was subject to fishing by other vessels between voyages so the total catch removed was unknown. Correira Bank was unlikely to have been fished by other vessels and Farquhar had not.

At Correira Bank, no consistently decreasing trend with time occurred for the combined catch rate of all demersal species, but was observed for the target species, *P. filamentosus*. At Farquhar no trend occurred for individual species but was observed for the combined demersal catch. The biomass prececeding each voyage was estimated by regression of standardised catch rate on adjusted cumulative catch for *P. filamentosus* at Correira Bank (Fig. 8, Table 5) and all demersal species at Farquhar (Fig.9, Table 5). No attempt was made to partition effort directed at *P. filamentosus* in the case of Correira Bank. This species formed approximately 50% of the catch and at the depth range fished (> 70 m) it was the target species. Thus the total effort was assumed to be directed at this species.

In Seychelles *P. filamentosus* is caught in the depth range 75 - 150 m (Mees, 1993). The net rate of production for *P. filamentosus* at Correira Bank was 2.5 kg day^{-1} km^{-2} of the intermediate depth range (Table 5) or 0.6 kg day^{-1} km^{-1} of the 100 m isobath. For all demersal species at Farquhar, where fishing occurred in the shallow stratum, it was 0.25 kg day^{-1} km^{-2}.

Discussion

Mothership - catcher boat operations excert significant fishing pressure at localised areas over a short time period. At large banks local depletion may occur during any one voyage (as appeared to be the case during Voyage 3 at Fortune Bank, Fig. 4) but differences in precise fishing location and the relatively larger standing stock at these locations mean depressed catch rates are not observed between voyages. However, it is apparent that depletion of small isolated areas can be significant, and that catch rates remain depressed from one fishing occasion to the next indicating that insufficient time has elapsed to allow complete recovery.

The rate of recovery, or production, was estimated. At Correira Bank the stock of *P. filamentosus* had fully recovered between voyage 1 and 3. The production estimate of 2.5 kg km^{-2} day^{-1} equates to 914.6 kg km^{-2} $year^{-1}$ (228.0 kg km^{-1} at 100 m isobath). Mees (1993) estimated the sustainable yield of this species to be 716.8 kg km^{-2} $year^{-1}$. Polovina and Ralston (1986) estimated the total yield of all snappers and groupers at the 200m isobath in the Marianas to be 300 kg km^{-2} $year^{-1}$ whilst Polovina *et al.* (1990) give mean estimates of 380 kg km^{-1} on reefs and 1, 460 kg km^{-1} at sea mounts for all species at the 200m isobath. Given the differences in depth, and the fact that *P. filamentosus* represented approximately 50% of the catch, the estimate of production is of the right order and sufficient to generate the estimated yield for this resource.

Incomplete recovery had occurred at Farquhar between voyages 2 and 4. Production was estimated to be 0.25 kg day^{-1} km^{-2} in the shallow stratum which is rather low. The total area of Farquhar Atoll is an inappropriate value to apply. It is not clear that fishing actually took place inside the lagoon: this is not permitted, and the maximum depth of the lagoon is 14.6m, whilst the mean fishing depth was around 50m. It is most likely that localised depletion of a smaller area has occurred. At Farquhar the anchoring positions for voyages 2 and 4 were 8 nautical miles apart. However, the catcher boats fish within a radius of approximately 10 nautical miles of the mothership and so the same area would have been exploited. Assuming a fished reef area of 10 - 20 nmi by 0.5-1 nmi (17 km^{-2} - 69 km^{-2}) the production estimate becomes 2.5 - 0.62 kg day^{-1} km^{-2}.

Polovina (1986) indicated that the catchability of subordinate species in a multispecies assemblage is inversely related to the abundance of a more dominant species, although this change in catchability may have a time lag associated with it. He also showed that the pooled estimate of abundance for three species representing 90% of the exploitable population was 71% of the estimate derived for these species individually. From this we may conclude the biomass derived for all species at Farquhar may be underestimated on each voyage, but not necessarily the production. At Correira *P. filamentosus* was dominant in the catch.

Whilst the results presented for *P. filamentosus* are of the correct order and support previous estimates of yield, there are potential sources of bias and error. During each period of fishing the model assumed a 'closed' study population due to the short time frame involved. Between fishing it was 'open'. Hilborn and Walters (1992) discuss sources of error in estimates based on closed population depletion assessments and suggest that over a short time frame catchability may decline with the removal of stupider or more aggressive fish, increasing q and depressing estimates of B_0. Catchability was assumed to be constant for each fishing occasion although its real value may change within each fishing period in this manner. The time interval between fishing occasions (145 days at Farquhar; 302 at Correira Bank) was considered sufficiently long to negate such a change by the start of the second fishing period. In contrast to this potential bias, q may be underestimated and B_0 overestimated if errors occur in the measurement of the cumulative catch or effort. These are considered to be reliable.

It has been demonstrated that commercial data may be used for depletion estimates of stock size and production. The analyses possible were constrained by lack of replicates which under research conditions would have been contained in the experimental design : particularly depth fished; duplicate fishing trials at certain locations despite low catch rates; longer time series at each location. Nevertheless, for single voyages depletion estimates of stock size were frequently possible (see Mees, 1993, for *P. filamentosus*; Mees[9], for *P. filamentosus* and *L. nebulosus*). For estimating production between voyages it was seen that the number of site specific comparisons was limited.

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[9] Mees, C. C. (unpublished) Pecheur Breton : an analysis of data relating to a mothership - dory fishing operation in Seychelles waters from March 1991 - June 1992. Seychelles Fishing Authority, SFA/R&D/023, October, 1992.

Additionally, depletion estimates of abundance are subject to the bias discussed. Nevertheless, it is argued that despite these limitations, valuable information has been gained at minimal cost, and that this method will be of increasing value as more data becomes available from future voyages.

Acknowledgements
The author is grateful to Mahe Peche Ltd. and Seychelles Fishing Authority (SFA) for permission to publish this data, collected and compiled by SFA observers and computer staff under an SFA funded demersal fisheries project. The author was financed through the British Overseas Development Administration Fish Management Science Programme. Mark Bravington of MRAG Ltd. helped significantly with the statistical treatment of data and development of the biomass model. Professor John Beddington and Julie Rossouw critically reviewed the text.

References

Gulland, J.A. and S. Garcia (1984) Observed patterns in multispecies fisheries. In : Exploitation of marine communities : report of the Dahelm workshop on exploitation of marine communities, April 1-6 Berlin 1984, Ed. R.M. May, Springer Verlag, Berlin. *(Life Sciences Research Report; 32) pp 155-190*

Hilborn, R and C. J. Walters (1992) *Quantitaive Fisheries Stock Assessment, choice dynamics and uncertainty.* Chapman and Hall, New York and London, 570pp

Kerr, S. R. and R.A. Ryder (1989) Current approaches to multispecies analyses of marine fisheries. *Can. J. Fish. Aquat.Sci 46 : 528-534*

Leslie, P. H. and D.H.S. Davis (1939) An attempt to determine the absolute number of rats on a given area. *J. Anim. Ecol.* 8:94-113

Mees, C.C. (1993) Population biology and stock assessment of Pristipomoides filamentosus on the Mahe Plateau, Seychelles. *J. Fish Biol.* (in press).

Polovina, J. J. (1986). A variable catchability version of the Leslie model with application to an intensive fishing experiment on a multispecies stock. *Fishery Bulletin,* 84 (2): 423 - 428.

Polovina, J.J. (1992) Modeling fish stocks: applicability, problems and requirements for multispecies and multigear fisheries in the tropics. In : Papers presented at the sixth session of the standing committee on resources research and development. Colombo, Sri Lanka, 18-21 May 1990. *FAO Fish Rep No 463 Suppl. Rome 1992, pp 28-54.*

Polovina J.J. and S. Ralston (1986) An approach to yield assessment for unexploited resources with application to the deep slope fishes of the Marianas. Fishery Bulletin, 84(4): 759-770

Polvina, J. J., R. Benco, A. Carlot, E. Cillauren, P. Dalzell, N. Howard, D. Kobayashi, T. Latu, P. Lokani, G. Nath, H. Pili, A. Sesewa, R. Shomura, T. Sua, G. Tiroba, and S. Tulua (1990). Summary of the methods and results from the tropical stock assessment workshop, Honolulu, HI, July 5-26, 1989. *NOAA - Technical Memorandum - NMFS - SWFSC* - 148: 8pp.

UNEP/IUCN (1988) *Coral Reefs of the World, Volume 2: Indian Ocean, Red Sea and Gulf.* UNEP regional seas directories and bibliographies. IUCN, Gland, Switzerland and Cambridge.

TABLE 1 : Details of the Fishing Voyages undertaken between March 1991 and March 1993

Voyage	Fishing dates	Days	Fishing locations	Boat-days
1	03/03/91-02/05/91	70	Mahe Plateau (MP)	169
			Banks south of MP	547
2	23/10/91-16/12/91	54	Mahe Plateau	297
			Banks south of MP	142
			Platte Plateau	4
			Amirantes group	58
			Providence / Farquhar	137
3	08/01/92-12/03/92	64	Mahe Plateau	73
			Banks south of MP	252
			Amirantes group	325
4	11/04/92-27/05/92	46	Providence /Farquhar	501
5	26/10/92-20/12/92	55	Amirantes group	13
			Providence / Farquhar	443
			Aldabra / Cosmoledo	79
6	10/01/93-22/03/93	71	Mahe Plateau	12
			Banks south of MP	60
			Platte Plateau	12
			Saya de Mahla bank	591

TABLE 2 Parameters derived by multiple linear regression for standardisation of fishing effort relative to hand-lines, January and the south-east edge of the Mahe Plateau (MP).

Parameter	Detail	Log value	Value
α_2	February	0.0417	1.0697
α_3	March	0.0421	1.5664
α_4	April	0.0467	1.7115
α_5	May	0.0520	1.1500
α_6	October	0.0612	1.9031
α_7	November	0.0406	1.6164
α_8	December	0.0527	1.7403
β_2	unknown (gear)	0.0829	0.0291
β_3	lines and reels	0.0291	1.0009
β_4	reels only	0.0399	1.2479
γ_2	Junon Bank	0.1665	0.9871
γ_3	South Edge MP	0.1367	1.1702
γ_4	Banks south of MP	0.0368	1.2525
γ_5	Platte Plateau	0.1342	0.9407
γ_6	Amirantes	0.0486	1.5601
γ_7	Providence/Farquhar	0.0458	2.2391
γ_8	Aldabra/Cosmoledo	0.1063	1.1974
γ_9	Saya de Mahla Bank	0.0546	2.4658

TABLE 3 : Locations visited on two or more voyages for more than one day, and the fishing areas in shallow and intermediate depth strata where available.

Fishing location	Area (km^2) 0-75 m	Length of 100 m contour (km)	Area (km^2) 75-150 m
BANKS SOUTH OF THE MAHE PLATEAU			
Constant Bank	590.0	114.8	28.7
Correira Bank	17.4	33.3	8.3
Fortune Bank	600.0	120.4	30.1
Sea Mount '20'	6.6	11.1	2.7
Small Constant Bank	170.0	55.6	13.8
PROVIDENCE / FARQUHAR			
Bulldog Bank			
Farquhar	172.0[a]		
Sea Mount '25'			
Wizard Reef			

a Total area of Farquhar Atoll (UNEP/IUCN, 1988) - actual fishing area will be less than this.

TABLE 4 : The anchoring position of the mothership each day at each of the locations studied showing (*) the days used in the analyses.

Location	Voyage	Dates	Position	
Correira Bank	1	24/04/91	06° 29' S 57° 10' E	*
Correira Bank	1	25-27/04/91	06° 22' S 57° 05' E	*
Correira Bank	1	10/05/91	06° 22' S 57° 05' E	
Correira Bank	3	23-25/02/92	06° 21' S 57° 06' E	*
Correira Bank	3	26/02/92	06° 30' S 57° 16' E	
Small Constant	1	01-07/04/91	06° 03' S 56° 18' E	*
Small Constant	2	07-08/11/91	06° 04' S 56° 18' E	*
Small Constant	3	21-22/02/92	06° 03' S 56° 17' E	*
Farquhar	2	09-16/12/91	10° 08' S 51° 09' E	*
Farquhar	4	09-13/05/92	10° 08' S 51° 01' E	*
Farquhar	4	17/05/91	10° 05' S 51° 10' E	
Farquhar	5	17-18/12/92	10° 08' S 51° 59' E	
Farquhar	5	19/12/92	10° 11' S 51° 11' E	

TABLE 5 : Regression parameters derived for : *Pristipomoides filamentosus* at Correira Bank, and estimates of catchability, biomass, and production between voyages 1 and 3; all demersal species at Farquhar, and estimated values between voyages 2 and 4.

Parameter	Correira Bank	Farquhar
No. obs	7	13
R^2	0.9066	0.6724
α	3.017958	14.90345
β_2	0.108966	-4.73422
q	0.000126	0.000123
C_1	5426 kg	44788.0 kg
B_{01}	23903 kg	121177 kg
B_{02}	24766 kg	82684 kg
d_{1-2}	302	145
P_{1-2}	20.8 kg day^{-1}	43.4 kg day^{-1}
P_{1-2} km^{-2}	2.5 kg day^{-1} km^{-2}	0.25 kg day^{-1} km^{-2}

Figure A.4.1. Seychelles EEZ indicating the fishing locations visited by the mothership catcher vessel : Mahe Plateau, and Banks South of the Plateau, the Amirantes group, Providence / Farquhar group, and Aldabra / Cosmoledo group.

Figure A.4.2. To illustrate the mean standardised catch rate (kg / man-hour) for each voyage to the banks South of the Mahe Plateau, with approximate mean fishing depth (m) per voyage shown.

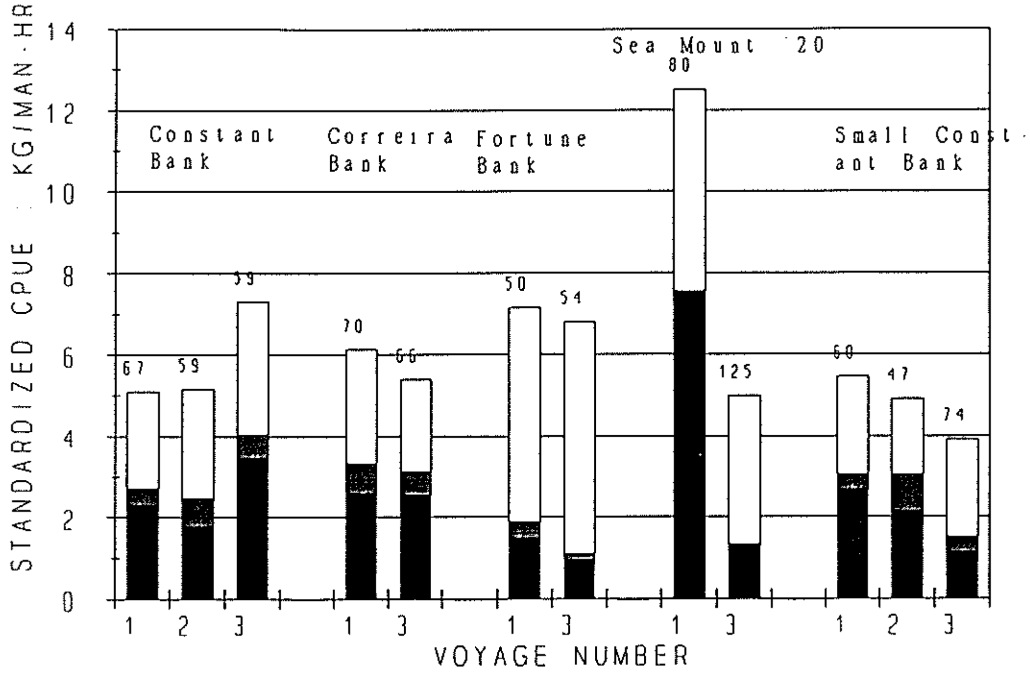


Figure A.4.3. To illustrate the mean standardised catch rate for each voyage to locations in the Providence / Farquhar group, with approximate mean fishing depth (m) per voyage shown.

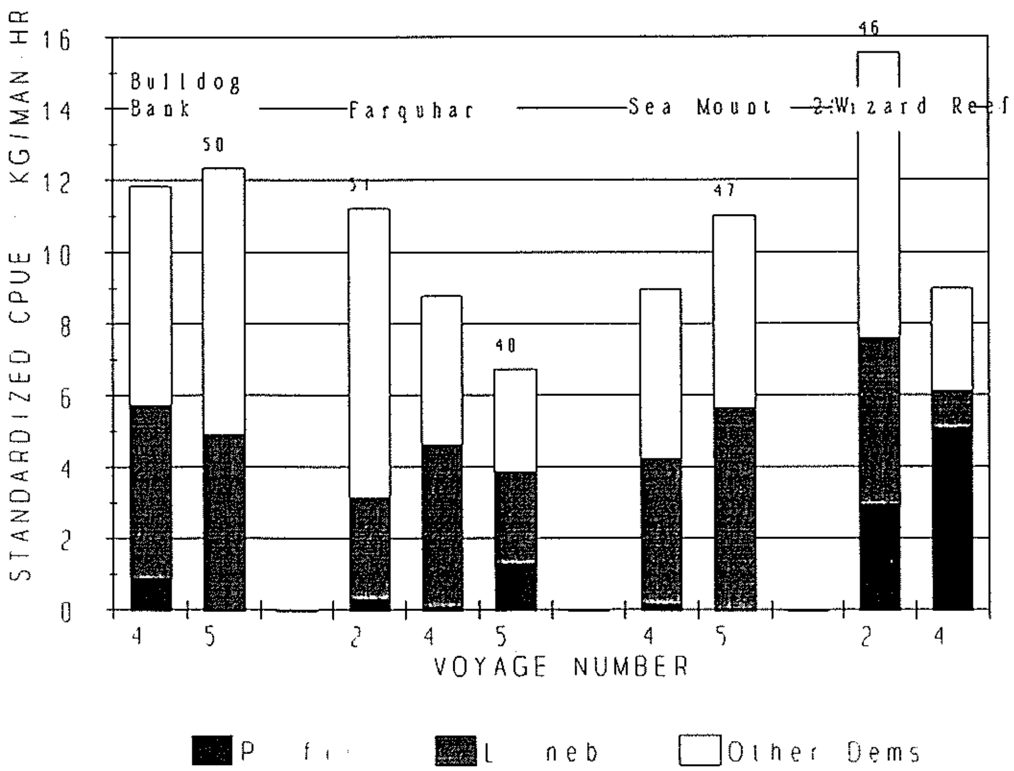


Figure A.4.4. Standardised daily catch rates at Fortune Bank. Note : in Figures 4 - 7 the X axis does not represent a linear scale. A break in the line indicates that the mothership moved location (within any voyage) or that the data relate to different voyages.

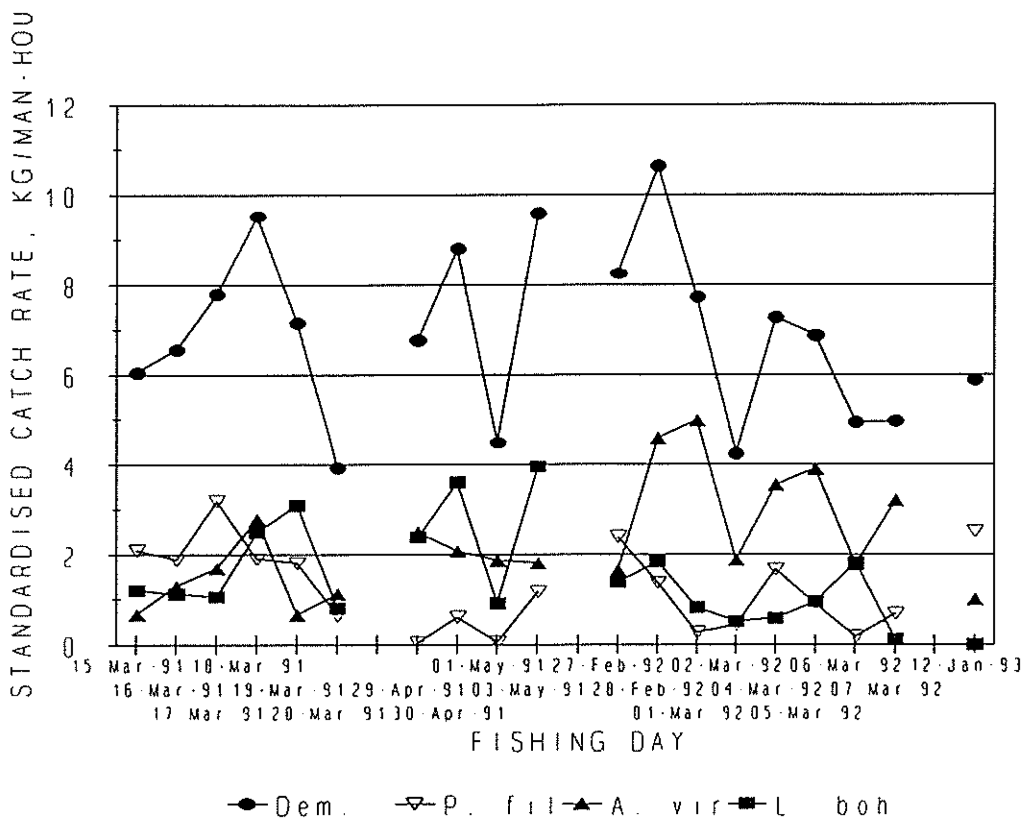


Figure A.4.5. Standardised daily catch rates at Correira Bank.

