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Some Key Concepts in Fisheries Research and Management, with Emphasis on Mozambique[a]

by

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ABSTRACT

Some basic concepts of fishery economics and management, and fish population dynamics are recalled, as presented during a course held at the Instituto de Investigação Pesqueira from 23 February to 15 March 1988 in Maputo, Mozambique. Also, some basic elements of length-based stock assessment are reviewed, with emphasis on their implementation through the "Compleat ELEFAN" package, used extensively during this course, when the participants analyzed their data and wrote first draft of manuscripts incorporating the results of these analyses. Some problems relative to sampling and to seasonal growth oscillations are discussed with special reference to conditions in Mozambique.

The need to publish research contributions is stressed and some advice concerning this is provided.

RESUMO

Neste artigo recordam-se alguns conceitos básicos de economia e gestão pesqueiras, e ainda de dinâmica de populações, tal como foram apresentados num curso realizado no Instituto de Investigação Pesqueira, de 13 de Fevereiro a 15 de Março de 1988, em Maputo, Moçambique. Revêem-se alguns elementos básicos de avaliação baseados em distribuições de comprimentos, principalmente no que respeita a sua aplicação, através do sistema de programas para computador "Compleat ELEFAN", usado por todos os participantes no referido curso.

Discustem-se alguns problemas relativos à amostragem e às variações sazonais do crescimento, com especial referência às condições em Moçambique. Inclui-se ainda uma chamada de atenção e recomendações sobre a necessidade de publicar os resultados das investigações.

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INTRODUCTION

The Need for Management

Living resources, such as, e.g., fish stocks or forests, differ from non-living resources, such as, e.g., manganese nodules or mineral oil in that they can replenish themselves. Hence, yields (or catches) which must be understood as rates (e.g., catch/year) determine how much can be extracted from a living resource. This is not the case with non-living resources whose total extractable yield is rate-independent.

This specific feature of living resources, combined - in the case of fisheries stocks - with their nature as "open-access common property" is the reason why fishery management is necessary, i.e., why fisheries are not self-regulating (Fig. 1). Thus, we might here define management as all measures that are taken to ensure that a resource is fished at some level defined as optimal in a given society.

