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THE MARINE LINEFISH RESOURCES OF MOÇAMBIQUE.
(status, developments and future research)

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CONTENTS

ABSTRACT

Marine linefishing is seen to be of major importance to the social well-being and economy of many coastal people of Mozambique. Aspects of the artisanal and semi-industrial fisheries of Mozambique are described and a recent significant increase in effort is noted.

Landings are seen to comprise a high proportion of vulnerable, endemic species, several of which are shared with neighbouring South Africa. Trends in CPUE, sex ratios and yield per recruit suggest that future landings may decline if conservative management is not introduced.

Strategies for data collection and biological research on key species are proposed.

RESUMO

A pesca à linha em águas marinhas parece desempenhar um papel importante para o bem estar social e economia da maior parte da população costeira de Moçambique. Neste trabalho são descritos alguns aspectos das pescarias artesanais e semi-industriais e observa-se um notório aumento do esforço de pesca nos últimos tempos.

As capturas desembarcadas parecem ser compostas por uma alta proporção de espécies endémicas vulneráveis, muitas das quais compartilhadas com a vizinha África do Sul. As tendências da CPUE, composição por sexos e rendimento por recruta sugerem que as capturas no futuro poderão decair, se não forem introduzidas medidas de gestão adequadas para a conservação do recurso.

São apresentadas algumas propostas para a colheita de dados e investigação da biologia das espécies mais importantes.

1. DESCRIPTION OF THE FISHERY

Moçambique is endowed with a rich and diverse marine linefish resource (Fischer et al 1990) that provides socio-economic benefit to all levels of society. It has been shown that informal fisheries of the world provide greater food and employment opportunities than formal commercial fisheries do, especially in tropical regions (Caring for the Earth; IUCN; 1992). This situation is believed to be especially true in Moçambique with the harvesting of linefish as an important aspect in the lives of coastal communities. (Silva & Sousa 1987, Dutton 1990, Momade, Cossa & Pinto 1992)

Study and assessment of the linefishery is exceedingly difficult. In southern Moçambique more than 50 species of linefish are harvested (see Appendix I), there are several hundred fishermen, numerous launching sites and a great many informal markets.

The linefish resource is harvested along the entire Moçambique coast but information at this stage is confined to activities south of Beira. At least three categories of linefish exploitation can be identified viz semi-industrial, artisanal and recreational. Each of these has different attributes and requires different research and management strategies. The following brief descriptions apply:

1.1 Semi-industrial fishing is conducted from port-based vessels, 15-20m in length, with refrigeration and a crew of 10-15. These vessels, which operate from Beira, Maputo and Inhambane, are required by law to be licensed with the Secretary of State for Fisheries (SEP) and spend approximately 5-10 days at sea on each fishing trip. (Dengo et al 1991)

1.2 Artisanal fishing takes place from a variety of small craft that range widely in level of sophistication and method of propulsion. Based on this three different types can be identified.

	LENGTH	CONSTRUCTION	AVERAGE CREW No.	PROPULSION
Type I	1.5-8m	tree trunks	1.3	oars, pole or sail
Type II	3-8m	planks or fibreglass	2.5	oars, pole or sail
Type III	1.5-10m	planks or fibreglass	3	outboard motor

Most of these fishermen are licensed with SEP and can launch from virtually any protected area along the coast.

1.3 Recreational fishing is conducted through local fishing clubs and also by tourist anglers. Most use skiboats or gamefishing boats to fish offshore but some angling from the shore and spearfishing does occur. None of these fishermen are presently licensed.

At present there are no management controls to regulate the harvesting of linefish in Moçambique. Consequently this is an open-access fishery with no effort or TAC limitations. Those who fish from craft are required to register such vessels with the SEP.

Although the precise effort associated with each category is not known there is convincing evidence that the overall fishing effort in the linefishery has increased in recent times as shown in Fig. 1.

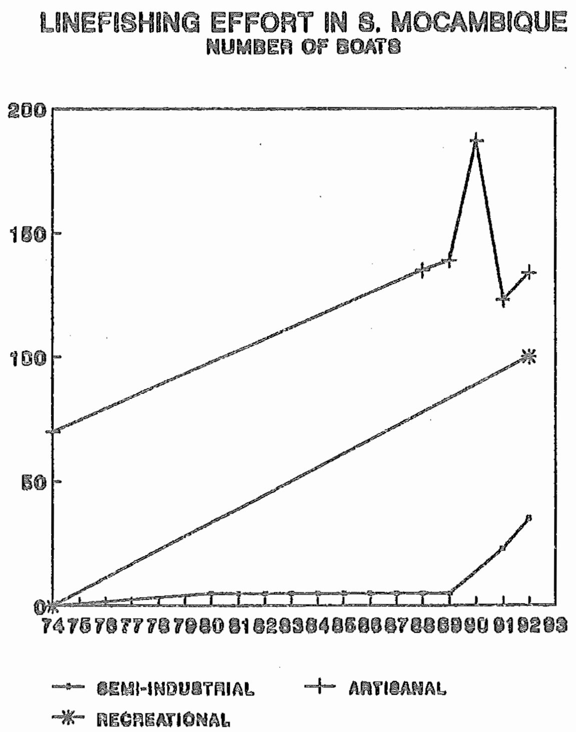


Figure 1 Linefishing effort in southern Moçambique

This trend clearly shows a huge increase in effort, especially in the semi-industrial sector. It is anticipated that recreational angling will increase manyfold, especially as South African tourists re-discover the rich fishing grounds of Moçambique. Articles about this have already appeared in local and South African publications.

2. RESEARCH

Scientific investigation into the Moçambique linefish resource has been limited due to a severe lack of manpower and the exceedingly diverse nature of this fishery. Nevertheless, progress has been made in some studies that should facilitate the assessment of stock and trends in the fishery. The sources of available data are listed in Appendix II, and can be divided into two categories: (i) fundamental biological information and (ii) fishery related information.