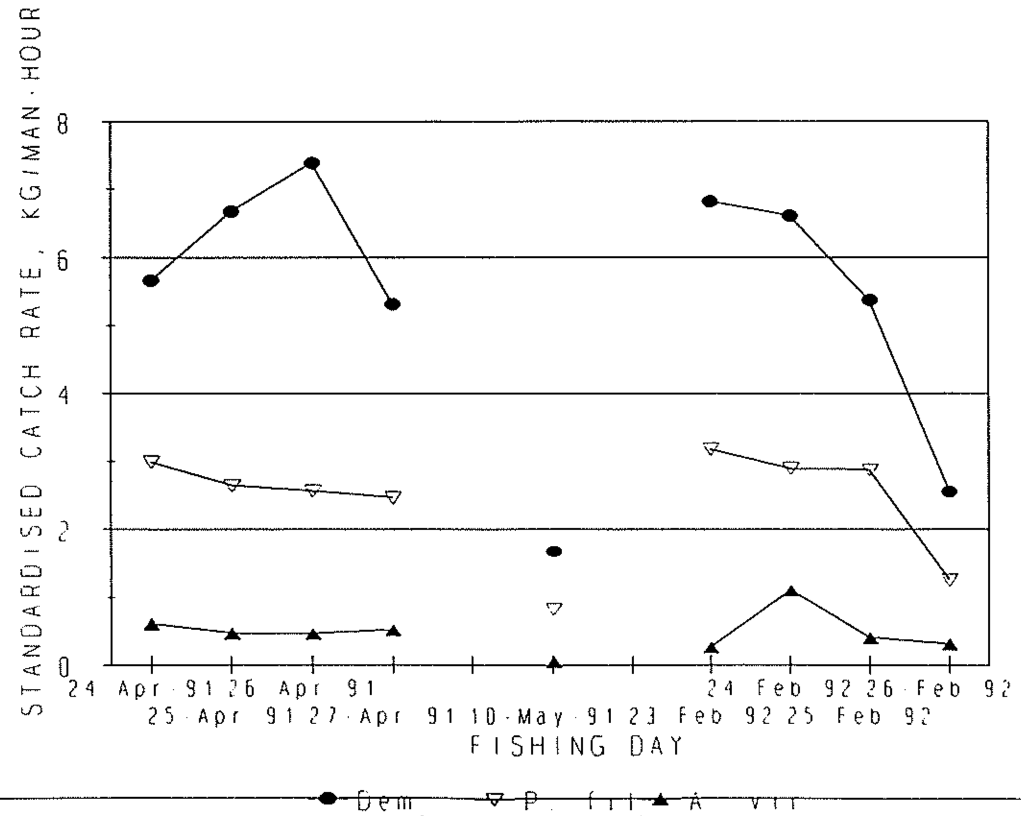


Figure A.4.6. Standardised daily catch rates at Small Constant Bank.

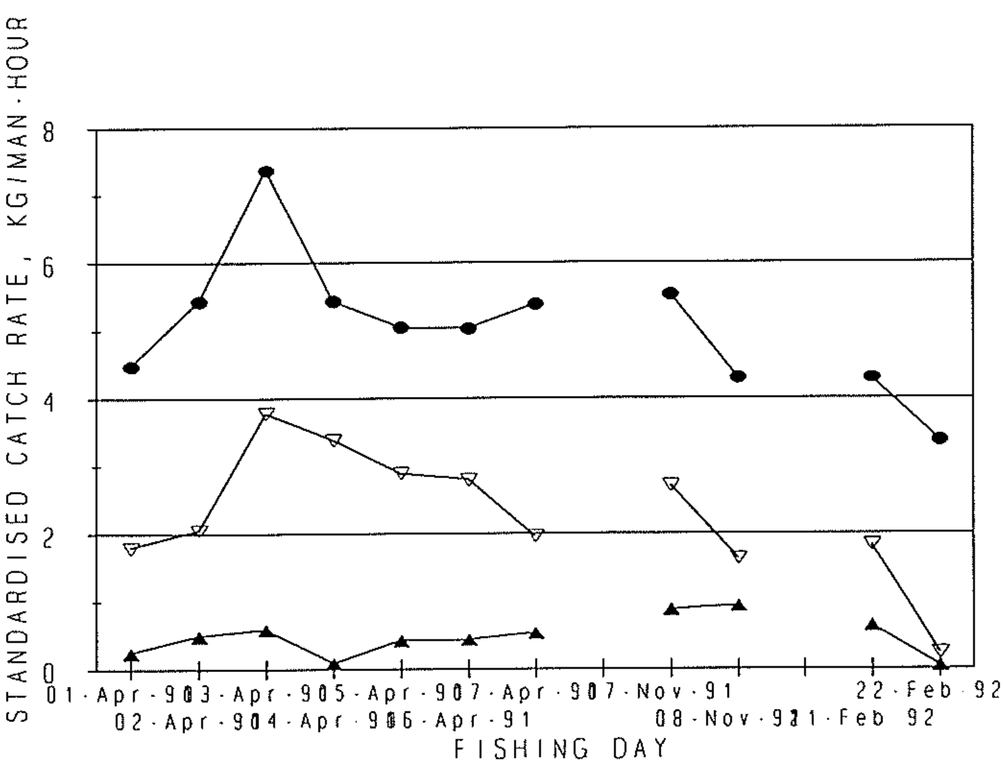


Figure A.4.7. Standardised daily catch rates at Farquhar.

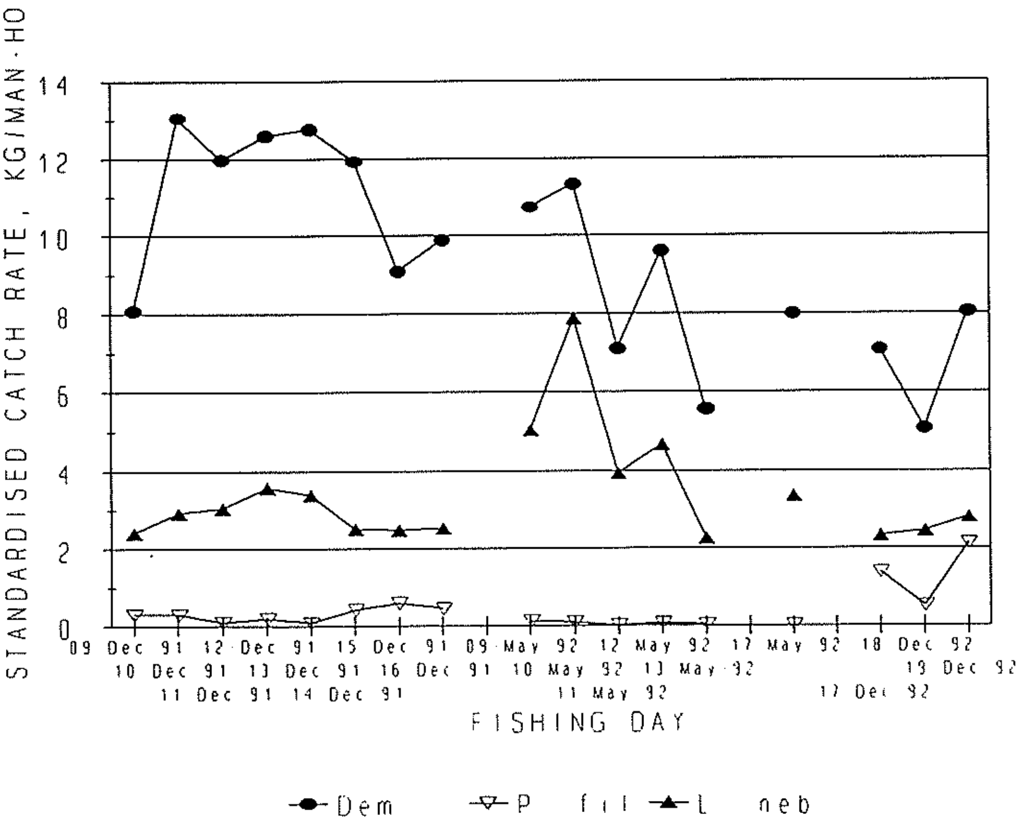


Figure A.4.8. Depletion of *Pristipomoides filamentosus* at Correira Bank during voyages 1 and 3. February 26 1992 was excluded from the analysis since the reported depth was significantly less than on the previous 3 days and the position had changed.

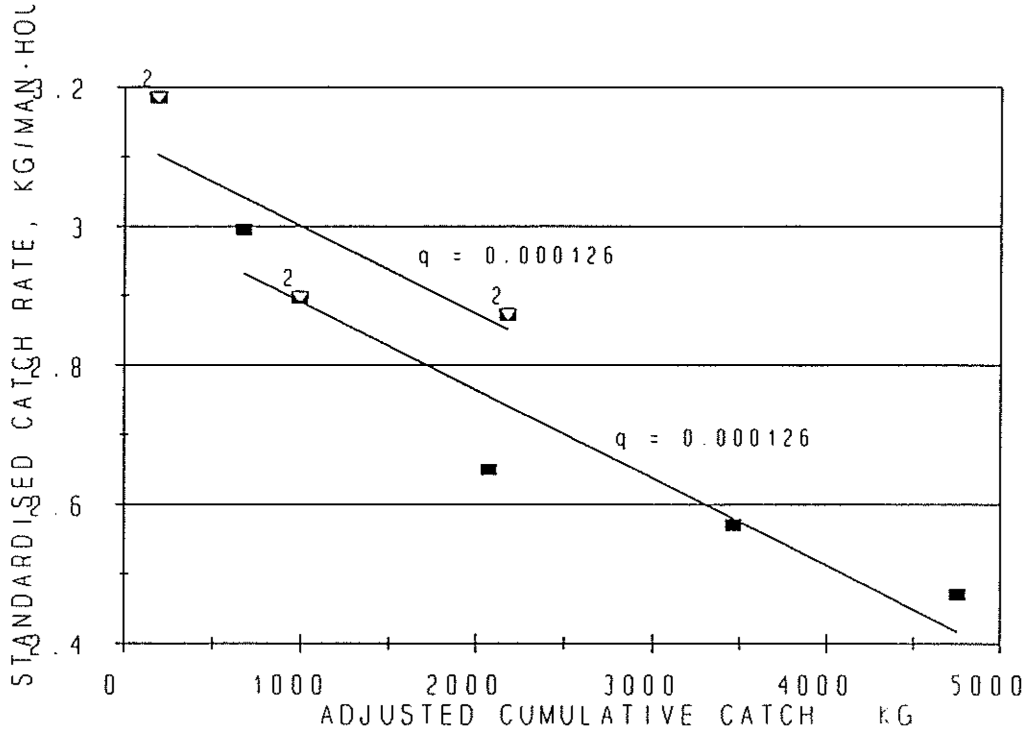
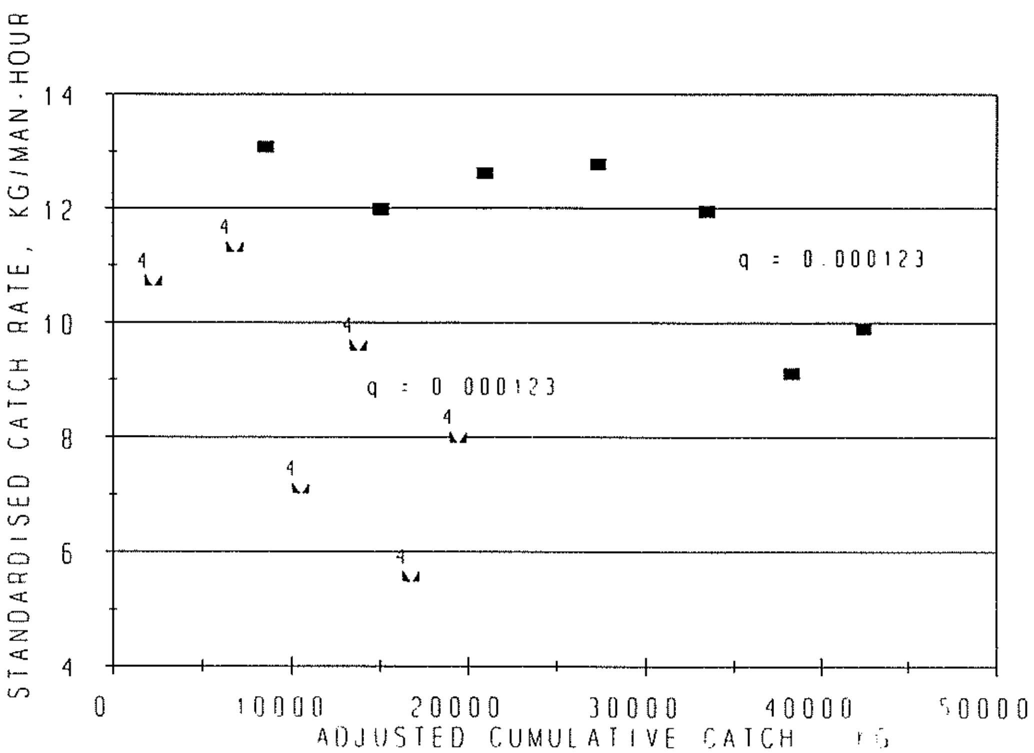


Figure A.4.9. Depletion of the total demersal species catch at Farquhar during voyages 3, 4 and 5. December 9 1991 and voyage 5 was excluded from the analysis.



ADDITIONAL INFORMATION

Mees (1991b) and Mees (1992c) presented details of analyses for individual mother-vessel voyages. It is clear that during a single trip local depletion may occur. The above paper examined locations at which fishing occurred during more than one trip and examined both depletion over a longer term and the recovery of fished reefs with time. A number of locations had been fished on more than one occasion, but because the time series was insufficient or due to changing target species or depth these locations were excluded from the analysis. The details are now presented:

Fig A.4.10.

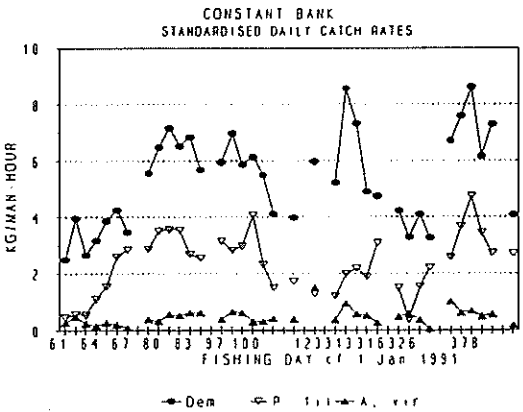


Fig A.4.11

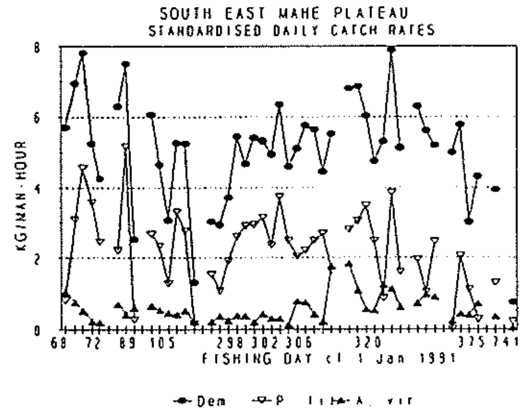


Fig. A.4.12

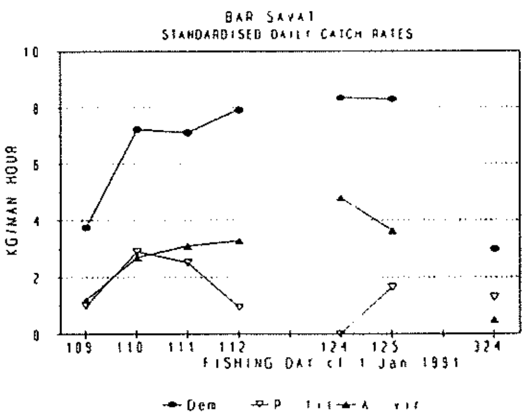


Fig A.4.13

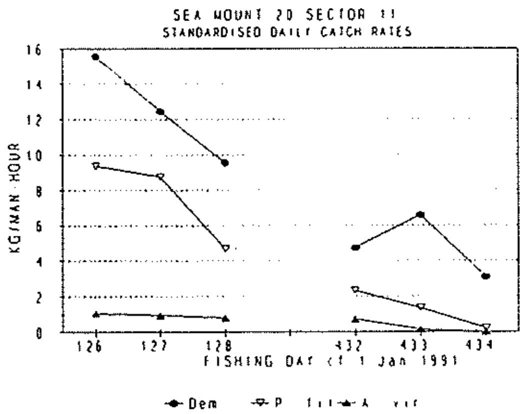


Fig A.4.14

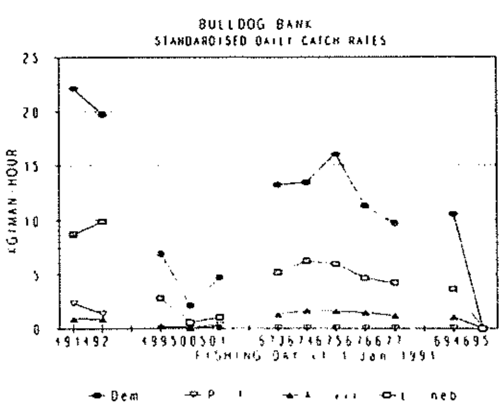


Fig. A.4.15

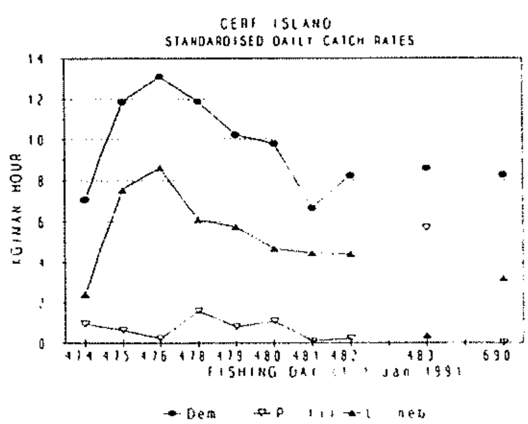


Fig. A.4.16

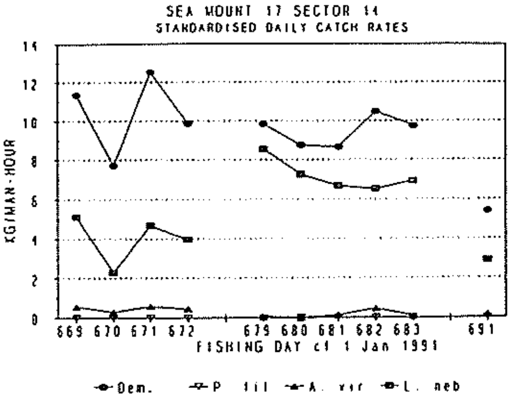


Fig. A.4.17

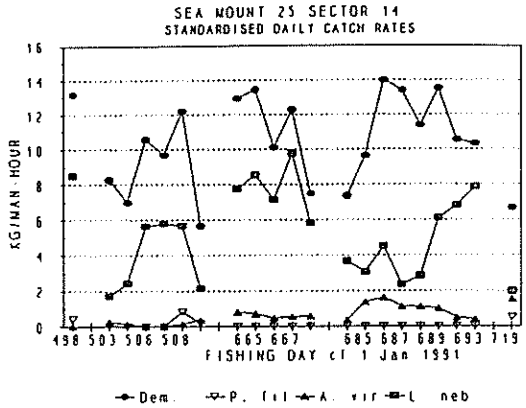
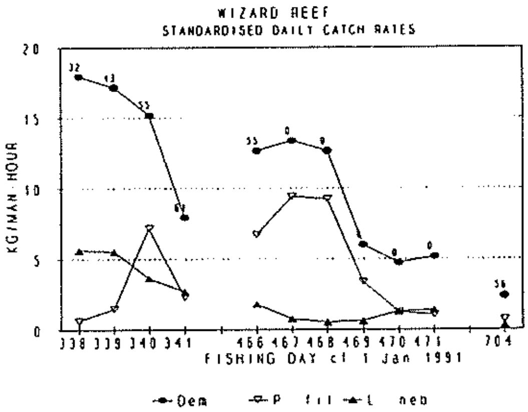


Fig A.4.18



ANNEX 5 : CEDA analyses for fishing sector 1 : estimation of exploited biomass.

Long term depletion suitable for analysis using biomass dynamic production models (Fox, Schaeffer) was only evident for fishing sector 1 (see 5.1.). The CEDA package (MRAG, 1992a) was used. Inputs required for the model are catch and effort (or an index of abundance). In addition CEDA requires that a parameter, 'initial proportion' (In%), is entered. This reflects the degree of exploitation prior to the period covered by the data set in order to back-calculate virgin biomass. Since exploitation in sector 1 is known to have occurred for a considerable time[10], sensitivities were performed on this parameter. Additionally CEDA offers a choice of 3 error models which may be fitted to the model in order to establish the best fit. Middle timing was always selected. The CEDA manual should be consulted for further details of model fitting.

A number of vessels exploited demersal species from sector 1. Rather than standardising fishing effort for all vessels and computing a total standardised effort, inputs for the model were GLIM standardised effort values for the traditional whaler fleet in sector 1 as an index of relative abundance, together with total catch estimates from all vessels (Table A.5.1).

Table A.5.1. The total catch landed from sector 1 by all boat categories, and the GLIM standardised catch rate for traditional whalers only in this sector.

SPECIES	DETAILS	YEAR				
		89	90	91	92	93
ALL DEMERSALS	Total catch (kg)	928100	1305899	1291100	977000	1115149
	Standardised cpue	49.40	43.16	30.81	15.69	14.60
BOURGEOIS	Total catch (kg)	141692	174114	340982	240677	207983
	Standardised cpue	16.98	4.50	9.27	3.92	3.60
JOB GRIS	Total catch (kg)	238468	539312	347958	192434	308298
	Standardised cpue	14.61	13.65	5.39	1.86	0.90
REMAINING LUTX	Total catch (kg)	191749	225749	113731	78331	69265
	Standardised cpue	9.31	4.53	1.61	0.66	0.08
MACONDE	Total catch (kg)	81217	73574	81274	106972	117948
	Standardised cpue	2.73	3.64	2.92	2.82	3.26
REMAINING SERX	Total catch (kg)	59617	67702	78985	69694	53645
	Standardised cpue	2.19	5.28	6.45	2.74	1.73
KAPTEN BLANC	Total catch (kg)	22793	34992	33443	30673	20998
	Standardised cpue	1.21	1.48	1.20	0.45	0.22
REMAINING LETX	Total catch (kg)	192564	190457	294728	258219	337011
	Standardised cpue	6.50	9.85	8.24	7.83	10.18

[10] Until the recent increase in the number of whalers (see Mees 1989c), however, the level of exploitation in sector 1 would not have been as great as today, and would have been more concentrated in coastal areas.

Initially all demersal species were grouped into one 'guild' and treated as a single species. The sensitivity of model outputs (K, carrying capacity; q, catchability; r, intrinsic rate of growth) to changes in initial proportion were examined. The fit of model to data was tested using three different error models in order to establish the best choice (Table A.3.2). Both Fox and Schaeffer models were tested but results were similar and neither model was obviously the best. Only results for the Fox model are reported.

The Log transform error model produced a poor fit with uneven distribution of residuals (they were positively biassed, eg, Fig A.5.1.) indicating that this error model should not be used. The gamma error model produced a fair fit of model to data with respect to distribution of residuals, but a good fit for an initial proportion of 0.6. Nevertheless, residuals tended to be positively biasses and the obserrved and expected catch rate data differed. Confidence intervals generated were also 'tight', and the R^2 value (goodness of fit) was greatest for this initial proportion (Fig A.5.2). The least squares error model produced the best fit of expected and observed catch rate, and residual distribution was good. However, at the best R^2 value corresponding to an initial proportion of 0.575 confidence intervals were wide (Fig A.5.3) and were better for In% 0.5 (Fig A.5.4). The Least squares model fitted the data best.

The point value of K was insensitive to changes in initial proportion except at low values when its value increased by a factor of 10. However, the range of values was least for an initial proportion of 1.0. 'r', the intrinsic rate of growth, increased with decreasing In% except at very low initial proportions when the value of r was obviously incorrect. For slow growing long lived species a value of r of around 0.2 might be expected. The goodness of fit parameter R^2 suggested that an initial proportion of around 0.6 was best for each model, but the insensitivity of the model to changes in In% indicated that there was little to choose between In% of 0.5-1.0. R^2 values indicated a poor fit with an initial proportion around 0.4, but the value increased again at very low values of initial proportion suggesting a better fit. The residual distribution was not as good, however, (eg. Fig A.5.5) and the better fit was indicated to be that with an initial proportion around 0.6. Furthermore, the value of r was particularly low at low In% and this led to very low estimates of MSY. Better r values occurred with initial proportions around 0.7-0.8, and although these values had a lower R2, the appearance of the fit was not greatly different suggesting this value of In% could be used. The lack of an obvious choice indicates that an estimate of catch and effort prior to the period of the data set should be considered to better infer the degree of exploitation.

The unexploited biomass, K, the biomass at MSY ($B^* = Ke^{-1}$), and the maximum sustainable yield ($MSY = rKe^{-1}$) were estimated (Table A.5.2). The present study estimated unexploited biomass to be 6280 t (0.5-1.64 $t.km^{-2}$, least squres, In% 0.7, area 6,000 km^2), and the MSY 422 t (0.07 $t.km^2$) achieved at an exploited biomass of 2310 t (confidence intervals[11] cannot be determined for these parameters from the information shown in Table A.5.3). The virgin biomass derived from trawl survey data on the Mahe Plateau during the 1970's was 1.46 $t.km^{-2}$ equivalent to 8,400 t (Lablache and Moussac, 1987; Lablache et. al., 1988), but specifically in relation to the inshore fishing areas Kunzel *et al.* (1983) found substantially lower stock densities (0.15 $t.km^2$ for handline caught demersal species). Mees (1992b) estimated the MSY to be 0.168 $t.km^{-2}$, around 1000 t. Catches from sector 1 each year since 1989 have ranged from 938 - 1306 t.

The present estimate of unexploited biomass for sector 1 was similar to that from trawl survey information applying the value derived by Lablache and Moussac (1987, 8400 t). Present MSY estimates however were lower than previous estimates (1008 t). The catch taken from this sector in recent years was at the upper limit of the estimate for sustainable yield. Catch rates have fallen dramatically, but do not correlate with the available catch information. Clearly something is happening to the inshore fishery to result in such dramatic decreases in catch rate for sampled data. However, total catch values have not fallen as might be expected, and exceed the estimated biomass from this analysis (in 1993 the biomass is estimated to be around 300 tonnes). Clearly there is either an error in the estimation of raised total catch (eg. catches from outside sector 1 have been included due to poor reporting of fishing location) or the estimation of aggregated catch rates masks other factors happening in the fishery (eg. new boats exploiting demersal species are less efficient). Prior to extending this analysis to other species closer examination of the data is required.

[11] Confidence intervals for MSY will be available in the next version of CEDA, due out in June 1995.

Table A.5.2. Sensitivity tests for different values of the parameter 'initial proportion' with the Fox production model and 3 different error models. Data fitted was total catch from sector 1 with relative abundance indices from standardised catch rates of traditional whalers.

In %	R^2	K	$K_{0.025}$	$K_{0.975}$	q	$q_{0.025}$	$q_{0.975}$	r	$r_{0.025}$	$r_{0.975}$	FIT	B	MSY
LEAST SQUARES													
1.000	0.975	6043.4	4410.4	6961.6	0.0000091	7.3E-06	1.3E-05	0.060	5.4E-09	0.366	OK	2223.3	134.1
0.800	0.977	6638.2	3736.8	8670.9	0.0000103	7.4E-06	1.9E-05	0.106	3.5E-08	0.055	OK	2442.1	259.4
0.700	0.980	6280.0	2978.2	9867.3	0.0000125	7.4E-06	2.7E-05	0.182	8.0E-08	0.080	OK	2310.3	421.6
0.600	0.989	4159.0	2167.8	11263.5	0.0000216	7.7E-06	4.1E-05	0.499	3.2E-07	1.259	OK	1530.0	763.8
0.575	0.991	3448.7	2033.9	11394.5	0.0000269	7.9E-06	4.4E-05	0.674	9.3E-07	1.365	OK	1268.7	855.7
0.500	0.971	2260.3	1467.1	7699.4	0.0000440	1.2E-05	6.5E-05	1.208	0.200	2.042	OK	831.5	1004.4
0.400	0.972	15200.5	1414.3	17214.2	0.0000089	7.3E-06	7.2E-05	0.013	4.9E-08	2.144	OK	5591.9	1565.7
0.200	0.971	32321.6	6148.6	34224.7	0.0000084	7.6E-06	3.5E-05	5.3E-06	2.3E-08	0.5126	OK	11890.4	0.1
0.100	0.971	64612.1	16108.1	68414.6	0.0000084	7.6E-06	2.8E-05	2E-07	1.3E-08	0.264	OK	23769.5	0.0
GAMMA													
1.000	0.969	4575.2	3307.3	6419.6	0.0000112	7.3E-06	1.6E-05	0.282	3.6E-08	0.663	FAIR	1683.1	474.8
0.800	0.976	3499.1	2498.6	6792.1	0.0000185	8.8E-05	2.6E-05	0.593	0.053	1.030	FAIR	1287.2	763.8
0.700	0.982	3196.5	2294.5	6779.8	0.0000226	1.0E-05	3.2E-05	0.706	0.116	1.145	FAIR	1175.9	829.8
0.600	0.981	3354.1	2404.8	7043.8	0.0000242	1.1E-05	3.3E-05	0.674	0.149	1.080	OK-good	1233.9	832.1
0.500	0.241	57395.0	12523.7	110677.3	0.0000012	3.4E-07	6.6E-06	8.1E-08	8.3E-09	1.453	no fit	21114.5	0.0
0.400	0.506	34256.2	11999.0	63636.4	0.0000027	1.0E-06	9.3E-06	1.0E-07	5.7E-09	0.207	no fit	12602.2	0.0
0.200	0.950	22394.1	14949.0	32426.0	0.0000107	7E-06	1.5E-05	0.047	1.1E-08	0.140	FAIR	8238.3	387.6
0.100	0.950	50751.0	35213.8	65238.3	0.0000095	6.9E-06	1.3E-05	0.018	8.4E-09	0.074	FAIR	18670.2	341.7
LOG TRANSFORM													
1.000	0.963	3916.3	2709.5	6017.4	0.0000135	7.6E-06	2.1E-05	0.449	0.017	0.920	poor	1440.7	647.5
0.800	0.973	2961.5	1784.9	5261.3	0.0000223	1.1E-05	4.2E-05	0.785	0.237	1.606	poor	1089.5	855.7
0.700	0.982	2257.3	1475.6	3936.9	0.0000328	1.8E-05	5.3E-05	1.170	0.506	2.036	poor	830.4	971.7
0.600	0.987	1914.6	1425.7	3036.6	0.0000422	2.6E-05	5.6E-05	1.454	0.785	2.110	poor	704.3	1024.1
0.500	0.974	1908.6	1371.6	3645.3	0.0000464	2.4E-05	6.2E-05	1.469	0.645	2.208	poor	702.1	1031.5
0.400	0.942	3846.1	1896.4	17170.5	0.0000281	6.2E-06	5.0E-05	0.639	5.1E-08	1.523	poor	1414.9	903.6

Fig A.5.1. The best fit of the Fox model to inshore fishery data achieved with the log transform error model and an initial proportion of 0.6. Note that whilst R^2 was high (0.987) the residual points were all positively biased indicating a poor fit.

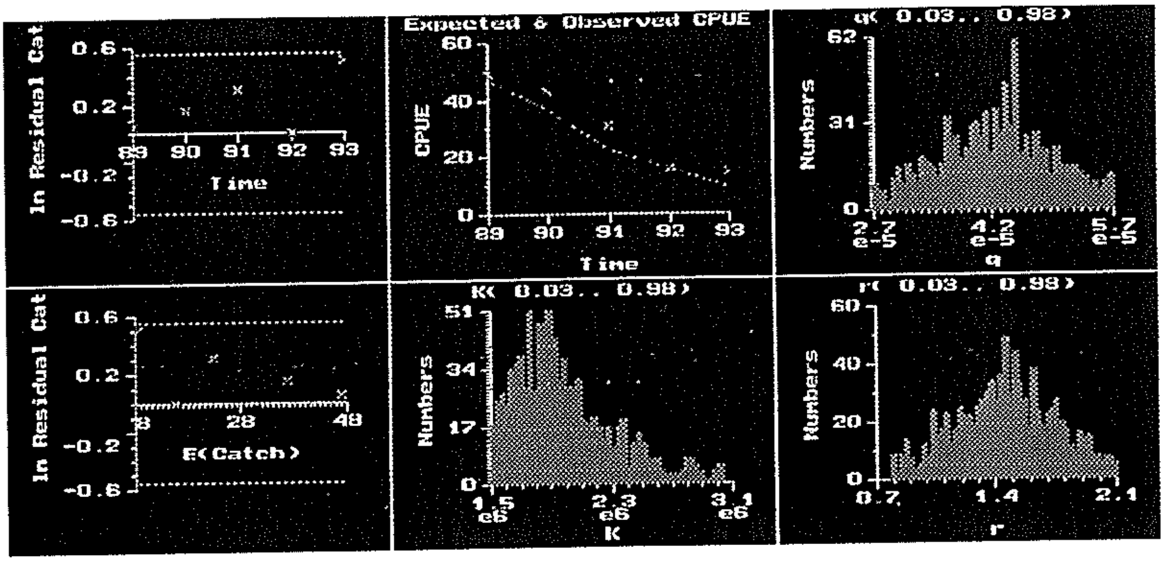


Fig A.5.2. The best fit of the Fox model to inshore fishery data achieved with the gamma error model and an initial proportion of 0.6. Note the small spread for confidence intervals and the reasonable distribution of residuals. The expected and observed catch rate fit is not as good, however as that for the least squares error model.

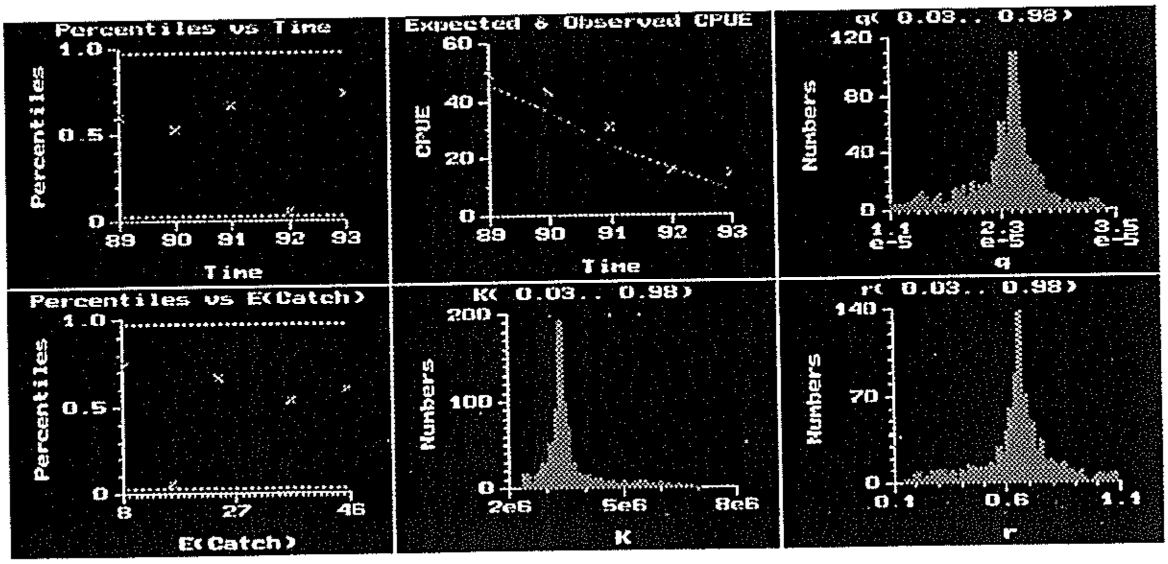


Fig. A.5.3. : The best fit of the Fox model to inshore fishery data achieved with the least squares error model and an initial proportion of 0.575. The fit of expected and observed catch rates is good and residuals are evenly spread. Confidence intervals are poor, however.

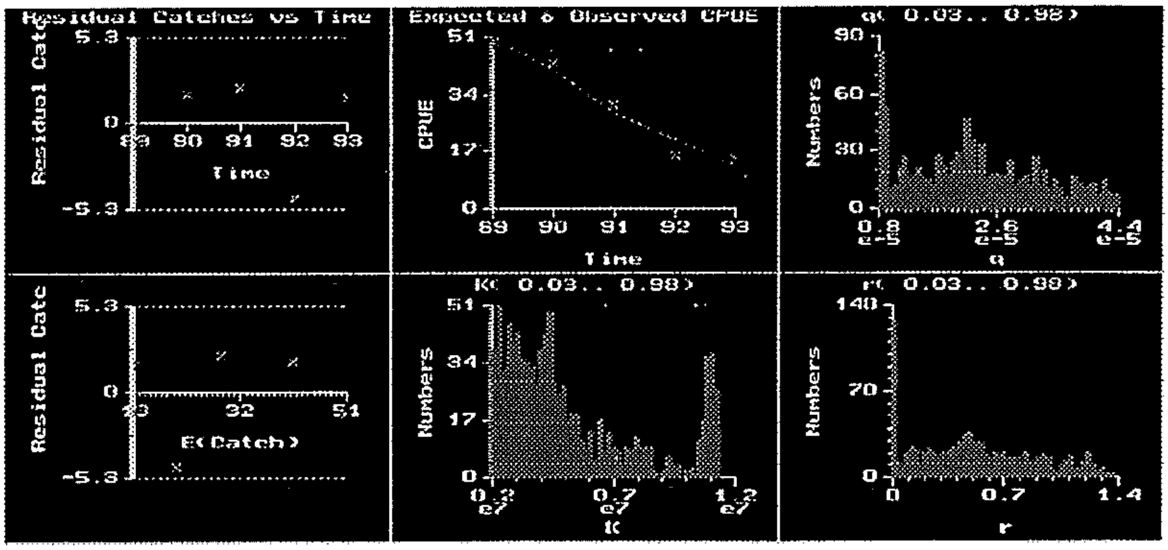


Fig A.5.4. The fit of the Fox model to inshore fishery data achieved with the least squares error model and an initial proportion of 0.7.

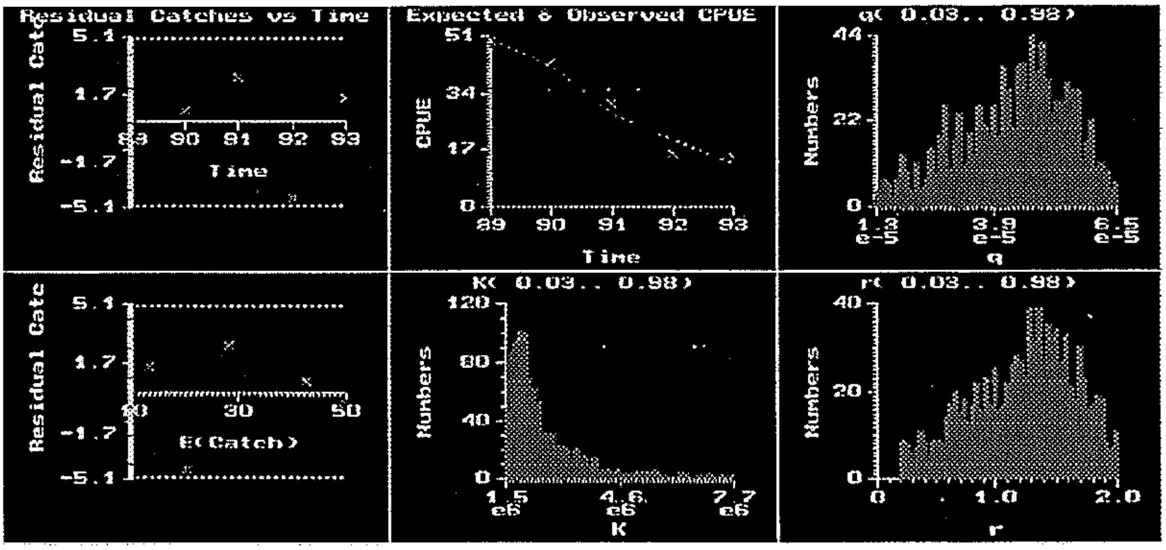
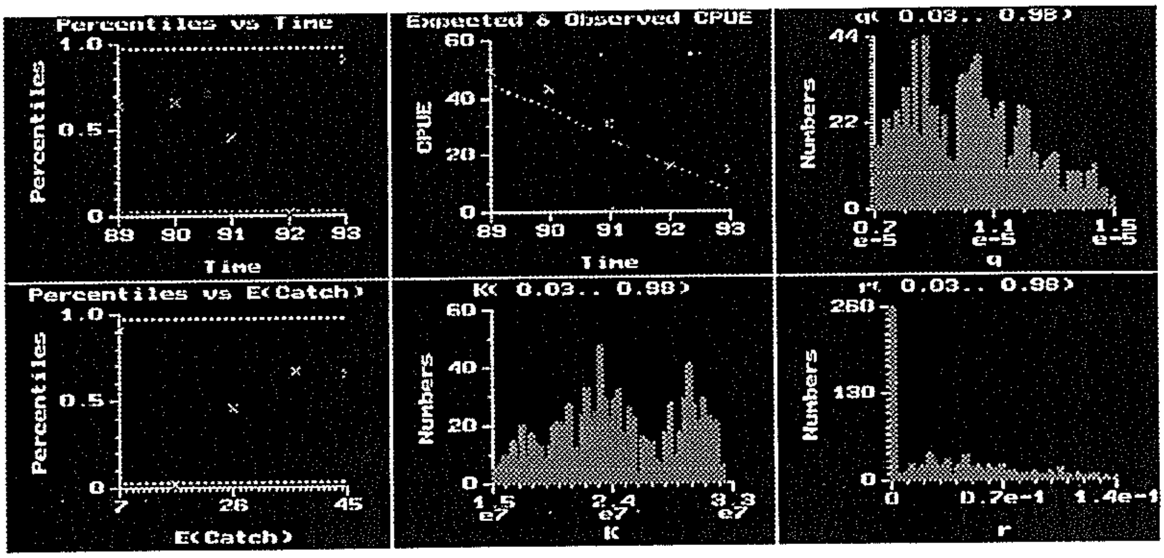


Fig A.5.5. The fit of the Fox model to inshore fishery data achieved with the gamma error model and an initial proportion of 0.2. Residuals show a curved pattern not seen with ln% of 0.6, indicating a poor fit. The spread of confidence intervals is poor.



ANNEX 6 : Summary of length frequency and biometric data

Length frequency data was collected for *P. filamentosus, A. virescens, L. sebae, E. chlorostigma* and *L. nebulosus.* Additional information was collected during biometric studies on *P. filamentosus, A. virescens* and *L. nebulosus* (see Section 4). Data was collected mostly from schooners landing fish to Seychelles Marketing Board (SMB) at Port Victoria, and from SFA research vessels. Initially gear type and fishing location were not recorded, but where possible, this information was collected from 1990 onwards.