2.1 Fundamental information on several important population dynamics parameters have been obtained as a result of specific research initiatives.

For example, growth parameter and mortality rate estimates for a few key linefish species have been made using length frequency assessments such as ELEFAN. (Dengo, David & Piotrovski 1991). Additional information has been obtained from collaboration with ORI scientists who study in part the same resource. This has provided information on yield per recruit, optimal fishing effort and spawner biomass per recruit estimates for several key species. Growth parameters were also determined based on otolith analysis. This information is available in van der Elst & Adkin 1991 and Beckley & van der Elst (1993).

2.2 Fishery generated information has been obtained from a number of sources including commercial landings, on-board sampling, creel surveys of artisanal fishermen and voluntary catch cards from recreational anglers.

3. STOCK ASSESSMENT

Due to the detailed data requirements and lack of sufficient historical time series, many standard techniques of stock assessment cannot be successfully applied to linefisheries.

Butterworth et al 1990 have developed techniques that have more direct application to linefish stock assessment in the SW Indian Ocean. The following techniques and guidelines are recommended for use in stock assessment of Moçambique linefish.

3.1 Consider only single species models

3.2 Adopt a conservative management strategy for species that are known to be vulnerable due to endemism, complex life history styles, slow growth rates, long maturation periods and low fecundity.

3.3 Consider biological "over exploitation" to have occurred when the original population size has decreased by 50% when compared to the unexploited stock. Hence a decline of 50% in CPUE relative to the unexploited situation would be cause for alarm and necessitate management controls.

3.4 In the case of protogynous and protandrous species a simple yet effective assessment of stock can be made by monitoring changes in sex ratios. In particular Chrysoblephus puniceus populations undergo significant changes in sex ratio as fishing effort is increased (Garratt 1985).

3.5 In order to prevent over exploitation of the linefish resource and to ensure cost effective exploitation the $F_{0.1}$ strategy should be adopted where the marginal yield per recruit (YPR) is minimized. (Gulland 1968). Alternatively, limiting F to a level equal to or lower than M for individual species is a useful "rule-of-thumb" technique for stock protection (Gulland 1971).

3.6 The species composition provides a quick assessment of stock, especially if a time series is available. It is important to identify that component of the fish catch that comprises vulnerable species (such as C. puniceus) and monitor the proportion of this over time. Such composition should ideally be in numbers of fish per unit of effort.

3.7 Length frequency data of the major species should be used in the calculation of mean size, growth coefficients of fast growing species and mortality rates by means of length converted catch curves. Pauly's emperical equation can be used to estimate M but several different methods should be used simultaneously. For example, M can also be determined by the Rikhter & Efanov equation.

3.8 Age based models can be very usefully applied to assess Moçambican linefish, especially to predict their behaviour under different fishing strategies. In particular the YPR model is useful and software for this is available at IIP and ORI (PC-Yield by Punt 1990). For this to be implemented good growth models are needed, many of which exist though some remain outstanding and should be addressed.

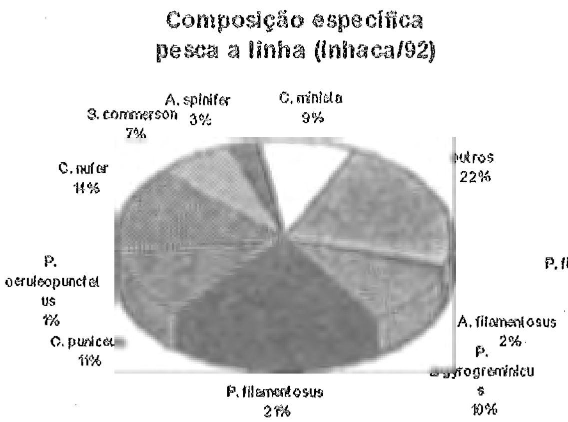
4. STATE OF STOCKS

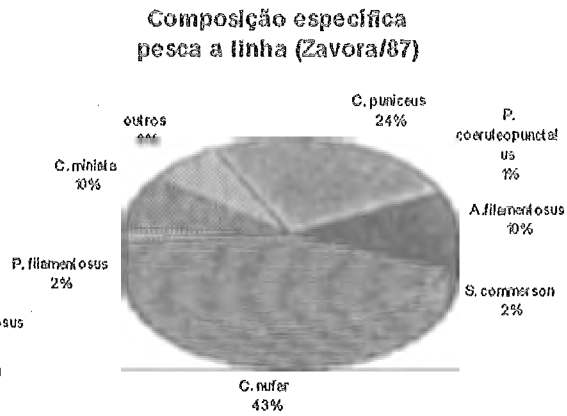
Although data is limited, there are a number of indicators which can be used to assess the present status of stocks.

4.1 **Species composition.** Vulnerable species are defined as those which have all or some of the following criteria: limited distributions (endemic), locally resident, undergo sex change, have slow growth and have already been depleted in some regions. The species that fall into this category are the following (partly based on van der Elst and Adkin 1991):

Chrysoblephus puniceus
Chrysoblephus anglicus
Argyrops spinifer
Argyrops filamentosus
Polysteganus praeorbitalis
Epinephelus andersoni
Epinephelus marginatus
Epinephelus albomarginatus

Various compositions of catches sampled by IIP are given in Fig. 2, below.





It is clear that the vulnerable species feature prominently in catches. However, this also indicates that the resource has been able to sustain the fishing pressure otherwise these species would not be present in such numbers.

Data on the trends in composition with time are inadequate although the information from the 1987-88 study shows a greater proportion of *C. puniceus* than the sample from 1992. This could be an indication of a change in composition.

4.2 The sex ratio of *C. puniceus* gives insight into the status of that species and indirectly also of the entire linefishery because if the sex ratios remain within satisfactory limits then it is unlikely that other species will have been more depleted. Garratt (1985) indicated that a virgin population of *C.puniceus* has a sex ratio of m:f as 1:4. However, in severely depleted situations he found ratios of 1:18-22. In the Moçambique samples the following sex ratios were recorded.

DATE	AGENCY	REGION	NUMBER	m:f	REFERENCE
79/81	IIP	Quissico	615	1:9	Piotrovski 1990
87/89	IIP	Quissico	790	1:13	Piotrovski 1990
90	IIP	Zavora	75	1:5	Piotrovski 1990
91/92	IIP	Xai-Xai	100	1:8	Piotrovski 1990
92	IIP/ORI	Boa Paz	240	1:8	IIP-unpublished
92	IIP/ORI	Zavora	156	1:2	Paula e Silva 1992

The above data mostly indicate a favourable stock situation with low sex ratios. Two data sets are confusing. The 87/89 ratio appears high while the 92 sample is too low. However, the overall situation suggests relatively low impact of exploitation at this stage.

4.3 **Yield per recruit.** One of the most useful techniques of predicting the behaviour of linefish stocks under different management strategies is the yield-per-recruit method. This model requires a number of input parameters that can be reasonably determined for species in the Moçambique linefishery. Although these parameters still need to be determined with confidence it is possible to demonstrate the value of this method with preliminary data for the slinger *Chrysoblephus puniceus*. A per-recruit analysis for *C.puniceus* captured in the linefishery off southern Moçambique is outlined in Appendix I. It is shown that for two different growth curves (estimated from length frequency) MSY is attained at fishing mortality rates ranging from 0.35 to 0.5 yr^{-1}. However, at these rates the spawning biomass-per-recruit will be substantially reduced to levels <<35% when compared to an unfished level. Such reduction could possibly affect recruitment rates over the long term. No estimates of current fishing mortality exist but by comparing observed sex ratios to predicted sex ratios at various levels of fishing mortality rates it was deduced that the current F is <<0.1 yr^{-1}, indicating that the slinger stock off Moçambique during 1990 to 1992 was virtually pristine. It is recommended that the best management strategy for slinger is to constrain fishing mortality to levels between 0.1 - 0.25 yr^{-1}.

5. FUTURE RESEARCH

The main thrust of future research should focus on those issues that will provide fishery managers with the essential information needed to manage exploitation of the linefish resource. In particular this should assist in documenting adverse trends in the fishery before they become a problem. The research and management strategy should be on an "optimal" rather than "maximal" basis.

This means that "maximum yield" may not be the only objective and that utilization of linefish landed should satisfy the needs of all categories of linefishermen. For example, while semi-industrial fishermen may want a maximum tonnage of fish, recreational fishermen may want to land certain species of a specific size. The data needed for this will involve primarily the collection of fishery related statistics and several key biological parameters that can aid stock assessment. In particular the following strategy is recommended.

5.1 There is an urgent need to appoint a **full time scientist** with overall responsibility for linefish research in Moçambique. This person should be assisted by sampling technicians and student assistants. In collaboration with others this person should develop a five year linefish research strategy that will address the needs of the nation and those of resource managers and the fishermen themselves. This may be achieved by a joint application of IIP and ORI to fund an ORI consultancy and associated costs.

5.2 It is considered imperative to initiate a **regular forum** for discussion between all parties: fishermen, SEP, IIP (Fisheries REsearch Institute) and IDPPE (Institute for Small-Scale Development). This will build up the level of trust and give better insight into fishery problems, solutions and potential sources of data. In particular it is considered desirable to maintain the good collaboration between IIP and IDPPE to maximise productivity and ensure optimal development of the linefishery.

5.3 Determine the **total fishing effort** in all sectors of linefishing by ensuring that all vessels (semi-industrial, artisanal and recreational/charter) are licensed with SEP and that this information is available to IIP on a regular basis. Tourist anglers should be required to purchase a licence and divulge details of their activities which would provide an estimate of fishing effort.

5.4 Obtain **representative random subsamples** of each fishing sector in order to determine species and size composition, sex ratio (in some cases), catch per unit effort (CPUE) rates and basic biological data. The semi-industrial fishermen should be issued with personal logbooks which will reflect daily total catch. This should be supplemented and verified by random on-board sampling. Artisanal fishermen should be periodically surveyed by creel census to determine their total catch, CPUE, species composition and personal appraisal of the state of the fishery. Resident recreational anglers should be approached via their clubs to assist with data generation on a voluntary basis such as the submission of daily catch cards.

5.5 Several important **biological parameters** can be obtained by the on-board sampling of semi-industrial fishermen. A modus operandi for this has been developed and includes: catch and effort, length and species composition of the catch and sex ratios. Where possible otoliths for age determination should also be collected. Improved data handling procedures can be developed in conjunction with ORI.

5.6 Useful information can be efficiently collected by conducting a periodic fisherman survey using a questionnaire. It is recommended that this is undertaken with some urgency, especially for the artisanal fishermen to determine their frequency of operations, target species and possible problems with the linefish resource.

5.7 There is a need to develop a simple data base to store the linefish subsample information. From this it will be easy to filter out the required data for analysis on a spreadsheet. Some standardization of the species and locality codes could be useful and will be pursued. The development of this data base can be part of the linefish research plan application.

6. CONCLUSIONS

While the status of linefish stock in southern Moçambique appears satisfactory and is probably not yet fully exploited, there is a reason to be cautious. A major challenge facing management will be the sustained harvesting of the vulnerable species that comprise the major component of this fishery. Furthermore, it will be a challenge to develop strategies that will allow for multiple use of the linefish resource by all categories of fishermen without creating user conflict. The role of linefish in drawing tourists has enormous economic potential and should be carefully developed to maximize benefits without jeopardizing artisanal and semi-industrial use.