For each species, a summary of all data aggregated by gear type and location is given for length frequency and biometric studies, and the number of fish sampled by gear, location and year are indicated (Tables A.6.1 - A.6.15). The latter indicate that in many cases insufficient data exist to perform analyses on dissagregated data.

TABLE A.6.1 : Summary of *P. filamentosus* length frequency information. All data : all gears and locations pooled

YRMON		TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
89	11	634	1.29	165	52.5	32.0	75.1	128	50.2	33.4	72.8	341	55.6	32.9	76.6
89	12	395	1.41	165	50.0	30.3	76.1	117	49.3	31.2	70.0	113	53.4	28.3	74.8
90	1	452	1.51	95	52.0	32.0	73.4	63	53.2	38.0	71.4	294	49.8	31.6	77.2
90	2	335	0.91	83	48.1	31.2	69.1	91	49.7	31.4	69.7	161	53.6	30.1	74.4
90	3	729	1.08	180	49.5	31.2	76.6	166	50.1	32.4	70.2	383	52.4	31.1	75.4
90	4	1010	1.32	250	51.6	29.1	77.6	189	47.1	6.0	70.8	571	55.3	31.7	75.0
90	5	551	1.07	171	50.6	32.6	76.7	160	49.6	31.2	71.1	220	53.6	32.5	79.5
90	6	254	1.24	92	43.7	32.6	70.8	74	44.0	33.1	64.2	88	48.1	31.5	75.7
90	7	304	0.86	103	46.7	31.6	71.0	120	46.2	31.6	71.8	81	44.5	33.1	71.4
90	8	58	1.82	31	45.4	25.6	69.5	17	45.7	34.2	64.1	10	43.3	26.1	65.6
90	9	465	1.10	201	50.9	29.6	74.0	182	50.0	29.6	70.1	82	53.0	26.0	75.0
90	10	822	1.17	329	51.1	29.2	73.1	281	50.3	28.1	77.6	212	52.4	28.7	73.8
90	11	531	1.05	208	54.0	30.3	72.8	198	52.7	30.9	71.4	125	53.7	33.9	70.3
90	12	511	1.14	198	54.7	31.8	76.3	174	51.8	29.2	74.2	139	55.5	37.9	70.6
91	1	241	1.31	85	46.3	31.8	66.7	65	45.8	30.1	67.5	91	48.2	30.7	72.0
91	2	95	1.48	40	46.7	33.4	68.3	27	43.7	33.2	58.3	28	49.7	34.7	68.1
91	3	235	2.16	106	50.9	25.1	78.8	49	52.3	35.1	78.2	80	51.4	31.5	78.3
91	4	609	1.56	259	48.9	31.4	86.6	166	47.4	29.3	78.0	184	49.2	25.2	68.6
91	5	1400	1.35	568	48.3	22.9	77.7	420	45.8	20.2	73.7	412	51.9	22.4	77.5
91	6	928	1.40	352	51.8	31.8	75.1	251	50.5	28.2	78.4	325	56.3	25.6	76.0
91	7	580	1.63	267	52.1	34.3	70.1	164	50.8	33.7	65.2	149	54.2	40.2	74.8
91	8	235	2.15	131	46.3	27.3	70.2	61	44.5	24.4	68.4	43	49.0	27.5	70.0
91	9	748	1.44	329	49.4	27.1	79.0	228	46.9	28.1	74.3	191	49.5	26.5	77.6
91	10	1473	1.75	679	50.8	23.4	78.4	388	47.4	25.6	77.9	406	50.8	25.3	78.4
91	11	1544	1.28	622	49.2	22.9	77.5	487	47.9	25.3	75.1	435	51.3	24.1	87.8
91	12	518	1.26	228	42.9	27.2	68.4	181	39.9	26.0	66.9	109	42.2	27.5	62.0
92	1	1297	2.14	543	51.3	29.5	77.0	254	49.4	29.4	72.3	500	51.7	33.3	77.5
92	2	1460	1.24	621	45.3	21.6	76.2	500	43.6	22.1	69.5	339	49.0	21.5	76.2
92	3	1384	1.37	592	43.4	25.2	74.9	432	42.2	22.0	70.0	360	45.3	23.5	75.8
92	4	1374	1.26	480	44.3	24.0	76.0	382	43.7	26.2	79.9	512	50.4	23.5	75.5
92	5	703	1.18	250	40.0	24.7	73.2	211	37.3	25.0	69.2	242	56.4	26.3	70.1
92	6	1351	0.90	425	46.0	24.9	71.0	470	39.5	23.5	71.6	456	47.1	22.8	80.0
92	7	310	1.13	128	46.6	31.4	72.3	113	40.2	31.9	66.5	69	45.5	30.9	72.3
92	8	343	1.06	148	49.8	26.6	72.5	140	50.1	30.9	73.1	55	48.8	31.5	78.0
92	9	581	1.30	236	45.0	28.9	68.9	181	45.4	28.2	69.3	164	45.0	22.0	70.4
92	10	594	0.98	259	42.9	25.5	75.0	265	42.9	26.9	68.5	70	43.1	27.2	74.2
92	11	545	1.41	161	52.8	28.5	75.0	114	51.0	29.0	72.2	270	53.9	28.5	76.1
92	12	244	1.11	73	47.4	29.9	71.3	66	43.5	28.3	64.6	105	55.8	31.0	72.0
93	9	50	1.37	26	54.3	26.2	76.0	19	57.2	36.2	76.0	5	55.8	39.2	67.4
93	10	70	3.17	19	41.8	27.5	64.5	6	41.8	34.5	49.0	45	47.7	41.0	65.0
93	11	216	1.10	74	54.6	28.5	77.0	67	54.7	33.6	71.3	75	62.1	38.0	76.6
93	12	369	1.40	146	44.4	30.5	74.0	104	43.1	29.0	69.8	119	51.9	29.0	73.5
TOTAL		26548	1.30	10118	48.3	21.6	86.6	7771	46.3	6.0	79.9	8659	51.4	21.5	87.8

Table A.6.2. Summary of *P. filamentosus* biometric study information. All data : all gears and locations pooled

YR	MON	TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
89	12	21	0.11	2	56.3	55.7	56.9	19	47.6	40.3	51.5				
90	1	95	0.86	44	50.3	31.0	69.6	51	46.1	30.1	69.2				
90	2	261	1.03	130	53.4	36.6	72.9	126	53.1	35.1	71.7	5	55.7	54.2	57.5
90	3	175	1.06	90	55.8	34.6	72.0	85	54.3	33.4	72.5				
90	4	122	1.10	64	58.0	40.0	73.6	58	51.8	38.1	71.2				
90	5	41	0.95	20	52.4	32.9	68.4	21	53.0	36.2	68.4				
90	7	45	1.25	25	51.6	43.1	69.3	20	52.5	44.9	68.0				
90	9	44	1.00	21	45.5	31.0	66.7	21	45.1	33.5	64.4	2	35.0	32.3	37.6
90	10	190	1.14	100	50.3	36.1	69.0	88	48.7	32.0	66.6	2	56.6	52.6	60.5
90	11	40	0.90	19	47.8	39.2	66.6	21	54.9	39.5	72.6				
90	12	174	1.19	94	56.7	35.4	72.0	79	56.5	36.5	73.1	1	30.5	30.5	30.5
91	1	33	2.00	22	52.2	38.2	67.0	11	58.8	48.7	65.6				
91	2	41	1.05	21	44.1	35.9	61.9	20	50.7	40.4	66.6				
91	4	81	0.93	39	53.9	43.5	71.0	42	57.6	40.7	69.5				
91	5	71	0.82	32	52.6	27.0	71.5	39	51.9	36.2	68.0				
91	6	45	2.00	30	45.6	34.7	61.6	15	41.3	30.5	56.1				
91	7	19	2.17	13	55.6	43.3	65.7	6	56.1	47.8	62.6				
91	8	95	0.84	43	46.1	26.3	72.0	51	43.5	22.5	68.4	1	23.7	23.7	23.7
91	9	56	1.00	28	50.2	41.4	71.6	28	50.2	41.4	61.8				
91	10	93	0.67	37	38.4	28.2	74.6	55	41.9	27.9	69.6	1	32.3	32.3	32.3
91	11	11	1.75	7	50.4	42.6	59.0	4	51.8	48.3	56.2				
TOTAL		1753	1.02	881	51.8	26.3	74.6	860	50.9	22.5	73.1	12	45.7	23.7	60.5

TABLE A.6.3. Number of length frequency measurements per year per sector by gear : *P. filamentosus*

UNSPECIFIED GEAR

SECTOR	89	91	92	93	TOTAL
2	0	135	1	0	136
4	0	88	1	0	89
5	0	158	0	0	158
6	0	301	0	0	301
7	0	296	1	0	297
8	0	509	0	0	509
9	0	814	0	0	814
11	0	472	0	0	472
13	0	369	0	0	369
14	0	270	0	0	270
?	1029	826	1544	194	3593
TOTAL	1029	4238	1547	194	7008

HANDLINES

SECTOR	90	91	92	93	TOTAL
2	220	23	380	0	623
3	0	5	388	0	393
4	0	0	43	0	43
5	0	313	24	0	337
6	867	277	488	0	1632
7	873	436	376	115	1800
8	136	453	1	0	590
9	305	89	93	32	519
10	58	0	278	0	336
11	510	94	0	0	604
13	221	341	0	0	562
14	250	12	0	0	262
?	2582	1041	1370	83	5076
TOTAL	6022	3084	3441	230	12777

ELECTRIC REELS

SECTOR	92	93	TOTAL
5	0	13	13
6	196	57	253
9	168	0	168
11	0	50	50
13	76	0	76
?	1	0	1
TOTAL	441	120	561

DROP LINES

SECTOR	91	92	TOT
7	78	0	78
13	110	79	189
?	0	9	9
TOTAL	188	439	627

GILL NETS

SECTOR	91	92	93	TOTAL
6	0	1204	0	1204
7	313	374	0	687
8	0	321	0	321
11	0	93	0	93
13	324	0	161	485
?	459	2326	0	2785
TOTAL	1096	4318	161	5575

TABLE A.6.4. : Number of fish measured for biometric studies per year per sector by gear : *P. filamentosus*

UNSPECIFIED GEAR

SECTOR	89	90	91	TOTAL
2	0	325	0	325
3	0	0	30	30
4	0	0	1	1
5	0	49	51	100
6	21	209	126	356
7	0	264	30	294
8	0	79	168	247
9	0	0	14	14
10	0	44	17	61
11	0	209	0	209
13	0	8	18	26
TOTAL	21	1187	455	1663

HANDLINES

SECTOR	91	TOTAL
13	11	11

GILLNETS

SECTOR	91	TOTAL
7	79	79

TABLE A.6.5 : Summary of *A. virescens* length frequency data
ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL N	TOTAL M:F	MALE N	MALE AVG FL	MALE MIN FL	MALE MAX FL	FEMALE N	FEMALE AVG FL	FEMALE MIN FL	FEMALE MAX FL	UNDETERMINED N	UNDETERMINED AVG FL	UNDETERMINED MIN FL	UNDETERMINED MAX FL
91	1	450	1.68	156	57.4	28.3	83.4	93	51.9	29.5	86.5	201	58.7	23.2	84.2
91	2	623	1.41	236	59.0	29.2	81.0	167	56.9	28.8	89.9	220	59.1	31.2	88.6
91	3	895	1.51	368	56.0	28.5	85.8	243	53.4	29.4	85.8	284	63.6	28.9	87.3
91	4	1049	1.85	417	63.8	31.1	89.3	226	58.1	31.6	86.0	406	66.2	25.3	86.8
91	5	847	2.81	379	63.8	32.6	91.6	135	59.3	23.0	80.4	333	66.5	33.0	89.5
91	6	612	1.70	225	53.0	21.0	87.7	132	49.5	30.8	87.4	255	62.6	29.4	88.6
91	7	629	1.71	253	50.4	29.4	88.0	148	47.9	27.9	88.8	228	62.7	34.5	86.8
91	8	368	1.60	157	60.1	31.3	82.3	98	50.9	27.0	88.2	113	61.4	32.4	79.3
91	9	293	2.23	116	58.8	32.1	83.2	52	54.1	32.7	81.2	125	67.3	34.0	86.9
91	10	658	1.53	226	61.2	33.2	83.6	148	58.3	32.6	85.0	284	63.7	30.8	89.5
91	11	1074	1.60	419	60.9	35.3	82.2	262	60.5	38.0	86.5	393	66.1	34.8	91.5
91	12	821	1.51	344	62.3	35.7	87.4	228	62.5	40.0	94.0	249	68.0	34.3	90.0
92	1	732	1.93	284	62.5	24.3	86.8	147	63.1	27.0	88.0	301	64.9	34.5	88.4
92	2	443	2.16	175	60.4	31.0	82.0	81	59.6	33.9	87.3	187	66.7	35.2	89.2
92	3	1447	2.46	482	60.6	31.4	87.5	196	59.8	24.4	92.0	769	66.1	32.0	89.8
92	4	1007	1.99	306	60.6	34.5	84.0	154	61.5	35.0	87.5	547	66.4	37.2	94.7
92	5	697	2.20	213	64.3	28.0	84.6	97	63.1	37.7	84.5	387	69.0	37.8	93.0
92	6	107	2.92	35	59.0	40.5	76.4	12	58.3	38.2	70.5	60	69.8	47.2	94.0
92	8	4	0.00					2	86.0	81.5	90.5	2	86.0	81.8	90.1
92	9	23	3.50	7	61.7	52.3	66.4	2	74.3	64.6	84.0	14	65.1	58.5	74.5
92	10	108	1.41	45	51.0	27.3	73.5	32	55.0	25.1	86.2	31	66.2	42.5	81.5
92	11	278	4.04	97	64.0	43.0	82.0	24	60.5	43.2	74.9	157	64.7	40.1	87.5
92	12	163	3.26	62	56.9	34.5	75.1	19	55.5	43.5	72.0	82	65.4	42.2	88.0
93	1	88	1.76	37	63.0	26.5	79.8	21	67.3	31.5	84.4	30	61.6	30.6	79.0
93	2	73	2.75	11	64.5	45.5	80.5	4	73.9	60.3	82.5	58	70.2	47.6	90.5
93	3	379	1.89	85	62.2	46.1	81.8	45	65.1	40.6	96.3	249	70.3	35.8	88.4
93	4	399	1.72	93	61.2	35.2	88.8	54	64.5	42.7	90.3	252	69.0	39.4	89.0
93	5	170	1.96	55	62.8	39.9	80.3	28	59.4	37.2	86.5	87	68.9	37.0	88.0
93	6	143	3.07	43	65.8	46.0	81.4	14	60.6	43.3	73.5	86	68.9	42.3	87.0
93	7	108	1.73	38	61.7	31.3	77.3	22	58.7	39.0	77.6	48	65.5	44.6	80.2
93	9	25	2.75	11	73.4	64.5	82.5	4	69.1	63.5	78.3	10	74.4	43.5	85.3
93	10	421	1.43	140	60.4	37.2	82.0	98	62.2	28.5	92.4	183	64.8	38.5	80.7
93	11	620	1.06	216	50.0	30.4	86.2	203	46.9	32.3	84.1	201	62.5	36.7	88.3
93	12	241	1.14	74	57.6	34.5	79.3	65	54.0	33.0	75.4	102	60.7	35.5	81.7
TOTAL		15995	1.78	5805	59.8	21.0	91.6	3256	57.3	23.0	96.3	6934	65.3	23.2	94.7

TABLE A.6.6 : Summary of *A. virescens* biometric study data

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL			MALE					FEMALE					UNDETERMINED			
		N	M:F		N	AVG FL	MIN FL	MAX FL		N	AVG FL	MIN FL	MAX FL		N	AVG FL	MIN FL	MAX FL
91	4	80	2.81		59	65.6	43.0	78.2		21	63.9	39.0	76.5					
91	5	78	1.17		42	62.6	38.5	84.5		36	66.3	39.4	86.9					
91	6	30	0.88		14	56.5	37.4	70.3		16	61.9	37.7	76.0					
91	7	103	1.55		62	60.2	36.5	83.7		40	62.1	38.8	82.4		1	57.8	57.8	57.8
91	8	33	0.94		16	61.4	46.4	78.1		17	64.2	48.9	77.1					
91	9	33	0.94		16	74.0	70.0	77.1		17	74.6	66.3	80.8					
91	10	43	1.87		28	69.3	61.1	80.5		15	69.3	56.5	86.1					
91	11	86	1.87		56	56.8	36.9	81.9		30	59.2	35.5	76.1					
91	12	35	1.06		18	62.7	57.5	66.7		17	66.5	57.8	83.8					
92	1	15	1.14		8	70.2	62.5	75.1		7	77.2	65.1	86.1					
92	2	54	0.69		22	51.7	41.1	75.4		32	49.1	38.0	70.8					
92	3	81	1.38		47	56.9	43.2	80.3		34	61.1	46.2	79.6					
92	4	22	0.47		7	57.5	42.6	73.5		15	65.3	44.2	85.2					
92	5	63	1.52		38	66.9	49.1	80.4		25	66.9	50.2	84.0					
92	6	43	0.87		20	43.5	35.7	54.4		23	46.9	37.3	61.0					
92	11	24	1.00		12	61.6	43.5	75.2		12	69.3	54.8	79.9					
92	12	19	0.19		3	75.7	74.4	76.6		16	74.6	63.0	81.6					
93	3	51	1.43		30	31.0	25.4	39.5		21	31.3	27.0	37.8					
93	4	21	0.54		7	57.0	45.5	72.7		13	54.4	31.8	87.8		1	35.4	35.4	35.4
TOTAL		914	1.24	59.3	505		25.4	84.5	61.0	407		27.0	87.8	46.6	2		35.4	57.8

TABLE A.6.7 : Number of length frequency measurements per year per sector by gear : *A. virescens*

UNSPECIFIED GEAR

SECTOR	91	92	93	TOTAL
2	220	2	0	222
3	0	64	0	64
6	51	3	0	54
7	318	0	1	319
8	60	0	0	60
9	669	0	0	669
10	105	0	0	105
11	23	0	0	23
13	312	0	0	312
14	139	0	0	139
?	4050	1995	1111	7156
TOTAL	5947	2064	1112	9123

HANDLINES

SECTOR	91	92	93	TOTAL
2	131	17	69	217
3	18	351	63	432
4	48	177	9	234
5	141	28	33	202
6	228	345	244	817
7	153	188	205	546
9	470	822	226	1518
10	142	96	228	466
12	51	15	0	66
13	351	74	17	442
14	18	0	0	18
	546	689	206	1441
TOTAL	2297	2802	1300	6399

ELECTRIC REELS

SECTOR	92	93	TOTAL
2	0	51	51
5	0	24	24
6	0	8	8
9	27	0	27
10	0	4	4
11	0	28	28
	76	48	124
TOTAL	103	163	266

DROP LINES

SECTOR	91	92	TOTAL
13	23	9	32

GILL NETS

SECTOR	91	92	93	TOTAL
4	0	1	0	1
6	0	7	4	11
7	0	10	14	24
9	0	1	0	1
11	0	9	0	9
13	52	0	9	61
99	0	0	55	55
?	0	3	10	13
TOTAL	52	31	92	175

TABLE A.6.8. :Number of fish measured for biometric studies per year per sector by gear : *A. virescens*

UNSPECIFIED GEAR

SECTOR	91	92	TOTAL
1	10	0	10
2	67	65	132
3	94	0	94
4	40	0	40
5	11	0	11
6	14	19	33
8	5	0	5
9	176	111	287
10	60	57	117
13	0	69	69
TOTAL	477	321	798

HANDLINES

SECTOR	91	93	TOTAL
2	2	24	26
3	2	48	50
7	18	0	18
9	22	0	22
TOTAL	44	72	116

TABLE A.6.9 : Summary of *L. nebulosus* length frequency data

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
92	3	119	1.86	26	55.8	31.5	72.5	14	60.0	47.3	74.6	79	55.2	33.5	79.0
92	4	38	2.33	21	46.5	37.5	66.0	9	51.2	41.7	64.5	8	51.1	35.7	67.8
92	5	50	1.36	19	49.6	36.2	63.4	14	53.0	36.5	68.0	17	48.9	39.2	69.5
92	6	5	3.00	3	64.7	61.1	68.3	1	42.0	42.0	42.0	1	62.3	62.3	62.3
92	8	337	2.49	127	42.0	29.0	58.5	51	44.0	30.7	56.8	159	40.6	24.7	62.3
92	10	132	0.98	40	56.2	28.4	69.0	41	56.6	27.5	68.6	51	55.2	27.2	69.5
92	11	176	2.45	27	48.8	36.0	65.1	11	47.5	37.8	64.5	138	49.2	18.5	72.6
92	12	3	NA	1	62.3	62.3	62.3					2	55.8	45.5	66.1
TOTAL		860	1.87	264	47.5	28.4	72.5	141	50.9	27.5	74.6	455	48.0	18.5	79.0

TABLE A.6.10 : Summary of L. nebulosus biometric study data

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
92	4	50	0.62	18	48.5	31.5	71.1	29	49.5	37.5	73.7	3	39.1	34.5	46.1