Clearly there is also a need to secure financial support for linefish research initiatives and the proposed tourist licensing system could generate useful revenue for this purpose.

The single most important task ahead is to develop a linefish research and management strategy for the next five years with clearly defined goals and deadlines.

7. ACKNOWLEDGMENTS

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APPENDIX I

A preliminary assessment of the status of the slinger (*Chrysoblephus puniceus*) off the coast of Moçambique based on a per-recruit analysis

The current status of the deep reef sparid *Chrysoblephus puniceus* off the coast of Moçambique was assessed utilizing a modified Beverton and Holt yield-per-recruit (YPR) and spawning biomass-per-recruit (SBR) model. Von Bertalanffy growth parameters were obtained from length frequency data utilising ELEFAN (Dengo *et al.*, 1991) and Shepherd's Length Composition Analysis (SLCA). The SLCA was performed on length frequency data collected from 1990 to 1992. Biological parameters were obtained from Dengo *et al.*(1991), Piotrovski (1990) and van der Elst and Adkin (1991). Table I summarises the input parameters to the per-recruit analysis.

Table I. Estimates of parameters utilized in the per-recruit analysis. Definitions of the symbols are given in the text.

PARAMETER	ESTIMATE	SOURCE
M	0.3 yr^{-1}	assumed
t_m	2 yrs	van der Elst and Adkin (1991)
t_c	2 yrs	Piotrovski (1990)
L_∞	72 cm	Dengo *et al.*(1991)
K	0.25 yr^{-1}	Dengo *et al.*(1991)
L_∞	62.8 cm	this study
K	0.168 yr^{-1}	this study
t_0	-0.67 yrs	this study
a	0.10464	Dengo *et al.* (1991)
b	2.467	Dengo *et al.*(1991)
max	20 yrs	assumed

THE MODEL

The per-recruit model is described briefly in the following sections. Mean weight-at-age (W_t) is described by the Von Bertalanffy growth equation and the length-weight relationship:

$$_t = a(L_\infty(1 - e^{-K(t-t_0)}))^b \qquad (1)$$

where

a,b = weight-length parameters,

L_∞= asymptotic mean length,
K = rate at which mean length-at-age approaches L_∞,
t_0 = theoretical length at "zero" age, and
t = age

The following exponential survival model describes the decline in fish numbers:

$$N_t = Re^{-(F_t+M)} \tag{2}$$

where

N_t = Number of fish at age *t*,
R = number of recruits,
F_t = Fishing mortality-at-age,
M = Natural mortality rate .

The Baranov catch is used to describe the catch-at-age (C_t):

$$C_t = N_t \frac{F_t}{F_t + M} (1 - e^{-(F_t+M)}) \tag{3}$$

Assuming knife-edge selectivity and by setting *R* to one, the yield-per-recruit can be calculated as :

$$YPR = \sum_{t=t_c}^{max} W_t C_t \tag{4}$$

where

t_c = age-at-first capture,
max = is the maximum observed age.

The spawning biomass-per-recruit is calculated as:

$$SBR = \sum_{t=t_m}^{max} W_t N_t \tag{5}$$

where

t_m = age-at-50%-maturity.

RESULTS AND DISCUSSION

Figure 1 shows the yield-per-recruit and spawning biomass-per-recruit curves for *C. puniceus*, based on two different growth curves while Table II shows some target management fishing mortality rates based on these curves.

Table II. Estimates of target fishing mortality rates for *C. puniceus*. Note that all estimates are only approximate values and where estimated graphically from Figure 1. F_{max} is the fishing mortality rate at which MSY is obtained. F_{S50} and F_{S35} are the fishing mortality rates at which the spawning biomass-per-recruit is reduced to 50% and 35% levels when compared to the unfished state (i.e. when F=0), respectively.

TABLE II. Fishing mortality rates for *C. puniceus* estimated graphically from FIG. 1.

PARAMETER	ELEFAN (Dengo *et al.*(1991)	SLCA (this study)
F_{max}	0.5	0.35
F_{S50}	0.18	0.14
F_{S35}	0.24	0.27

For both growth curves the YPR curves are domed shaped (Figure 1) and MSY is achieved at fairly low fishing mortality rates (see F_{max} estimates in Table II). The growth curve estimated from ELEFAN predicts higher YPR values than that estimated from SLCA, simply because the former growth curve predicts a faster growth rate than the latter curve (Table I, Fig. 1). Both growth curves show that the SBR is reduced to 50% and 35% levels at fishing mortality rates much smaller than the rates at which MSY is achieved. This indicates that if the primary management objective in the fishery is to maximise the catch, then, over the long term there will be reduction in the spawning biomass which could possibly result in recruitment reduction.

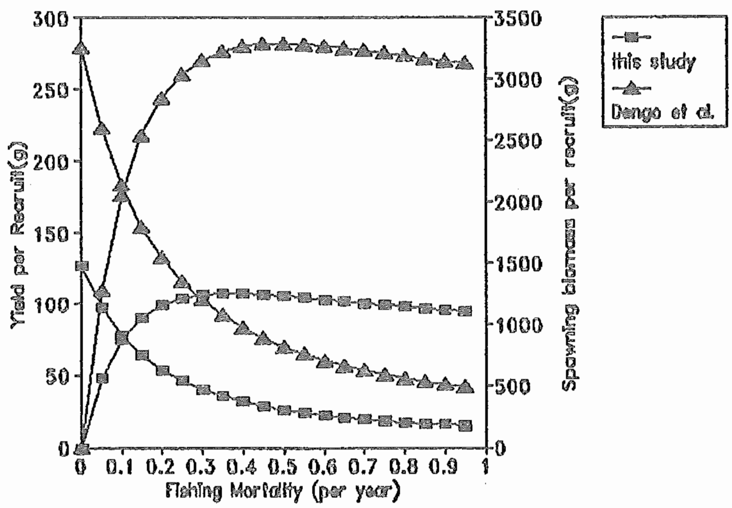

Figure 2 YPR and SBR curves for *C. puniceus* captured in the linefishery off Mozambique.

Note that the F_{max} estimates shown in Table II indicate fishing mortality rates that are greater than the value of *M* assumed. Hence, maintaining *F=M* may seem to be a feasible management strategy for *C. puniceus* as this will result in yield values only marginally less than MSY but the great disadvantage is that SBR will probably be less than 35% when compared to an unexploited level. At present there is no reliable estimate of the current *F* for *C. puniceus* in the Moçambique linefishery. In order to provide some estimate of the current *F* value the above

YPR and SBR model was modified to indicate possible sex ratios at different *F* values. This was achieved by assuming that all fish above 48cm were male while those below this length were female (Piotrovski 1990). The predicted sex ratios at various fishing mortality rates are shown in Figure 3.

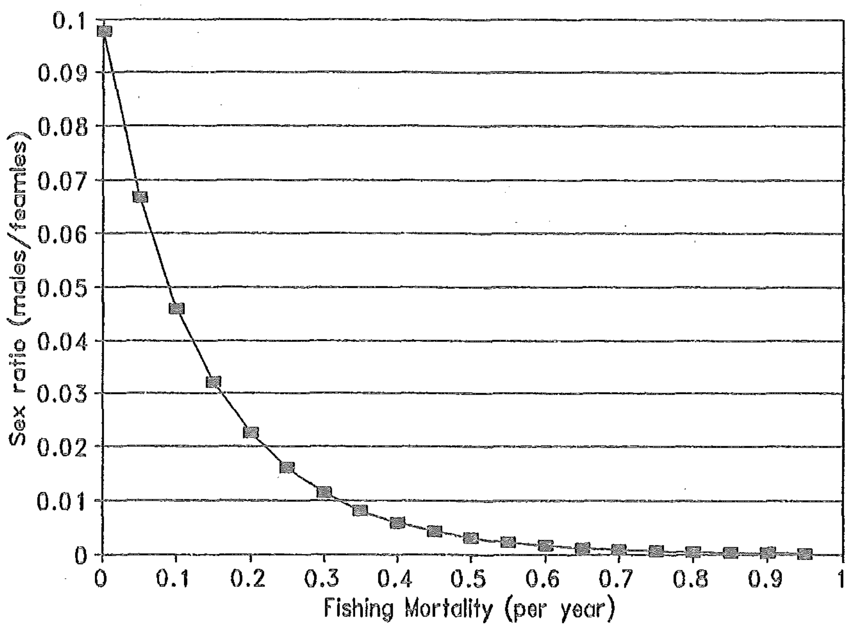

Figure 3 Predicted sex ratios for slinger for various fishing mortality rates

As can be seen in an unexploited fishery the predicted sex ratio is 1:10 (males:females) (Figure 2). Piotrovski (1991) estimated the sex ratio in Moçambique to be 1:11, 1:9 and 1:10. This indicates that the slinger linefishery of Moçambique is probably at a virtually pristine level with the current *F* at a very low value (<<0.1). The sex ratio is reduced to 1:20 at an alarmingly low *F* value (0.1 yr^{-1}). This analysis indicates that by simply monitoring the sex ratio one can reasonable predict the current *F* value.

CONCLUSIONS

Irrespective of the growth curve applied, SBR is reduced to 50% of the unexploited state at very low fishing mortality rates. Hence constraining the fishing effort on slinger is extremely important. This can be achieved by setting bag limits or quotes or limiting entry into the fishery. A minimum size limit will not be effective since this will protect only the females as they are confined to the smaller size classes. Current sex ratios indicate that the fishery is lightly exploited. It is recommended that monitoring the sex ratio, as the fishery expands, will provide a quick and cost effective means of providing an estimate of the current *F* and further to indicate the status of the stock. It should be noted that this analysis was based on length frequency data, as a result, the age estimates are relative and not absolute ages.

It is recommended that an age determination study on slinger be initiated as soon as possible. The age distribution of this virtually pristine stock can be used to estimate such elusive parameters such as *M*.

APPENDIX II

A RECOMMENDED STRATEGY FOR LINEFISH SAMPLING AND STOCK ASSESSMENT IN SOUTHERN MOÇAMBIQUE

Moçambique is endowed with a diverse and plentiful supply of linefish. This resource has in recent years been subjected to only moderate fishing pressure and indications are that the status of stocks remains healthy (David 1993). However, the rapid growth in the semi-industrial linefishing sector and anticipated growth in recreational fishing necessitates careful investigation of the fishery so that it can be developed on a sustained basis.

Although considerable progress has been made by IIP, IDPPE and South African linefish scientists, there remains a need to develop several key aspects of research specifically into the Moçambique linefishery. These have been identified as follows.

1) Define the **unit of effort** to be used in linefish studies that will be compatible with Mozambican, South African and other regional linefish data. If possible develop a model that will allow for conversion between different effort types. For instance, do number of hooks influence the CPUE (hence effort) linearly? This can perhaps be derived from IIP data obtained from the vessel Makaira and ORI data obtained from research cruises.

2) Derive the best estimate of **present linefishing effort** in southern Moçambique using available data. It may be necessary to divide the region into sub-regions (possibly the seven zones suggested by Piotrovski 1990) to facilitate data collection and analysis. Three types of linefishing exist: semi-industrial, artisanal and recreational. The effort associated with each needs to be determined and monitored. It is important to note that not all effort is necessarily targeted at all species in the multi-species catch and care should thus be taken. A useful rule is in species which make up >50% of the catch all the effort for that period is used in calculations. This clearly underestimates less common species.