TABLE A.6.11 : Number measurements per year per sector by gear : *L. nebulosus*

LENGTH FREQUENCY DATA
UNSPECIFIED GEAR

SECTOR	92	TOT
0	334	334

HANDLINES

SECTOR	92	TOT
6	15	15
7	6	6
9	50	50
13	107	107
0	11	11
TOTAL	189	189

GILLNETS

SECTOR	92	TOT
0	337	337

BIOMETRIC STUDY DATA
HANDLINES

SECTOR	92	TOT
9	27	27
10	23	23
TOTAL	50	50

TABLE A.6.12 : Summary of *L. sebae* length frequency data

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
89	11	727	1.30	277	63.5	25.3	84.5	213	57.2	24.6	80.0	237	61.0	21.4	83.0
89	12	156	0.55	43	61.9	23.2	83.3	78	51.6	23.7	77.0	35	58.0	20.3	81.6
90	1	253	0.57	51	54.5	23.0	77.4	89	42.1	19.5	68.4	113	41.8	18.4	76.5
90	2	533	0.81	159	56.4	24.5	81.3	196	50.8	23.7	70.2	178	51.1	21.9	81.5
90	3	946	0.73	223	57.4	23.2	81.2	305	48.6	22.1	74.0	418	50.8	20.0	84.4
90	4	573	0.84	173	55.3	21.7	82.9	205	48.7	22.2	78.2	195	54.2	20.8	81.4
90	5	216	0.70	52	61.4	23.0	82.3	74	50.2	24.9	70.6	90	52.8	21.5	75.7
90	6	26	5.00	15	60.3	47.3	71.8	3	49.0	41.1	56.6	8	57.1	44.6	63.5
90	7	281	0.61	67	56.6	29.2	83.8	109	47.9	26.0	69.3	105	47.9	19.6	80.8
90	8	147	0.57	31	57.9	36.5	74.6	54	50.0	31.5	69.8	62	53.6	34.2	78.0
90	9	314	0.61	70	64.4	5.0	82.5	114	51.0	23.2	70.3	130	58.1	24.7	80.5
90	10	732	0.86	217	61.2	24.0	86.0	252	52.7	24.8	73.3	263	53.6	21.0	80.1
90	11	360	0.96	129	62.1	25.4	83.5	135	55.8	28.3	77.7	96	56.1	25.9	76.6
90	12	308	1.09	117	49.6	25.1	81.2	107	45.6	26.3	72.0	84	46.4	26.2	73.0
91	1	348	1.19	107	57.9	28.2	83.2	90	51.1	26.8	75.2	151	54.8	19.9	83.5
91	2	668	1.13	231	60.1	28.9	82.1	204	53.5	27.8	73.6	233	55.4	24.5	98.3
91	3	892	1.01	310	61.3	23.6	82.5	307	52.4	21.1	78.5	275	59.6	22.7	88.4
91	4	1133	1.12	448	62.5	25.6	84.4	400	56.7	27.8	78.2	285	58.4	20.5	80.7
91	5	1051	1.15	401	61.4	23.0	88.1	350	52.7	23.9	78.5	300	60.6	20.3	91.1
91	6	472	1.39	181	59.7	26.1	82.4	130	51.7	21.7	77.5	161	58.8	21.0	80.4
91	7	302	0.58	70	45.2	17.0	75.5	120	32.7	15.4	65.3	112	27.8	14.1	67.4
91	8	238	1.06	74	62.4	36.3	79.6	70	55.5	35.3	66.3	94	57.3	27.7	75.2
91	9	896	1.21	320	62.3	21.4	83.4	264	50.7	21.9	72.4	312	60.9	19.0	83.4
91	10	976	1.03	354	62.3	29.8	86.0	344	56.7	25.0	74.6	278	60.0	24.2	82.8
91	11	1088	1.37	447	60.4	30.5	83.9	326	54.6	27.2	70.9	315	62.5	27.5	82.0
91	12	417	1.12	138	62.6	21.6	84.2	123	51.0	20.6	75.4	156	59.1	20.9	84.6

TABLE A.6.12 : Summary of *L. sebae* length frequency data continued.

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YRMON		TOTAL		MALE				FEMALE				UNDETERMINED			
		N	M:F	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL	N	AVG FL	MIN FL	MAX FL
92	1	500	1.14	208	59.7	24.5	83.5	182	50.5	21.5	73.2	110	55.0	21.0	76.5
92	2	1110	1.28	398	59.9	22.3	82.8	312	51.5	23.0	81.6	400	59.1	22.2	94.0
92	3	2233	1.07	717	61.7	24.4	85.3	670	54.0	24.4	77.0	846	60.8	24.2	89.0
92	4	1124	1.04	331	61.1	29.7	82.4	319	53.8	27.3	80.2	474	60.6	24.5	85.2
92	5	1136	1.24	411	60.0	24.9	86.0	332	53.2	22.6	71.9	393	59.3	24.8	81.2
92	6	173	1.07	62	42.3	21.8	75.1	58	40.4	23.0	68.0	53	48.8	18.2	79.0
92	9	10	0.50	2	33.5	32.0	35.0	4	29.4	26.1	35.0	4	23.5	22.3	24.0
92	10	137	1.00	51	55.0	23.2	77.6	51	49.3	27.0	64.1	35	51.9	22.2	80.5
92	11	95	0.94	31	51.7	29.5	78.2	33	44.2	25.3	63.9	31	52.8	23.1	74.3
92	12	70	1.13	26	55.8	25.1	77.6	23	49.1	27.2	71.0	21	59.3	47.5	69.0
93	1	153	2.48	62	64.7	47.0	82.0	25	56.5	41.0	66.3	66	61.5	39.0	76.0
93	2	260	1.87	103	61.1	28.4	81.6	55	56.6	27.1	72.6	102	62.4	32.2	83.0
93	3	646	1.14	163	63.3	29.4	83.2	143	55.1	23.7	72.0	340	62.8	20.7	86.3
93	4	474	1.08	138	59.4	32.6	86.2	128	52.9	32.4	69.5	208	59.2	30.5	83.2
93	5	188	1.17	54	63.1	32.2	83.0	46	54.5	32.2	72.8	88	61.1	32.5	80.8
93	6	33	1.11	10	63.4	37.5	73.0	9	52.7	44.5	64.2	14	57.3	34.7	74.5
93	7	19	1.67	10	70.1	52.7	81.6	6	61.7	50.2	66.7	3	61.2	53.7	69.1
93	9	222	1.60	80	67.8	42.3	86.6	50	60.5	48.9	73.2	92	65.6	45.4	84.8
93	10	577	1.07	215	59.7	27.5	80.3	201	55.9	26.2	75.0	161	57.9	28.4	81.2
93	11	532	1.19	192	65.5	27.2	83.2	162	59.3	30.3	71.2	178	59.7	19.1	81.3
93	12	216	1.19	76	66.6	33.6	83.4	64	56.8	38.1	68.8	76	63.1	31.8	81.4
TOTAL		23961	1.07	8045	60.5	5.0	88.1	7535	52.6	15.4	81.6	8381	57.7	14.1	98.3

TABLE A.6.13 : Number of length frequency measurements per year per sector by gear : *L. sebae*

UNSPECIFIED GEAR

SECTOR	91	92	93	TOTAL
6	0	62	0	62
9	0	8	0	8
?	31	2344	1525	3900
TOTAL	31	2414	1525	3970

HANDLINES

SECTOR	89	90	91	92	93	TOTAL
2	0	153	624	22	10	809
3	0	0	119	467	0	586
4	0	0	183	180	42	405
5	0	0	317	132	114	563
6	0	67	904	824	118	1913
7	0	43	358	355	129	885
8	0	149	572	207	0	928
9	0	274	1049	475	29	1827
10	0	172	244	225	0	641
11	0	23	0	0	0	23
13	0	0	345	43	0	388
14	0	0	20	0	0	20
99	0	0	0	0	51	51
?	883	3808	3715	1205	1010	10621
TOTAL	883	4689	8450	4135	1503	19660

ELECTRIC REELS

SECTOR	93	TOTAL
2	72	72
?	136	136
TOTAL	208	208

GILLNETS

SECTOR	92	93	TOTAL
13	0	65	65
?	15	19	34
TOTAL	15	84	99

TRAPS

SECTOR	92	TOTAL
?	24	24

TABLE A.6.14 : Summary of *E. chlorostigma* length frequency data

ALL DATA : ALL GEARS AND LOCATIONS POOLED

YEAR	MON	SEX UNDETERMINED N	AVG FL	MIN FL	MAX FL
90	5	111	41.6	29.9	62.5
90	6	153	37.7	24.0	50.4
90	7	338	39.5	23.8	60.8
90	8	206	36.2	24.8	55.2
90	9	471	37.6	21.3	63.7
90	10	708	36.4	25.2	63.2
90	11	351	39.2	23.4	64.3
90	12	297	39.7	23.1	59.8
91	1	309	38.2	25.1	60.4
91	2	383	35.8	22.5	48.3
91	3	573	36.9	22.1	61.5
91	4	675	38.1	24.3	60.3
91	5	832	37.7	22.6	67.5
91	6	494	38.1	20.4	61.5
91	7	394	39.7	21.2	80.7
91	8	403	37.5	22.5	63.5
91	9	645	37.7	22.2	64.0
91	10	900	38.1	23.8	69.0
91	11	906	37.8	21.9	58.0
91	12	507	38.6	21.1	64.8
92	1	719	38.8	19.9	62.1
92	2	899	36.1	22.5	65.4
92	3	2019	36.4	20.4	58.7
92	4	1350	36.4	23.4	65.8
92	5	878	37.1	20.8	64.2
92	6	218	37.5	28.8	59.5
92	7	46	38.0	29.2	42.0
92	8	39	37.4	31.0	50.5
92	9	119	37.4	24.0	53.0
92	10	309	38.3	24.2	68.5
92	11	225	41.3	25.0	62.2
92	12	292	37.0	24.0	59.7
93	1	245	37.2	26.8	61.5
93	2	523	36.6	24.5	53.4
93	3	551	37.3	22.2	72.0
93	4	432	39.5	25.5	65.9
93	5	298	38.2	27.5	60.6
93	6	105	42.8	28.1	74.1
93	7	63	39.0	28.5	53.1
93	9	188	36.8	27.0	42.8
93	10	453	36.2	24.5	58.7
93	11	510	36.6	21.2	59.0
93	12	266	36.3	24.4	49.8
94	3	5	29.9	26.0	35.0
TOTAL		20408	37.5	19.9	80.7

TABLE A.6.15 : Number of length frequency measurements per year per sector by gear : *E. chlorostigma*

UNSPECIFIED GEAR

SECTOR	90	91	92	93	TOTAL
3	0	53	0	0	53
5	0	1	1	0	2
6	0	38	42	18	98
13	0	50	0	0	50
	2635	3948	2689	1173	10445
TOTAL	2635	4090	2732	1191	10648

HANDLINES

SECTOR	91	92	93	94	TOTAL
2	83	17	31	0	131
3	136	383	0	5	524
4	119	162	13	0	294
5	309	253	86	0	648
6	602	558	329	0	1489
7	25	471	326	0	822
8	164	0	0	0	164
9	238	567	149	0	954
10	33	45	100	0	178
12	0	18	0	0	18
13	138	44	5	0	187
99	0	0	41	0	41
	971	1505	756	0	3232
TOTAL	2818	4023	1836	5	8682

TRAPS

SECTOR	92	93	TOTAL
3	0	70	70
6	0	1	1
	59	0	59
TOTAL	59	71	130

ELECTRIC REELS

SECTOR	91	92	93	TOTAL
3	0	2	0	2
5	54	27	40	121
6	29	0	15	44
7	29	0	0	29
9	0	38	40	78
10	0	0	25	25
99	0	0	58	58
	0	0	110	110
TOTAL	112	67	288	467

DROPLINES

SECTOR	92	93	TOTAL
6	29	0	29
?	0	12	12
TOTAL	29	12	41

GILLNETS

SECTOR	91	92	93	TOTAL
5	1	0	0	1
6	0	0	9	9
7	0	12	27	39
11	0	83	0	83
13	0	0	28	28
99	0	0	22	22
?	0	108	150	258
TOTAL	1	203	236	440

ANNEX 7 : Reproductive Biology.

Fish measured during biometric studies were employed for assessment of reproductive biology. Although sex and maturity stage was recorded from incompletely gutted fish during length frequency measurements, these data were not employed except in the case of *L. sebae* for which no biometric data was available. Maturity was assessed on a scale of 1-5 for females, described in Mees (1992b). Fish at stages 3+, 4 and 5 were mature. A gonadosomatic index (GSI, gonad weight in grammes / total fish weight in kg) was determined for both sexes.

Summary analyses indicating size (fork length, cm) at maturity stage each year are given in Tables A.7.1-A.7.4 for *P. filamentosus, A. virescens, L. nebulosus* and *L. sebae* respectively, aggregated over gear and location. Gear type, although in theory capable of affecting sex ratio (eg. traps may catch more dominant males / ovigerous females?) was not considered likely to affect the results in relation to reproductive development. Similarly, location within Seychelles would have minimal effect on the timing of reproductive events. Annex 6 indicates the small amount of biometric data by gear and location for each species.

To examine the incidence of reproductive events over time and in relation to fork length, data were additionally aggregated annually. This increased the sample size, and 'averaged' slight annual variations. Since the samples derived from lightly fished locations, fishing pressure over time was unlikely to significantly affect parameters such as size at sexual maturity or the timing of life cycle events. Results are indicated in Figures A.7.1 - A.7.15. Despite aggregating annual data, the number of fish sampled at any one fork length was small (Tables A.7.5-A.7.7) and in the case of *A. virescens* a moving average was employed to smooth out erratic jumps in the data.

TABLE A.7.1. : *P.filamentosus* maturity stage analyses, data aggregated for all locations and gear types : biometric study data. Descriptive statistics by maturity stage per annum

NUMBER

YEAR	1	2	3	-3	3+	4	5	TOT
89	0	0	0	0	4	15	0	19
90	0	219	2	47	137	165	0	570
91	2	182	0	24	41	20	1	270
	2	401	2	71	182	200	1	859

MIN LENGTH

YEAR	1	2	3	-3	3+	4	5	TOT
89	0.00	0.00	0.00	0.00	46.30	40.30	0.00	40.30
90	0.00	30.10	45.40	37.30	36.60	38.10	0.00	30.10
91	30.80	22.50	0.00	48.20	46.40	44.10	62.00	22.50
	30.80	22.50	45.40	37.30	36.60	38.10	62.00	22.50

MEAN LENGTH

YEAR	1	2	3	-3	3+	4	5	TOT
89	0.00	0.00	0.00	0.00	47.58	47.55	0.00	47.55
90	0.00	44.81	46.00	55.70	55.11	58.20	0.00	52.06
91	31.00	43.10	0.00	59.93	60.87	61.73	62.00	48.65
	31.00	44.03	46.00	57.13	56.24	57.75	62.00	50.89

MAX LENGTH

YEAR	1	2	3	-3	3+	4	5	TOT
89	0.00	0.00	0.00	0.00	48.90	51.50	0.00	51.50
90	0.00	64.60	46.60	68.10	72.60	73.10	0.00	73.10
91	31.20	69.60	0.00	69.50	68.60	68.00	62.00	69.60
	31.20	69.60	46.60	69.50	72.60	73.10	62.00	73.10

Figure A.7.1 *P. filamentosus* maturity stage at fork length, all biometric study data 1989 -1991.

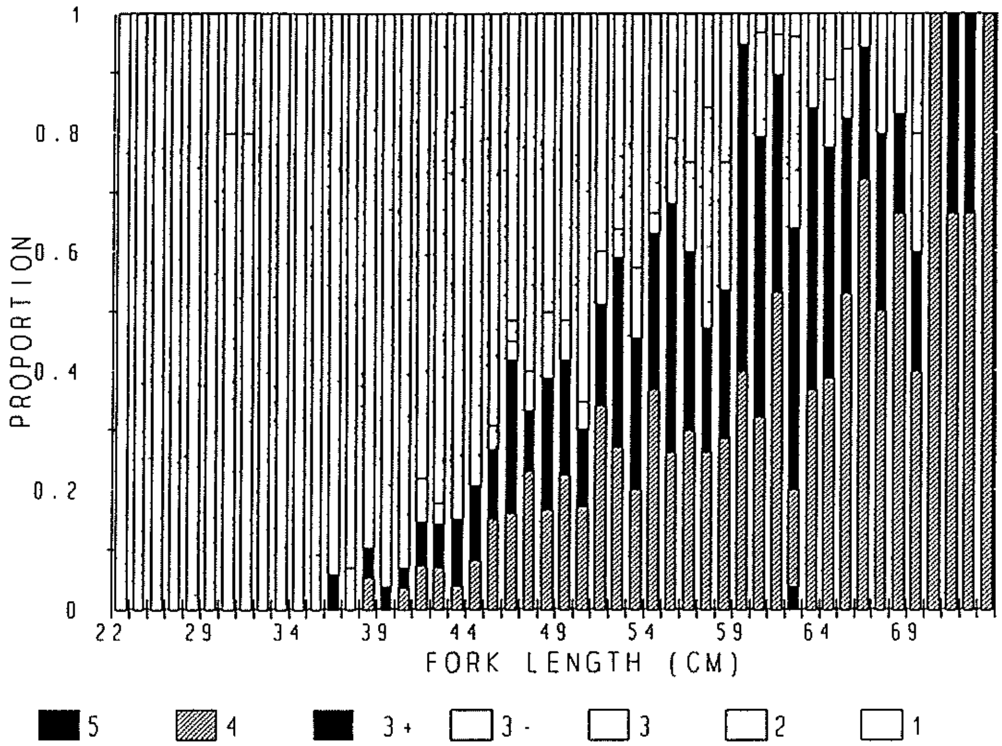


Fig. A.7.2. *P. filamentosus* mean GSI at fork length, all data.

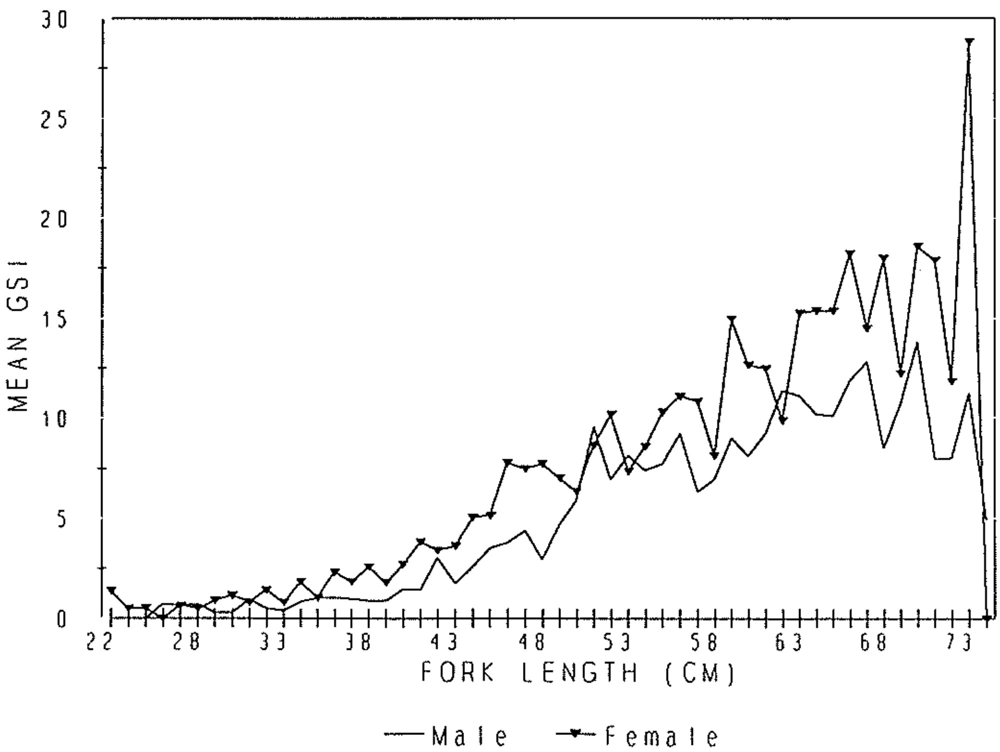


Fig. A.7.3. *P. filamentosus* maturity stage at fork length, all length frequency study data 1989 -1991.