   2.1 For artisanal fishing effort derive number from SEP list available at each centre. Consider asking fishermen how many days they spend at sea, what percentage are licensed and what fish they target by means of a questionnaire.

   2.2 For semi-industrial determine:
   * the number of boats operating : SEP responsibility
   * the number of days each spends at sea per month
   * the average number of fishermen per boat.

From this it should be possible to determine monthly linefishing effort. Investigate the literature, SEP and scientific reports to locate other estimates and attempt to plot these into some historic sequence. Even simply the number of boats operating can be useful.

2.3 For recreational angling it is suggested that these be divided into two groups, local clubs and foreigners, especially from RSA. Locals can be sampled through their clubs or at the wharf. It is recommended that a system be introduced to collect data from the foreign sector as it is likely to grow in intensity. Possibly consider introducing a fishing permit for non-residents that will generate data and revenue for IIP. Many anticipated South African fishermen are already accustomed to management controls.

3) Extensive data has been collected from the vessel Makaira by Mr. João Manuel. This system is now well established and can be expanded and enhanced to provide additional important information that will be of value to both IIP and the IDPPE in their development initiatives. It is suggested that Mr. Manuel extends his sampling to a further two boats by reducing his time on Makaira. In addition the sampling should include length measurements. A modified data register is proposed that accomodates the needs of IIP and IDPPE and will avoid duplication. (data sheet is appended) The following is suggested:

3.1 For each trip complete the boat details (1). For each sample (i.e. "faina" or actual fishing activity) complete the sections dealing with fishing effort (2), Hydrometeorological (3), Locality (4) and Catch (5). This is similar as is presently done but reduces recording of data that can be calculated or that will not be useful. Greater detail on species identification may be necessary, such as in the Serranidae where especially the endemic species should be recorded such as *Epinephelus albomarginatus, E.andersoni* and *E. marginatus (=guaza)*.

3.2 Starting on day 1, measure the lengths of all fish (ie non selected) until 200 have been measured (perhaps more of *C.puniceus* if possible). This information to be recorded on the reverse side of the same data sheet that describes the fishing activity etc. Do not bother to weigh individual fish although the total weight per species should be recorded. It is especially important to measure the key species that make up the bulk of the catch. It should not be necessary to measure fish from each locality but analysis of the data may eventually indicate a few regions that could be sampled separately.

4) Compile and introduce a daily log book for semi industrial linefishermen, possibly similar to the RSA version. The fact that only about 15 boats are

presently operating from Maputo makes this a realistic task, amounting to about 2500 fishing days per year. ORI will investigate the use of the NMLS system to aid analysis.

5) The determination of sex ratios in *C. puniceus* is considered essential. In view of the problems anticipated with gutting fishermen's catches, specimens may need to be purchased or else the assistance of fishermen should be sought. It is important to record sex only for species where this is likely to be of value e.g. the marreco, robalo etc.

6) Several key parameters needed for linefish assessment have not yet been determined in South Africa or Moçambique. These include the growth rate of several species, especially those of importance in Moçambique such as *Argyrops filamentosus*. It is suggested that IIP staff could undertake this task by collecting otoliths for such species so as to model their growth rates. The ORI can assist with growth modelling and interpretation of results. This would mean that much of the work of preparation and collection would occur in Maputo with final analysis at ORI. Species considered important are *Chrysoblephus anglicus, Polysteganus praeorbitalis, P. caeruleopunctatus, A.filamentosus, Argyrosomus thorpei* and *Scomberomorus commerson*. ORI will compile a list of needs for this study which lends itself very well for student involvement.

7) The data collected needs to be processed and interpreted on a regular basis to give information to both the scientists and fishery managers. It is suggested that a simple data base be established at this stage, possibly in DBXL or DBASE. The ORI can assist with this.

GUIDELINES FOR COMPLETING EXPERIMENTAL LINEFISH DATA SHEETS

1. Details of vessel. Record the information only at the departure from and return to the port. The number of pages should ensure that no data is mislaid. Thus each page has a sequential number out of the total number completed for the trip.

2. Fishing effort. Record this section for each sample (faina). Under technique use codes as follows:
   1= rod & line
   2= handline
   3= bottom longline
   4= surface longline

   Further detailed description of the gear can be made on a seperate sheet. It is important to make sure that all fishermen are using the same gear for any one sample.

3. Hydrometereological data. The main purpose of this section is to assist the IDPPE in evaluating potential improvements to fishing efficiency. It may also be useful in explaining trends in the fishery landings. For moon use phases 0 to 7. For wind use force and direction, for sea condition use the Beaufort Scale, for current use knots (=force) and direction in which it is flowing, for temperature take a bucket of water and measure in Centigrade, for turbidity measure with Sechhi disc at midday with overhead sun and record in metres.

4. Locality. For each sample record place name, code based on ORI linefish codes in kilometres, coordinates, depth in metres. The type of bottom, eg coral=1, rocky reef=2, sand=3, seagrass=4, surface fishing=5 etc. should be recorded where possible.

5. Catch. For each sample (faina) record every species caught, the total number caught and the total weight of the catch by species. If species cannot be identified then name it by family: species X. Only the scientific or common name is necessary. At the time of computer entry the Smith number will be allocated and used.

   The first 200 specimens of each species should be recorded on the reverse of the data sheet. No selection should take place and after 200 specimens there is no need to continue. It is suggested that fork lengths are recorded as routine. Additional data on total length, sex and gonad maturation stage can be collected if time and operations permit. This is most useful for slinger. On some vessels where gutting takes place at sea it may be possible to keep all slinger guts in one bucket and analize this for sex ratio later.