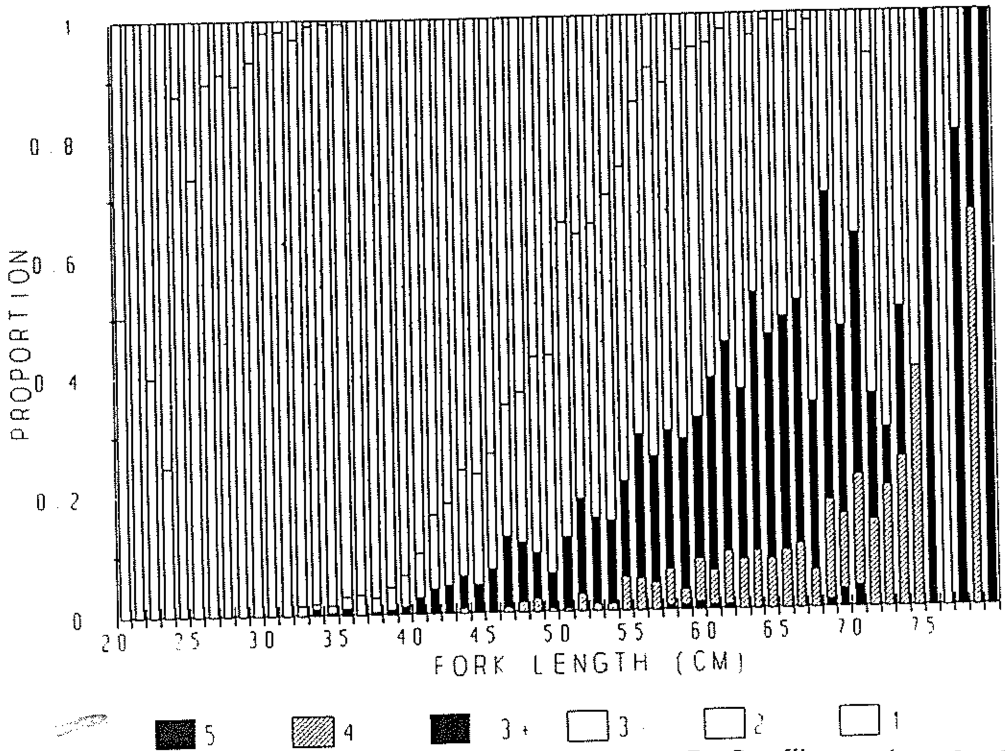


Fig A.7.4 *P. filamentosus*, proportion at maturity stage each month

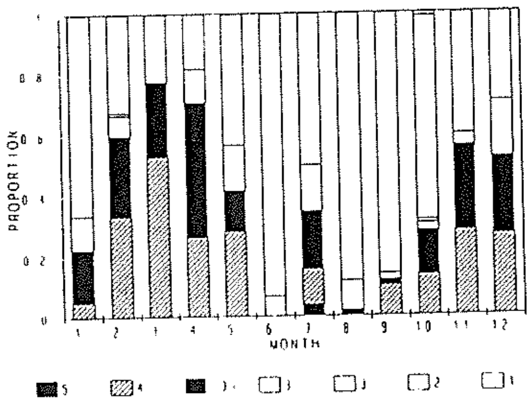


Fig A.7.5 *P. filamentosus*, mean GSI each month

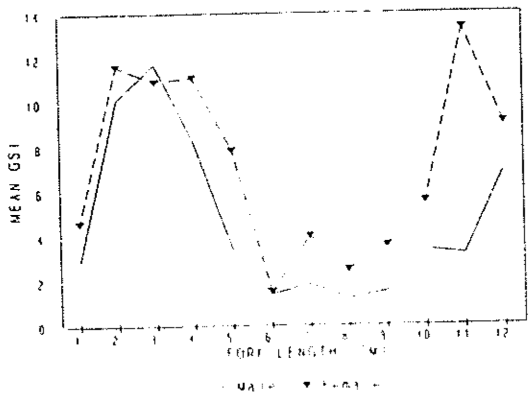


TABLE A.7.2 *A. virescens* maturity stage analyses, data aggregated for all locations and gear types : biometric study data. Descriptive statistics by maturity stage per annum

NUMBER

YEAR	2	3-	3+	4	5	TOT
91	64	60	35	25	17	201
92	63	25	71	4	1	164
93	28	5	0	1	0	34
TOTAL	155	90	106	30	18	399

MIN LENGTH

YEAR	2	3-	3+	4	5	TOT
91	35.50	52.00	51.00	64.00	63.30	35.50
92	37.30	50.20	38.00	42.40	72.10	37.30
93	27.00	57.90	0.00	54.90	0.00	27.00
TOTAL	27.00	50.20	38.00	42.40	63.30	27.00

MEAN LENGTH

YEAR	2	3-	3+	4	5	TOT
91	51.12	69.99	70.17	73.98	71.42	64.63
92	53.08	69.08	64.22	60.43	72.10	60.64
93	33.55	74.20	0.00	54.90	0.00	40.16
TOTAL	48.74	69.97	66.18	71.53	71.46	60.90

MAX LENGTH

YEAR	2	3-	3+	4	5	TOT
91	67.30	83.80	86.10	86.90	82.40	86.90
92	65.40	85.20	86.10	79.70	72.10	86.10
93	49.00	87.80	0.00	54.90	0.00	87.80
TOTAL	67.30	87.80	86.10	86.90	82.40	87.80

Fig. A.7.6. *A. virescens* proportion at maturity stage at fork length, all biometric study data 1991-1993 (Moving average proportion).

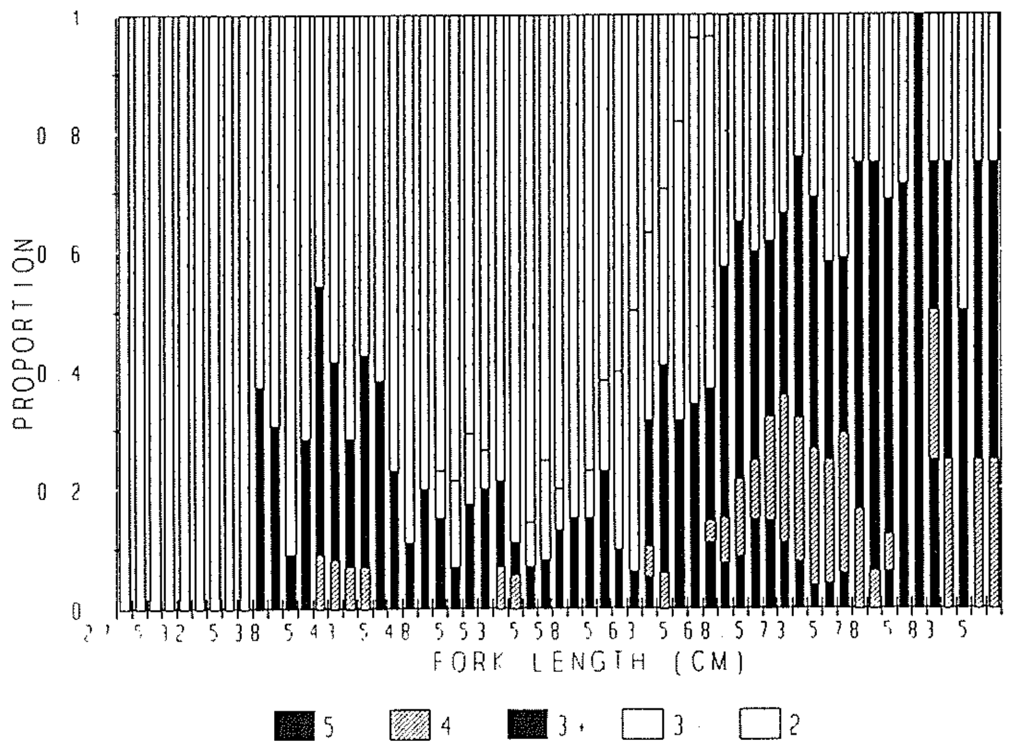


Fig. A.7.7. *A. virescens* mean GSI at fork length, all biometric study data 1989 - 1991.

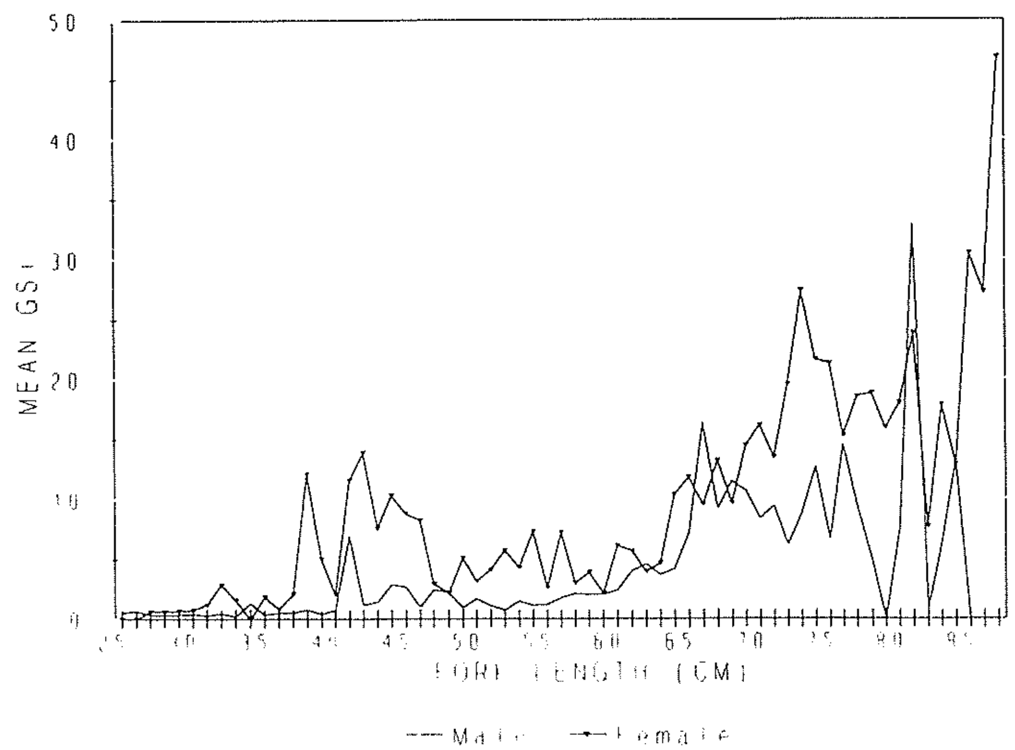


Fig. A.7.8. *A. virescens* maturity stage at fork length, all length frequency study data 1989 -1991.

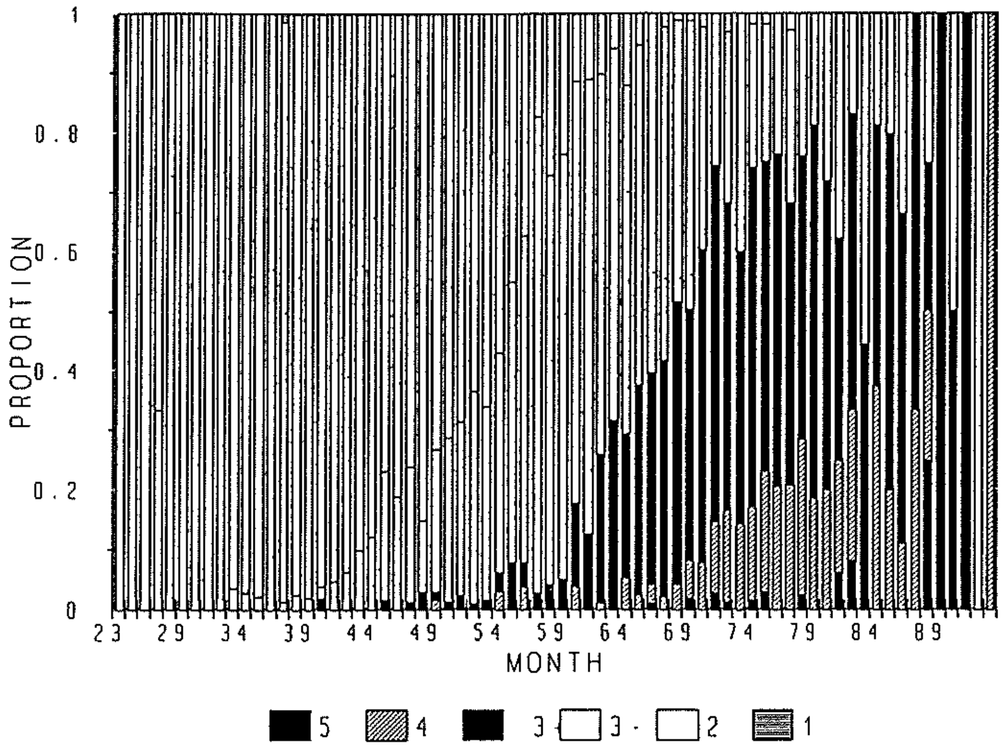


Fig. A.7.9. *A. virescens* proportion at maturity stage each month.

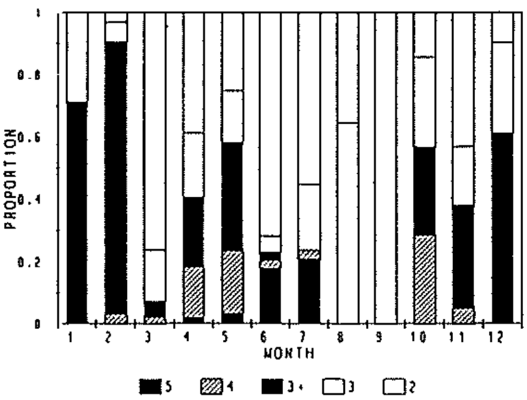


Fig. A.7.10 *A. virescens*, mean GSI each month

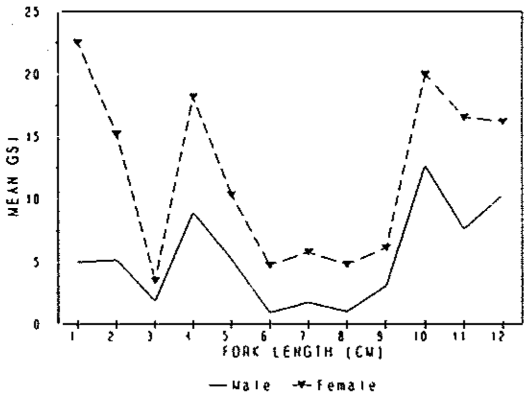


TABLE A.7.3. : *L. nebulosus* maturity stage analyses, data aggregated for all locations and gear types : biometric study data. Descriptive statistics by maturity stage per annum

DETAILS	YEAR	2	3-	3+	TOT
NUMBER	92	25	1	2	28
MIN FL	92	37.50	63.50	69.30	37.50
MEAN FL	92	47.15	63.50	71.50	49.48
MAX FL	92	61.60	63.50	73.70	73.70

Fig. A.7.11 : *L. nebulosus* mean GSI at fork length, all biometric study data (April 1992 only).

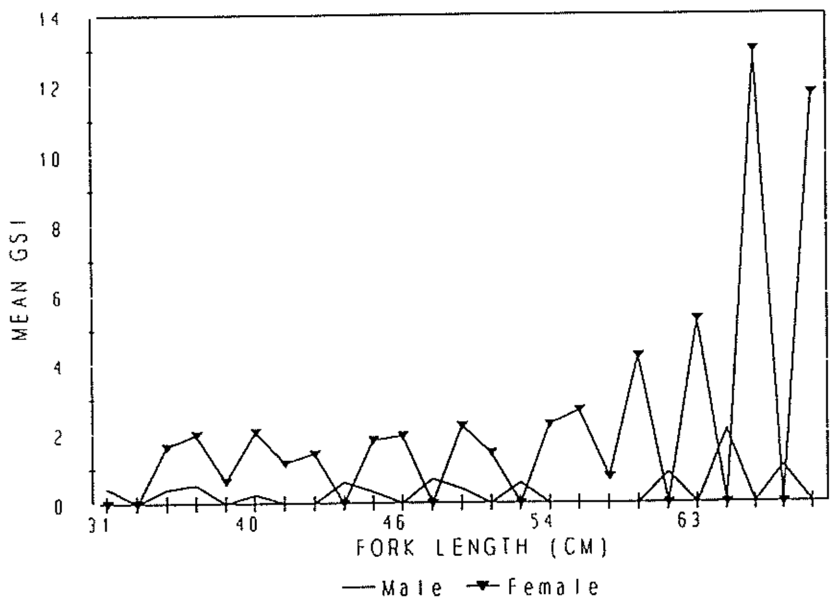


Fig A.7.12 *L. nebulosus* proportion at maturity stage at fork length, all length frequency study data

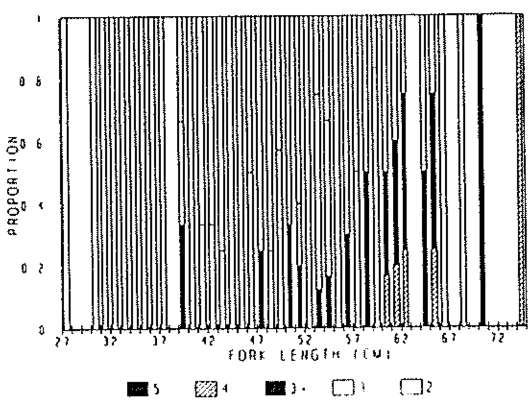


Fig A.7.13. *L. nebulosus*, proportion at maturity stage each month, all length frequency data

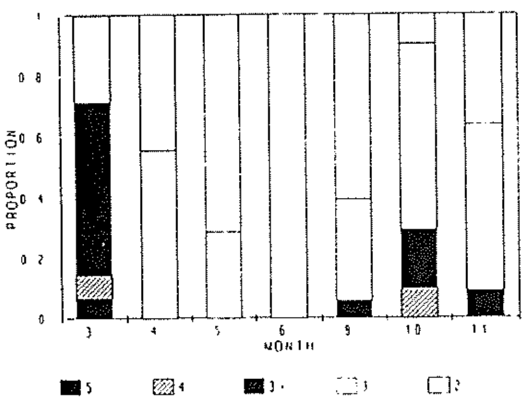


TABLE A.7.4 : *L. sebae* maturity stage analyses, data aggregated for all locations and gear types : length frequency data. Descriptive statistics by maturity stage per annum

NUMBER

YEAR	1	2	3	3-	3+	4	5	TOT
89	0	66	52	70	68	31	3	290
90	0	780	37	519	269	35	0	1640
91	2	977	1	1117	516	110	1	2724
92	2	658	1	857	406	55	0	1979
93	1	146	0	578	142	15	0	882
TOTAL	5	2627	91	3141	1401	246	4	7515

MIN LENGTH

YEAR	1	2	3	3-	3+	4	5	TOT
89	0.00	23.70	37.80	46.00	51.40	51.20	63.80	23.70
90	0.00	19.50	37.00	33.10	34.60	51.20	0.00	19.50
91	27.20	15.40	61.60	31.00	47.80	48.50	66.40	15.40
92	25.30	21.50	59.50	33.20	33.50	51.30	0.00	21.50
93	26.20	23.70	0.00	32.20	51.00	58.90	0.00	23.70
TOTAL	25.30	15.40	37.00	31.00	33.50	48.50	63.80	15.40

MEAN LENGTH

YEAR	1	2	3	3-	3+	4	5	TOT
89	0.00	40.97	58.45	57.65	61.61	63.02	66.43	55.59
90	0.00	38.31	57.51	58.45	63.57	63.31	0.00	49.79
91	40.10	38.89	61.60	59.07	63.46	64.18	66.40	52.86
92	26.40	38.41	59.50	57.88	61.66	64.16	0.00	52.32
93	26.20	40.81	0.00	58.56	62.64	63.41	0.00	56.33
TOTAL	31.84	38.76	58.11	58.52	62.78	63.86	66.43	52.56

MAX LENGTH

YEAR	1	2	3	3-	3+	4	5	TOT
89	0.00	59.80	77.00	66.30	70.00	69.80	68.20	77.00
90	0.00	61.90	69.30	74.40	78.20	74.00	0.00	78.20
91	53.00	75.20	61.60	78.20	78.50	77.50	66.40	78.50
92	27.50	68.50	59.50	80.20	77.00	81.60	0.00	81.60
93	26.20	75.00	0.00	73.20	72.80	66.50	0.00	75.00
TOTAL	53.00	75.20	77.00	80.20	78.50	81.60	68.20	81.60

Fig A.7.14. *L. sebae*, proportion at maturity stage at fork length, all length frequency study data.

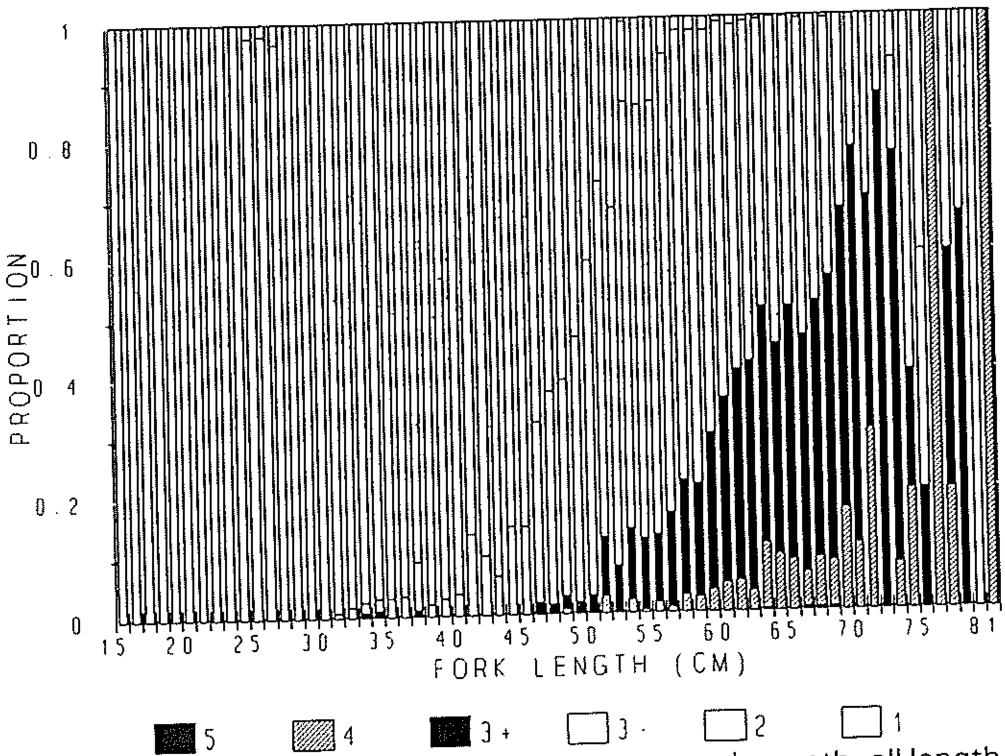


Fig A.7.15. *L. sebae*, proportion at maturity stage each month, all length frequency study data.

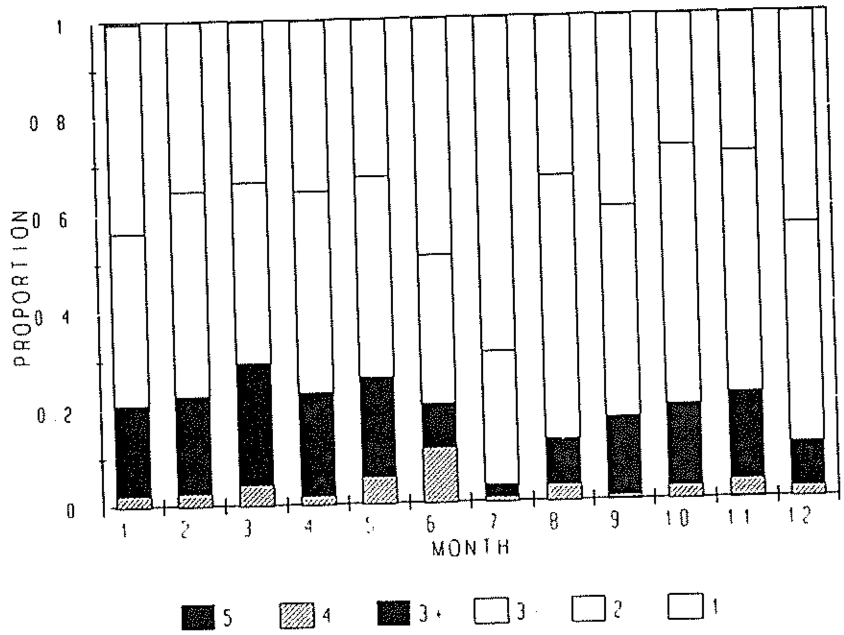


Table A.7.5. The number of fish sampled at length during biometric studies : *P. filamentosus*

FL	N	FL	N	FL	N	FL	N	FL	N
22	1	34	6	44	24	54	30	64	18
24	1	35	4	45	26	55	19	65	17
25	3	36	17	46	31	56	20	66	18
27	2	37	14	47	30	57	19	67	10
28	1	38	19	48	36	58	28	68	12
29	5	39	26	49	31	59	20	69	5
30	5	40	28	50	23	60	34	70	3
31	5	41	27	51	35	61	30	71	3
32	6	42	28	52	22	62	25	72	3
33	8	43	26	53	35	63	19	73	1

Table A.7.5. The number of fish sampled at length during biometric studies : *A. virescens*

FL	N	FL	N	FL	N	FL	N	FL	N	FL	N
27	1	38	4	48	3	58	7	68	13	78	6
28	3	39	9	49	7	59	6	69	13	79	10
29	4	40	2	50	6	60	7	70	10	80	6
30	2	41	5	51	8	61	6	71	10	81	1
31	5	42	6	52	9	62	4	72	24	82	1
32	4	43	6	53	6	63	12	73	12	83	3
33	2	44	8	54	8	64	7	74	13	84	1
35	2	45	6	55	10	65	10	75	13	85	1
36	1	46	7	56	4	66	12	76	11	86	3
37	4	47	6	57	8	67	14	77	6	87	1

Table A.7.5. The number of fish sampled at length during biometric studies : *L. nebulosus*

FL	N	FL	N
37	2	51	2
38	3	54	1
39	1	55	3
40	1	59	1
41	1	61	2
42	3	63	1
45	1	69	1
46	2	73	1
48	2		

Annex 8 : Gear Selectivity : Probability of capture

To investigate the probability of capture at length for each species by fishing gear, length frequency data (see Annex 6 for sample size) were aggregated by location. Annual length frequency distributions for *P. filamentosus* are indicated in Figs. A.8.1-A.8.5, *A. virescens* (Figs. A.8.6-A.8.10), *L. sebae* (Figs A.8.11-A.8.15), *E. chlorostigma* (Figs A.8.16-A.8.20) and *L. nebulosus* (Figs A.8.21-A.8.23). For specified gear types, annual length frequency distributions are similar except for:

- *P. filamentosus* and handlines (Fig A.8.2). 1993 data suggests a larger size of fish were caught that year, but sample size was small (230) compared to previous years (>3,000 fish)

- *P. filamentosus* and gill nets (Fig A.8.5) : 1991 and 1992 data (for each of which sample size was large) indicate different distributions. The major mode in 1991 was around 62 cm compared to 34 cm in 1992, suggesting different mesh sizes were employed each year. Unfortunately this information was not recorded with length frequency data, and suggests that this refinement should be added to data collection procedures.

- *L. sebae* and gill nets (Fig A.8.14) : 1992 data indicate a smaller size of fish were caught than in 1993. However, sample size was small in both cases.

For *E. chlorostigma* (Figs A.8.16-A.8.20) lines and traps select for small fish and above 42 cm (total length) and 40 cm respectively few larger fish are caught. By contrast, gill nets display a more usual length frequency distribution and although the major mode is around 34-36 cm, more larger fish are caught.

Gear specific selection parameters were derived from length frequency data using probability of capture at length information derived through catch curve analysis (Gayanillo *et al.*, 1994). A moving average was used :

$$P_{L,i(new)} = (P_{L,i-1} + P_{L,i(old)} + P_{L,i+1}) / 3$$

where P_L is the probability of capture for length L, a smoothed series of probabilities is produced from which Lc_{25} (probability of 25 % of all fish at that length being caught), Lc_{50} and Lc_{75} are estimated through linear interpolation. Lc, the first fully exploited length class was taken as the cut off point of the catch curve analysis (see Table ??!). As inputs, catch curve analysis requires estimates of growth parameters, and these were taken from the literature : *P. filamentosus* (Mees, 1993), *A. virescens* (Mees, 1992b), *L. sebae* (Lablache and Carrara, 1988), *E. chlorostigma* (Mees, 1992b), and *L. nebulosus* (Fishbase ref 002295, for Fiji, chosen because the $L\infty$ parameter estimate was closest to Lmax observed for this species in Seychelles). Owing to the uncertainty inherent in estimation of growth parameters through length frequency analysis from long lived slow growing species such as these, the sensitivity of Lc_{50} to changes in these parameters was tested (Figs. A.8.24-A.8.25). Changes in K had little effect on Lc_{50}. For values of $L\infty$ below Lmax, Lc_{50} tended to be underestimated, but Lc_{50} was insensitive to changes in $L\infty$ when this parameter was around, or greater than Lmax. This suggests that providing the value of $L\infty$ used is close to Lmax, we may be confident in the value of Lc_{50} derived, providing that the sample size was sufficiently large.

P. filamentosus : Annual length frequency distributions by gear type.

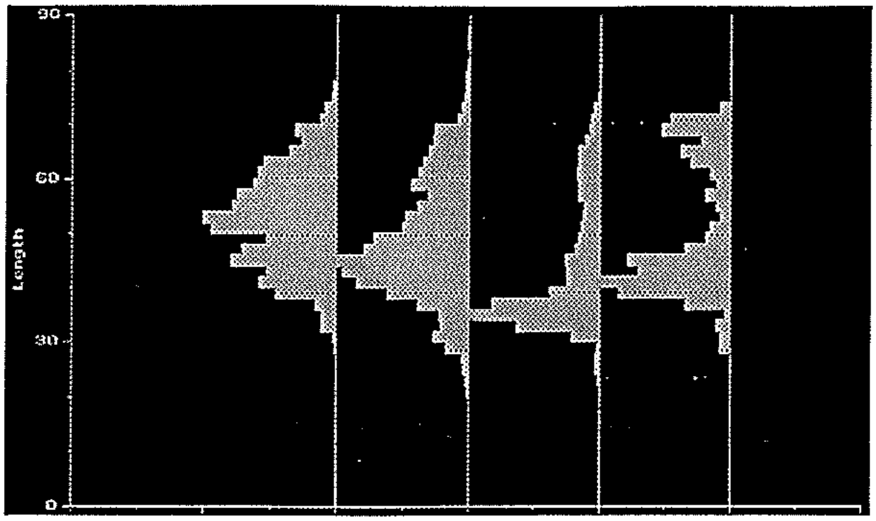


Fig. A.8.1 : Unspecified gear type for 1989, 1991, 1992 and 1993 respectively.

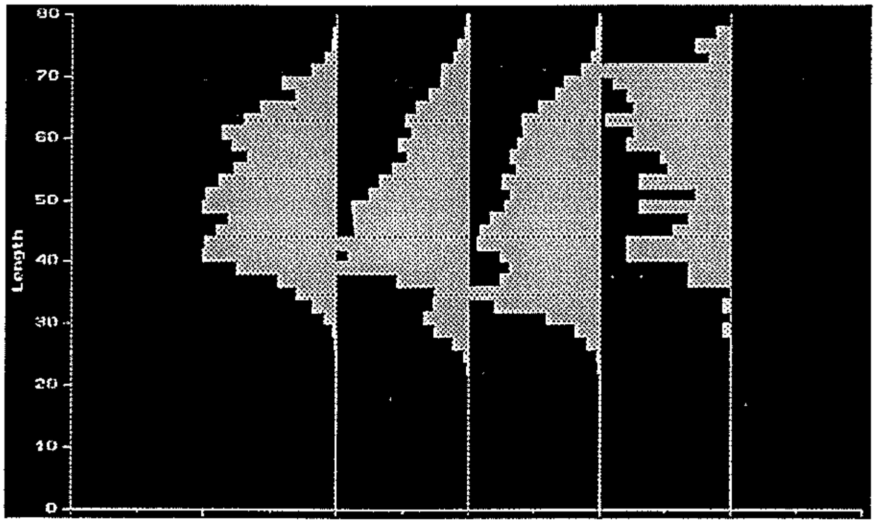


Fig A.8.2 : Handlines for 1990, 1991, 1992 and 1993 respectively.

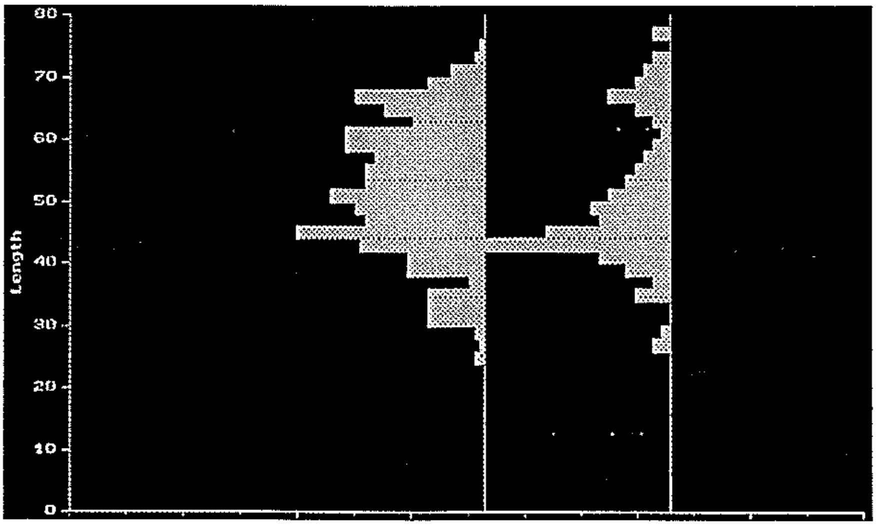


Fig. A.8.3 : Electric reels for 1992 and 1993 respectively.

P. filamentosus : Annual length frequency distributions by gear type.

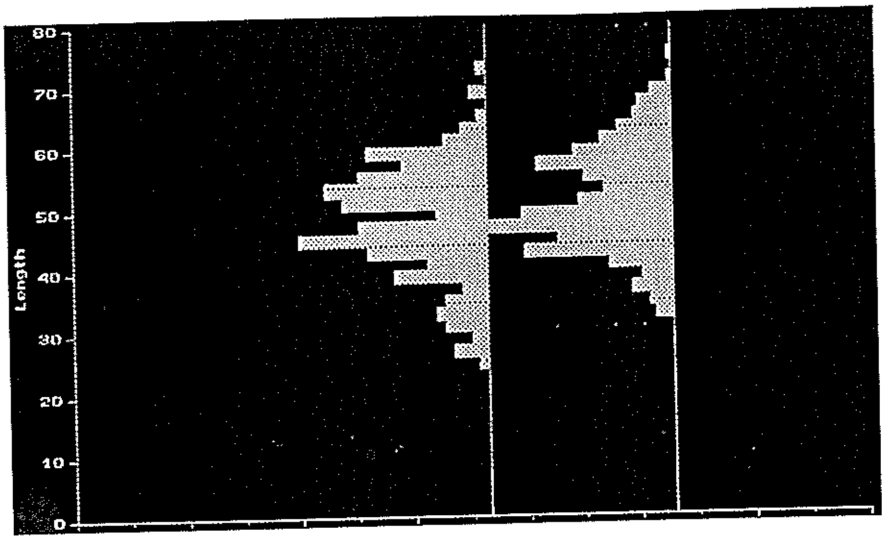


Fig. A.8.4. : Drop lines for 1991 and 1992 respectively.

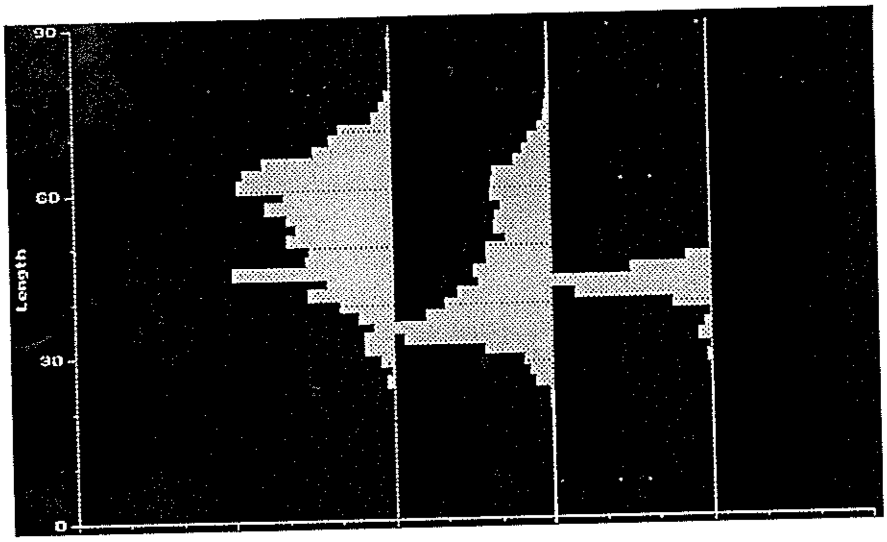


Fig. A.8.5. Gill nets for 1991, 1992 and 1993 respectively.

A. virescens : Annual length frequency distributions by gear type.

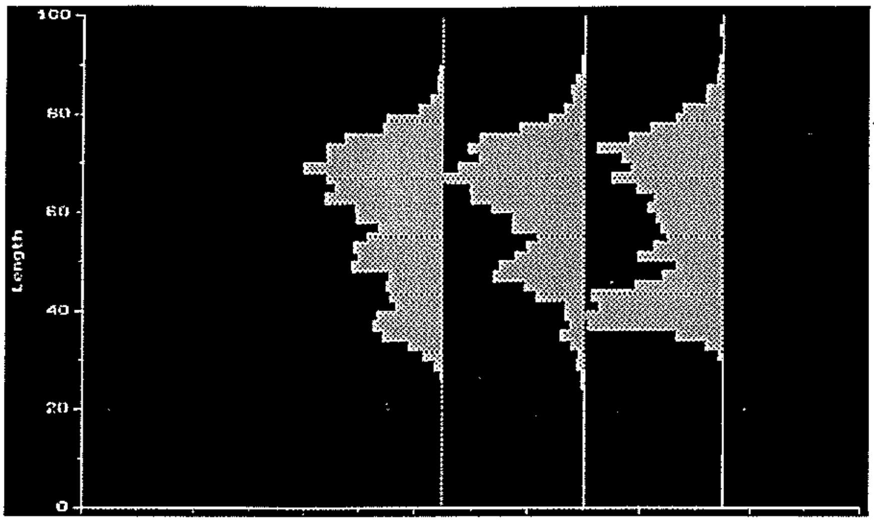


Fig A.8.6. : Unspecified gear type for 1991, 1992 and 1993 respectively.

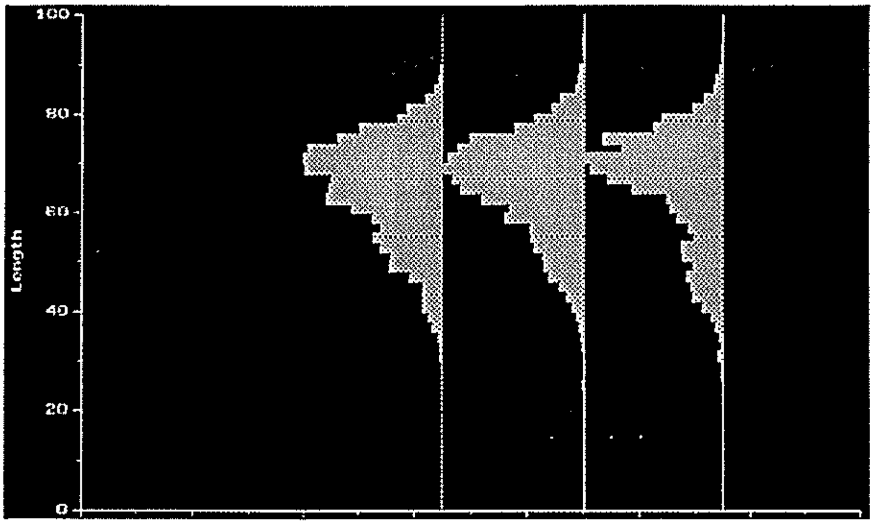


Fig. A.8.7. : Hand lines for 1991, 1992, and 1993 respectively.

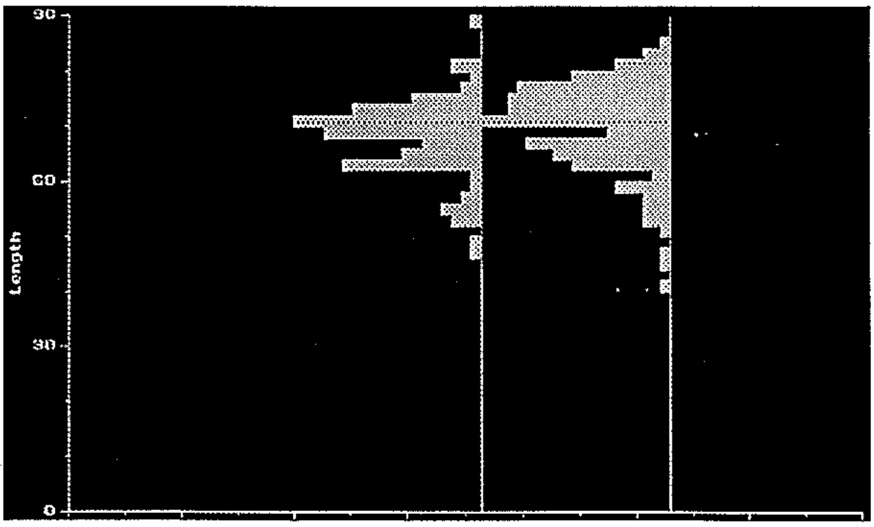


Fig. A.8.8. : Electric reels for 1992 and 1993 respectively.

A. virescens : Annual length frequency distributions by gear type

Fig. A.8.9. : Drop lines for 1991 and 1992 respectively.

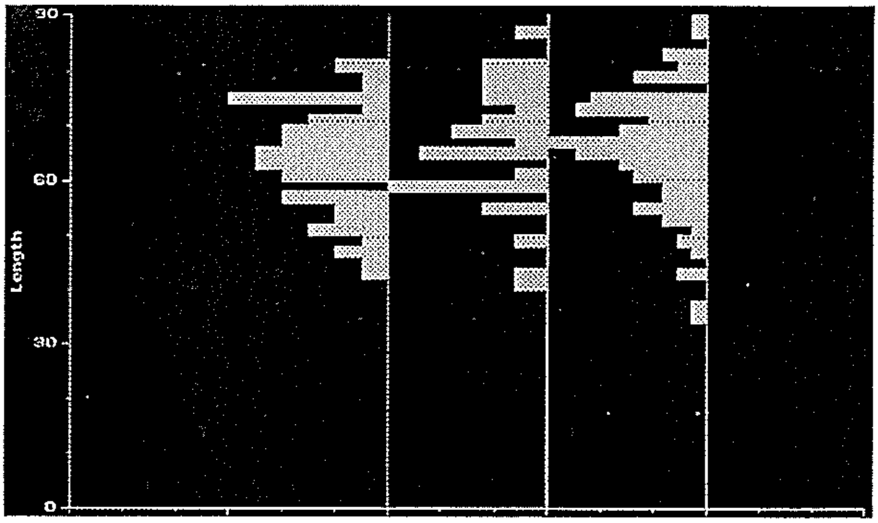


Fig. A.8.10. : Gill nets for 1991, 1992, and 1993 respectively.

L. sebae : Annual length frequency distributions by gear type

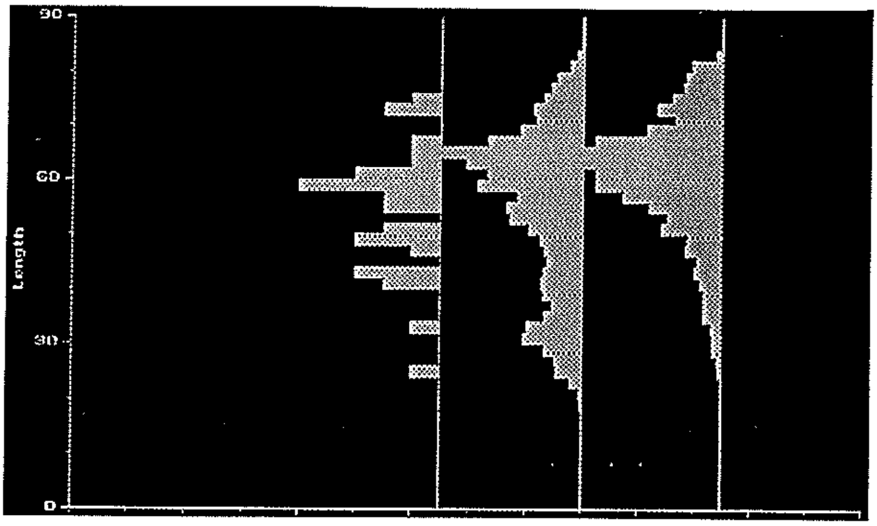


Fig. A.8.11. : Unspecified gear type for 1991, 1992 and 1993 respectively.