REGISTO DE INFORMAÇÃO DAS ACTIVIDADES E CAPTURA
PESCA EXPERIMENTAL E INVESTIGAÇÃO

1.

DETALHES DO BARCO

			SAÍDA	CHEGADA
NOME				
CAPITÃO		DATA	/ /9	/ /9
			No. página	/

2.

ESFORÇO DE PESCA

DATA DA FAINA	HORA DE FAINA		No. DE PESCADO-RES	TÉCNICA DE PESCA	No. DE ANZOIS POR LINHA
	INICIO	FIM			

3.

HIDROMETEOROLOGIA

FASES DA LUA	VENTO FORÇA/DIRECÇÃO		ESTADO DO MAR	CORRENTE FORÇA/DIRECÇÃO		TEMPE-RATURA DO MAR	MARÉ

4.

LOCALIZAÇÃO

NOME	CÓDIGO	LATITUDE	LONGITUDE	PROF(m)	TIPO DE FUNDO

5.

CAPTURAS

NOME CIENTÍFICO	NOME LOCAL	SMITH CODE	NÚMEROS TOTAIS	Kg TOTAIS

9/93 REGISTADO POR_______________

ANÁLISE BIOLÓGICA

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

ESPÉCIE:			
L^c	L^t	Sex	Mat

PROCEDURES AND DETAILS TO RECORD WHEN COLLECTING OTOLITHS FOR AGE STUDIES

1. From each fish remove a pair of otoliths. If one of the pair is broken, the other is still useful for age determination studies.

2. If the otoliths are large and robust they can be stored in an envelope or a plastic bag. Remember that the pair from each fish is stored together. With the storage of the otolith you *must* record:-
   - 2.1. the measured length of the fish (either fork or total length),
   - 2.2. the date of capture,
   - 2.3. locality of capture eg. Xai xai
   - 2.4. sex of the fish

3. If the otoliths are fragile, they can be gently wrapped in tissue or toilet paper and then stored in the plastic bag or envelope.

4. Following is a list of the scientific names of species that should be sampled in Mozambique.

SPECIES
Argyrops filamentosus
Argyrops spinifer
Polysteganus praeorbitalis
Polysteganus coerulepunctatus
Chrysoblephus anglicus
Chrysoblephus lophus
Pristipomoides filamentosus
Epinephelus marginatus
E. albomarginatus
E. rivulatus
E. andersoni

APPENDIX III

A preliminary list of species recorded from Maputo based linefishing boats

Species	(%)	Family
Pterocaesio chrysozona	0.14	Caesionidae
Pterocaesio marri	0.12	Caesionidae
Diagramma pictum	0.05	Haemulidae
Plectorhinchus chubbi	0.25	Haemulidae
Plectorhinchus flavomaculatus	0.16	Haemulidae
Parascolopsis eriomma	0.02	Nemipterida
Scolopsis bimaculatus	0.03	Nemipterida
Scomberomorus commerson	7.43	Scombridae
Variola albimarginata	0.03	Serranidae
Variola louti	0.52	Serranidae
Lethrinus conchyliatus	0.11	Lethrinidae
Lethrinus crocineus	1.40	Lethrinidae
Lethrinus harak	0.03	Lethrinidae
Lethrinus lentjan	0.03	Lethrinidae
Lethrinus microdon	0.07	Lethrinidae
Lethrinus nebulosus	1.92	Lethrinidae
Lethrinus rubrioperculatus	0.32	Lethrinidae
Lethrinus sanguineus	3.81	Lethrinidae
Lutjanus kasmira	0.01	Lutjanidae
Lutjanus monostigma	0.02	Lutjanidae
Lutjanus sanguineus	1.10	Lutjanidae
Lutjanus sebae	2.91	Lutjanidae
outros	9.37	Lutjanidae
Abalistes stellatus	0.06	Balistidae
Canrax sem	0.24	Carangidae
Carangoides malabaricus	0.51	Carangidae
Caranx ignobilis	0.09	Carangidae
Aphareus rutilans	0.04	Lutjanidae
Aprion virescens	0.41	Lutjanidae
Pristipomoides argyrograminicus	9.53	Lutjanidae
Pristipomoides filamentosus	20.79	Lutjanidae
Atractoscion aequidens	0.20	Sciaenidae
Arygosomus thorpei	?	Sciaenidae
Cephalopholis argus	0.04	Serranidae
Cephalopholis miniata	0.09	Serranidae
Cephalopholis sonnerati	1.82	Serranidae
Epinephelus andersoni	?	Serranidae
Epinephelus albomarginatus	0.03	Serranidae
Epinephelus chlorostigma	0.02	Serranidae
Epinephelus fasciatus	0.24	Serranidae
Epinephelus malabaricus	0.17	Serranidae
Epinephelus marginatus	?	Serranidae
Epinephelus rivulatus	0.08	Serranidae
Argyrops filamentosus	1.55	Sparidae
Argyrops spinifer	3.22	Sparidae
Cheimerius nufar	13.95	Sparidae
Chrysoblephus anglicus	4.72	Sparidae
Chrysoblephus lophus	0.06	Sparidae
Chrysoblephus gibbiceps	0.25	Sparidae
Chrysoblephus laticeps	0.24	Sparidae
Chrysoblephus puniceus	10.98	Sparidae
Polysteganus coeruleopunctatus	0.03	Sparidae
Polysteganus praeorbitalis	0.79	Sparidae

APPENDIX IV

Recommended Computer Software Developments

All sampled data need to be stored and retrieved electronically, preferably on a computer utilising software that can quickly sort and extract data for analysis. Furthermore, the data has to be extracted in a format that is compatible with other software such as spreadsheets or commercial statistical packages such as SAS or GENSTAT and wordprocessing packages such as WORDPERFECT. It is recommended that such a database be developed in DBASE, DBXL or CLIPPER as these software fit the above criteria. Such a database must not be developed and stored in spreadsheets as is currently being practised.

The spreadsheet QUATTRO PRO must be upgraded to at least version 4.0 as this package comes with an optimization routine which can be used to fit nonlinear curves using maximum likelihood methods or least squares. Furthermore, these spreadsheets have strong graphical capablities that produce quality hardcopies on laser printers. They also include some basic statistical functions.

With the compleat ELEFAN package, the Length Frequency Distribution Analysis Package (LFDA) plus manual should be obtained. This package estimates Von Bertalanffy growth parameters using two new methods: Shepherd's Length Composition Analysis (SLCA) and the Projection Matrix method. Both these methods performed better than ELEFAN utilising simulated data.

Growth curve fitting and yield-per-recruit analysis based on age data should be fitted and analysed utilising the PC-YIELD software. As some of the statistical analyses are quite demanding on processing speed it is recommended that this software be run on a computer fitted with a 386 or a 486 CPU and a maths co-processor.

In order to facilitate better and faster contact and exchange of ideas between local and international agencies it is highly recommended that E-MAIL be set up at IIP and other local fisheries agencies.

Generally, standard software use amongst IIP scientists should be encouraged.

APPENDIX V
Sources of existing linefish data currently available

SOURCE	PERIOD	TYPE	USEFUL?
SEMI INDUSTRIAL			
Canopus surveys	1992	species comp; biology	yes
	1990	length dist. cpue	
	1991	S. Moz.	
Sulpesca landings	1979-81	S. Mozambique	
	1987-88	all data	yes
Sulpesca	1980-90	" "	yes
Sulpesca (SEP)	1991-92	CPUE and Catch no.	yes
Makaira (IIP)	1993	species comp.; cpue	yes
SEP	1993	No. boats	yes
	1980/90	??	yes
RSA	??	cpue; species	?
ARTISANAL			
1 SEP	1992	number boats	yes
	1980/90	??	
2 creel survey	1992/3	Inhaca; Costa Sol; Catembe; Muntanhana effort; target spp.	yes
3		(Asceneso)	
RECREATIONAL			
1 Immigration	??	??	?
2 CLUBS	??	??	?
3 ORI catch cards	1991/2	Bazaruto	yes

OTOLITHS AVAILABLE AT ORI FOR USE IN MOÇAMBIQUE LINEFISH AGE MODELS.

Species	number of otoliths
Argyrops filamentosus	2
A.spinifer	37
Polysteganus praeorbitalis	12
P. ceruleopunctatus	1
Chrysoblephus anglicus	43
C. lophus	1
Pristipomoides filamentosus	21
Epinephalus marginatus	30
E. albomarginatus	20
E. andersoni	52

A list of species that have been tagged in Moçambique

MOZAMBIQUE TAGGING			
SMITH NO.	SPECIES	SCIENTIFIC NAME	NO. TAGGED
113.01	Barred needlefish	*Ablennes blans*	2
166.21	Peacock rockcod	*Cephalopholls mlnlata*	1
179.01	Niggerlip gaterin	*Dlagramma plctum*	2
181.00	Snapper spp.	*Lutjanidae*	1
181.03	Green jobfish	*Aprion vlrescens*	4
185.13	Blue emperor	*Lethrinus nebulosus*	2
196.00	Goatfish spp.	*Mullidae*	1
210.00	Kingfish spp.	*Carangidae*	4
210.04	Yellowtail shad	*Atule mate*	1
210.11	Yellowspot kingfish	*Carangoldes fulvoguttatus*	8
210.17	Giant kingfish	*Caranx ignobilis*	12
210.19	Bluefin kingfish	*Caranx melampygus*	4
210.20	Greenspot kingfish	*Caranx papuensis*	9
210.22	Bigeye kingfish	*Caranx sexfasciatus*	1
210.33	Garrick	*Lichia amia*	6
210.38	Talang queenfish	*Scomberoldes commersonlanus*	1
210.40	Saladfish	*Scomberoldes tol*	2
210.42	Lookdown fish	*Selene dorsalis*	1
210.50	Moonfish - wave garrick	*Trachinotus botla*	6

210.02	Indian mirrorfish	*Alectis indicus*	2
224.03	Great barracuda	*Sphyraena barracuda*	2
224.07	Pickhandle barracuda	*Sphyraena jello*	1
248.06	Walla walla	*trichiurus lepturus*	1
249.00	Tuna spp.	*Scombridae*	6
249.01	Wahoo	*Acanthocybrium solandri*	1
249.04	Eastern little tuna	*Euthynnus affinis*	8
249.06	Dogtooth tuna	*Gymnosarda unicolor*	1
249.07	Skipjack tuna	*Katsuwonus pelamis*	3
249.09	Striped bonito	*Sarda orientalis*	1
249.11	Mackerel	*Scomber japonicus*	2
249.12	King mackerel	*Scomberomorus commerson*	70
249.13	Queen mackerel	*Scomberomous plurilineatus*	4

MOZAMBIQUE TAGGING			
SMITH NO.	SPECIES	SCIENTIFIC NAME	NO. TAGGED
249.15	Yellowfin tuna	*Thunnus albacares*	6
252.00	Billfish spp.	*Istiophoridae*	1
252.01	Sailfish	*Istiophorus platypterus*	171
252.02	Black marlin	*Makaira indica*	11
252.06	Striped Marlin	*Tetrapturus audax*	1
38.01	Bonefish	*Albula vulpes*	4
9.8	Galapagos shark	*Carcharhinus galapagensis*	13
9.19	Tiger shark	*Galeorhinus cuvier*	1
9.29	Lemon shark	*Negaprion acutidens*	1
9.35	Blunthead shark	*Triaenodon abesus*	1