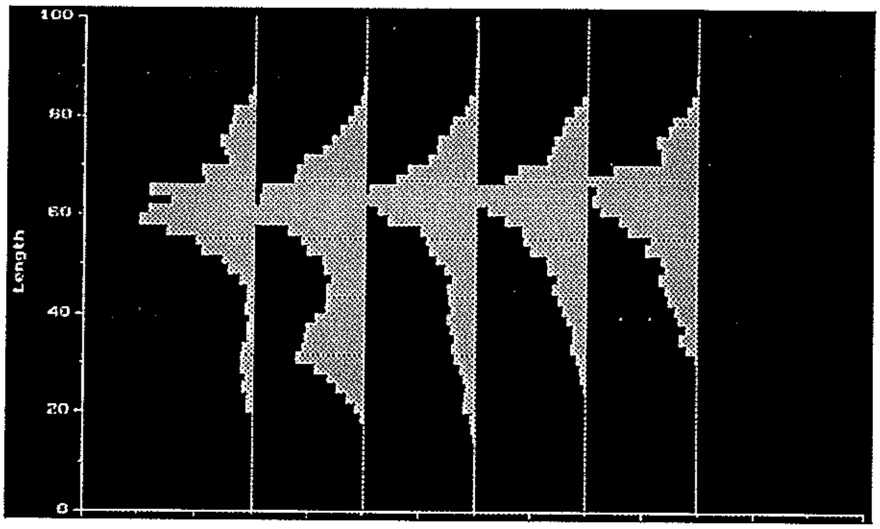


Fig. A.8.12. : Hand lines for 1989 - 1993 respectively.

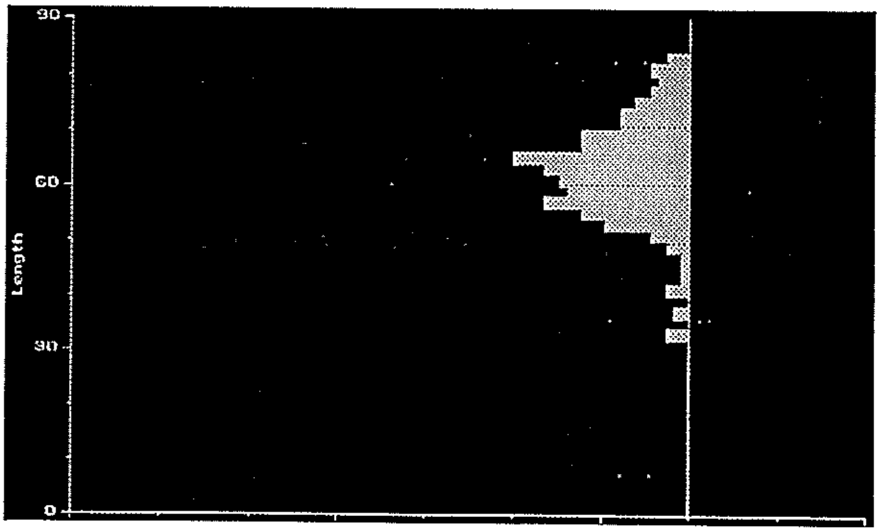


Fig. A.8.13. : Electric reels for 1991.

L. sebae : Annual length frequency distributions by gear type

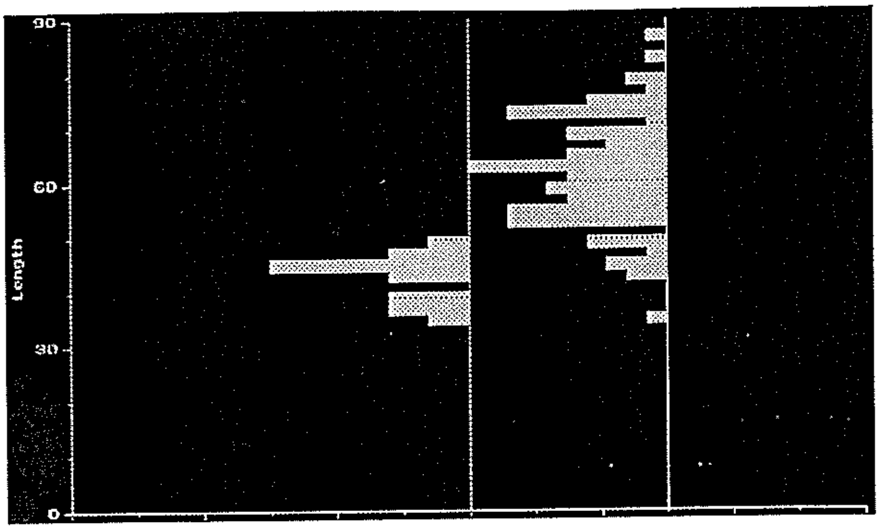


Fig. A.8.14. : Gill nets for 1992 and 1993 respectively.

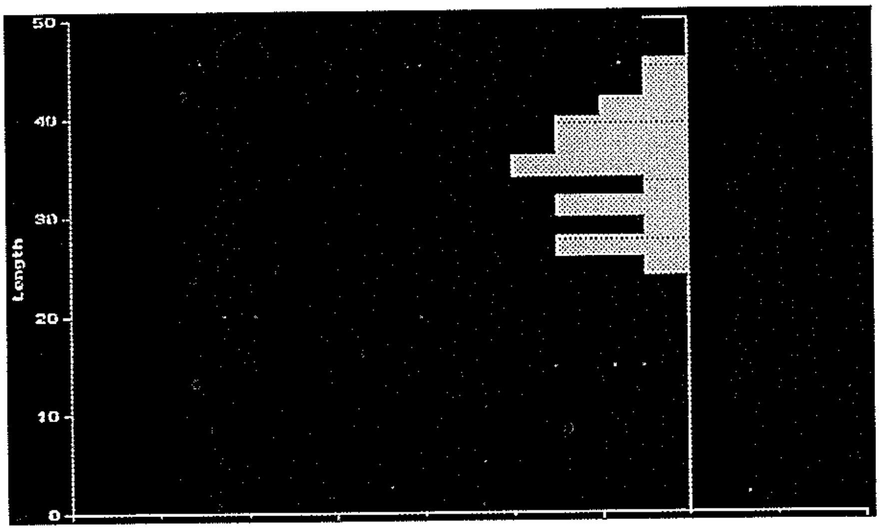


Fig. A.8.15 : Traps for 1992.

E. chlorostigma : Annual length frequency distributions by gear type

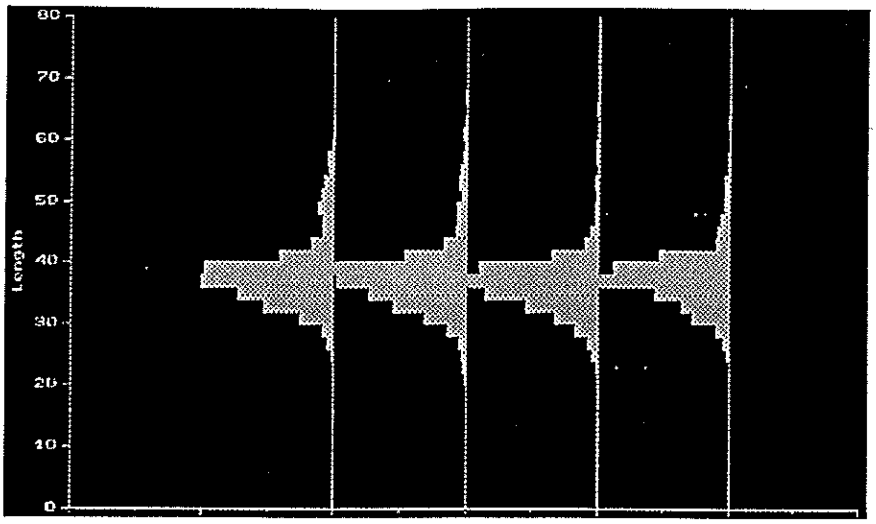


Fig A.8.16. : Unspecified gear type for 1990 - 1993 respectively.

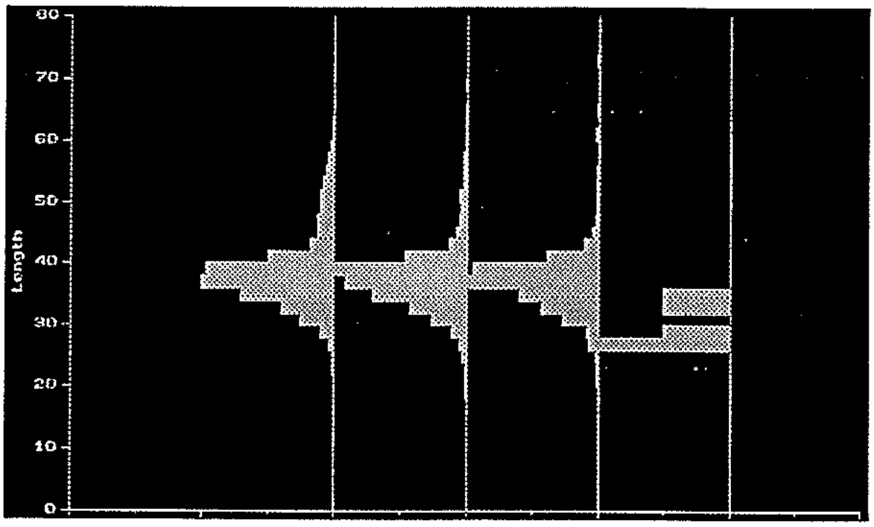


Fig. A.8.17. : Handlines for 1991 - April 1994 respectively.

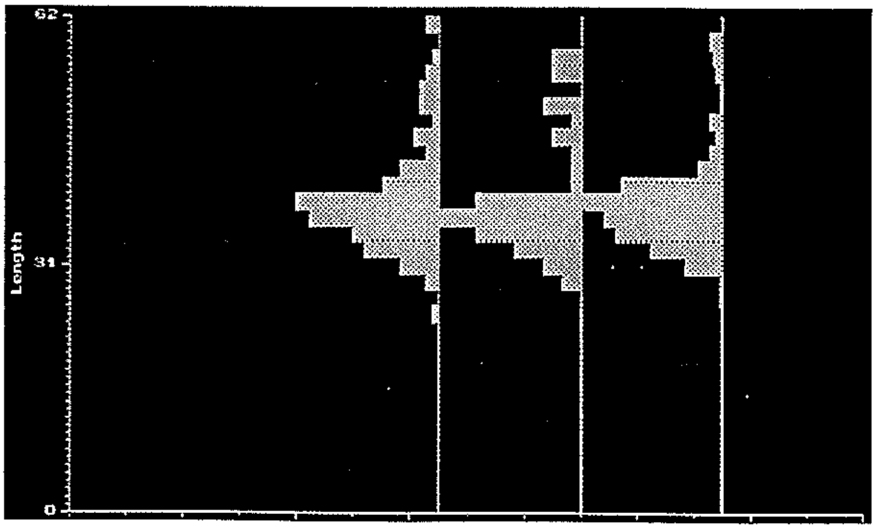


Fig. A.8.18. : Electric reels for 1991, 1992 and 1993 respectively.

E. chlorostigma : Annual length frequency distributions by gear type.

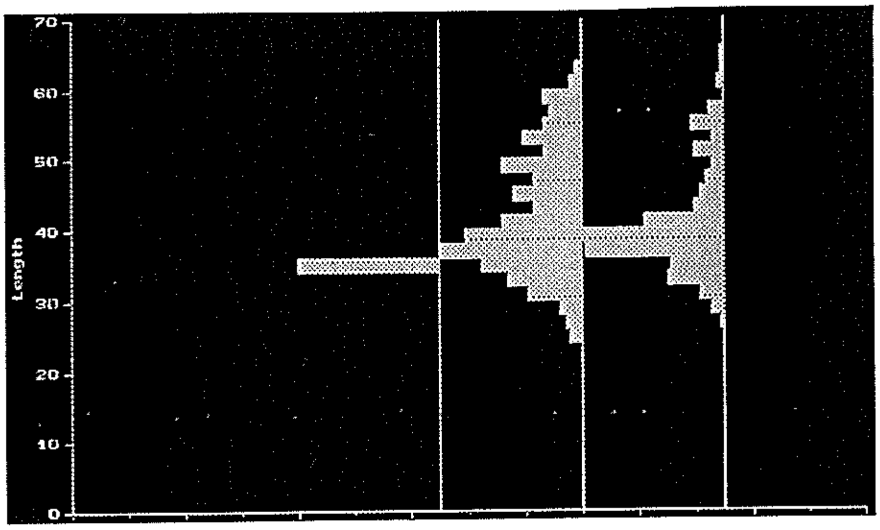


Fig. A.8.19. : Gill nets for 1991, 1992, and 1993 respectively.

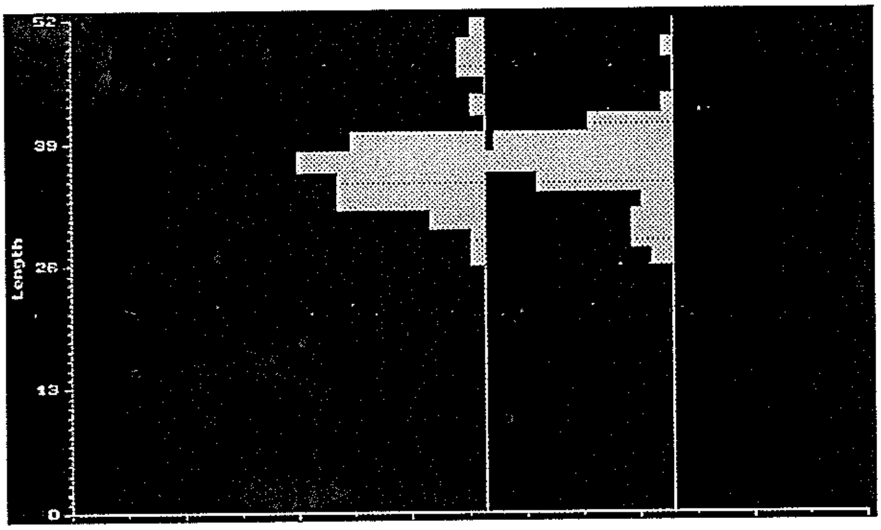


Fig A.8.20. : Traps for 1992 and 1993 respectively.

L. nebulosus : Length frequency distributions by gear type for 1992.

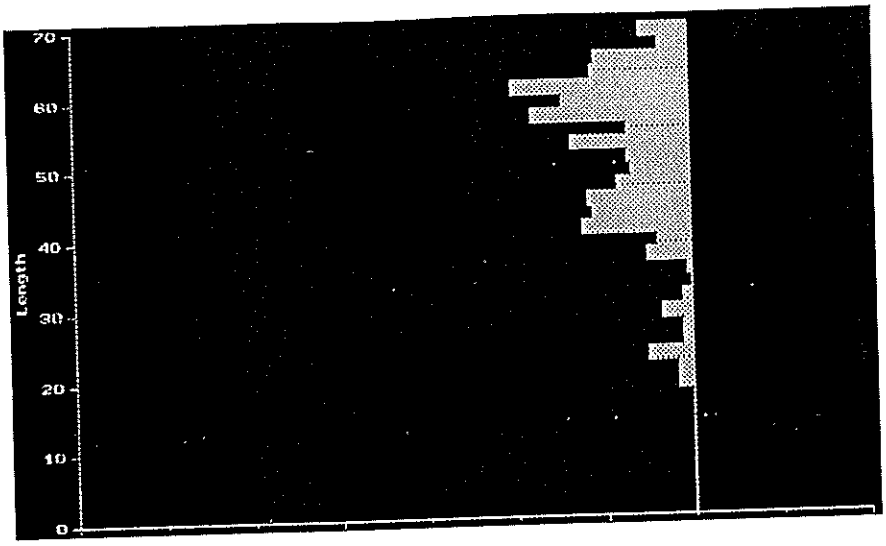


Fig. A.8.21. : Un-specified gear type.

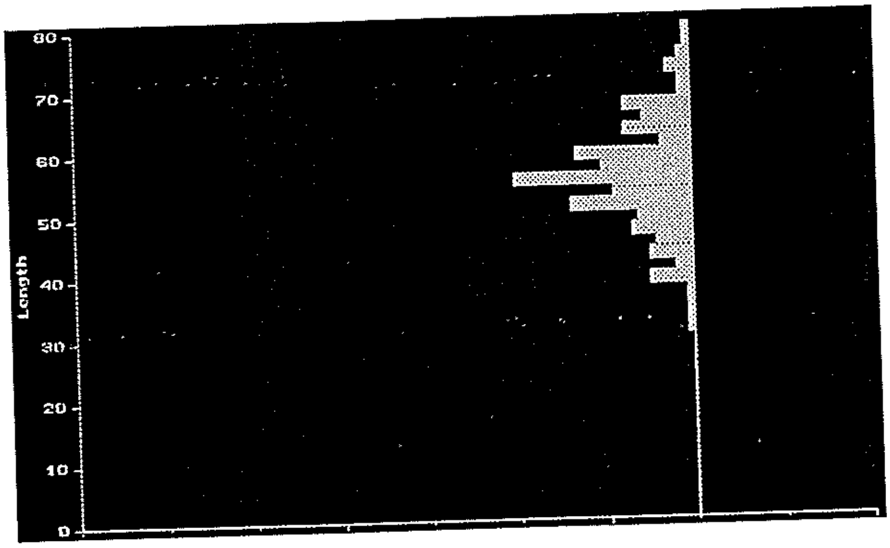


Fig A.8.22. : Hand lines.

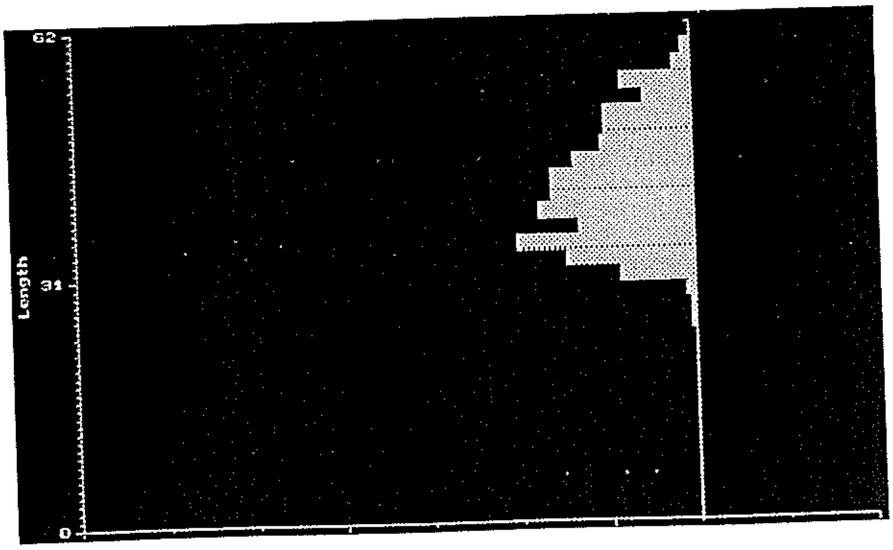


Fig A.8.23. : Gill nets.

Figs A.8.24 and 25 : Sensitivity of the estimate of Lc_{50} to changes in growth parameter estimates used during catch curve analysis.

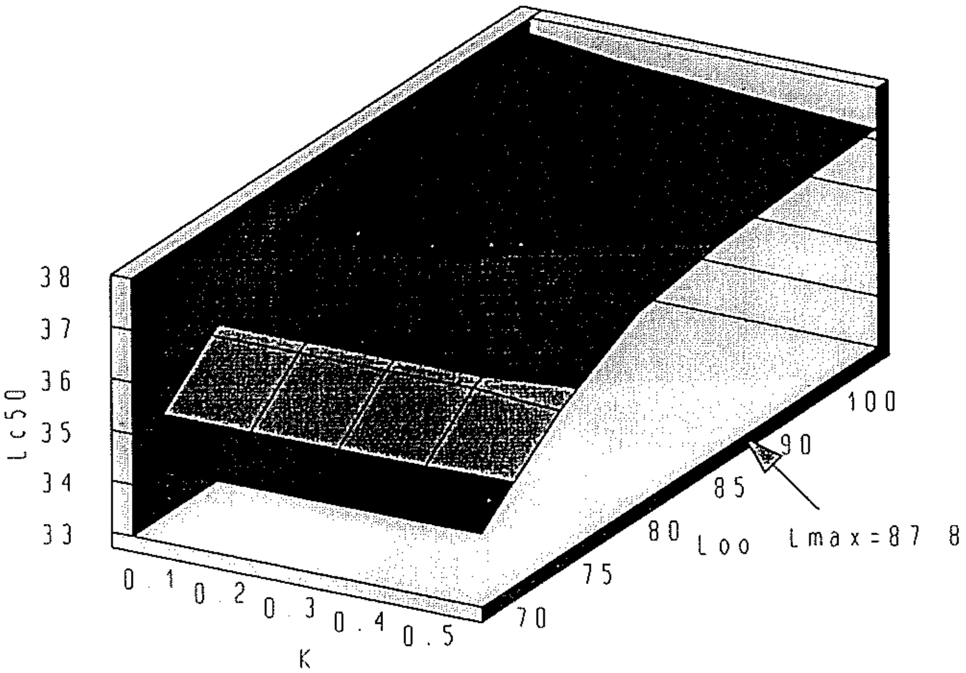


Fig A.8.24