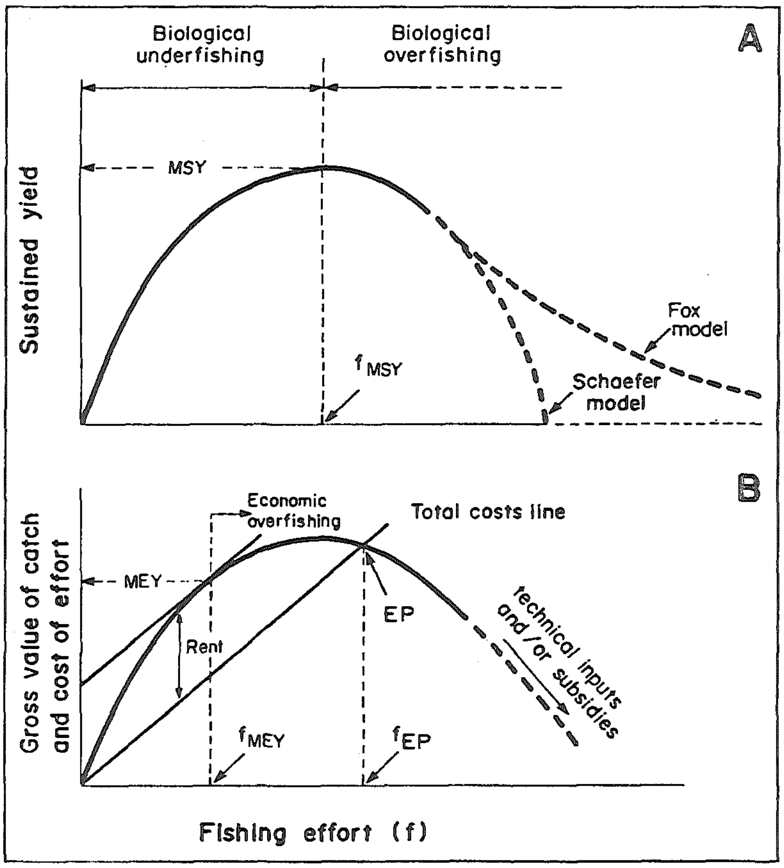

Fig. 1. Definitions of biological (A) and economic overfishing (B) using a simple surplus-production model of the Schaefer- or Fox-type. Note that Maximum Economic Yield (MEY) is achieved at a level of effort lower than needed to achieve Maximum Sustainable Yield (MSY), i.e., $f_{MEY} < f_{MSY}$. Note also that without restrictive management, effort will increase until total costs (including opportunity costs) equal the gross value of the catch, i.e., until the economic rent becomes zero (at the Equilibrium Point, EP). Note, finally that lowering the cost line through subsidies or technological improvements will, past MSY, lower the value of EP and thus reduce the catch.

Such measures may be grouped into three major classes:

- measures to regulate the sizes of the fish caught and/or landed (mesh size regulations, minimum legal sizes for marketed fish, etc.);
- measures affecting effective effort and hence fishing mortality through direct regulation of effort or by imposing the use of inefficient gears, e.g., light tackles in sport fisheries;
- restriction on gear deployment in space (i.e., closed areas) and/or time (e.g., closed season).

Some Targets for Management

Various meanings can be given to the concept of "optimality" and what is considered optimal exploitation of a resource may vary between fisheries and countries. Generally, however, three different levels of exploitation have been used to set targets for management:

1) the level of effort (f_{MSY}) or fishing mortality (F_{MSY})corresponding to Maximum Sustainable Yield (MSY);

2) the level of effort (f_{MEY}) or fishing mortality (F_{MEY}) corresponding to Maximum Economic Yield (MEY); and

3) the level of effort ($f_{0.1}$) or fishing mortality ($F_{0.1}$) corresponding to a marginal increase of yield equal to one-tenth that at very low level of f (or F).

Of these, MSY is the most commonly used target for management, particularly in developing countries, i.e., "we need all the protein we can get".

However, it is generally not appreciated that MSY is optimal only if fishing costs are assumed to be zero and that, in fact, fishing at MSY may seriously misallocate resources (fuel, spare parts, skilled personnel) which, especially in developing countries, could be put to better use in other sectors of the economy.

This becomes clear when one considers the major types of fishing costs, i.e:

i) fixed costs (boat maintenance and depreciation, salaries of permanent crews, etc.),

ii) variable costs (fuel, lubricants, spare parts, etc.) and, last but not least,

iii) opportunity costs.

The latter costs, which may refer to both capital investments (opportunity costs of investments) and crew salaries (opportunity costs of labor) represent what could be earned by investing into (resp. working in) another sector of the economy. Thus, for example, one can use diesel oil to fuel a tractor, which may increase agricultural production, or a fishing vessel, which may or may not increase catches. Investment into various sectors of an economy usually brings about returns of 10-20% per year, and real losses occur in that economy when a given sector absorbs investments without providing returns at least equal to the average rate of returns on investments. Hence opportunities for profitable investment that are lost must be counted as cost.

When all costs (including opportunity costs) are considered, MSY usually appears less attractive as target for management (Fig. 1) and it is indeed MEY which should be considered, even in Mozambique, as a long-term goal of the fishery sector as a whole.

The level of effort $f_{0.1}$ or fishing mortality $F_{0.1}$ are defined as that level of effort resp. fishing mortality at which the relationship between yield (or yield-per-recruit, see below) and effort (or F) increases at a rate one-tenth of that at the origin of the curve (Gulland & Boerema, 1973; Brinca & Santos, 1984 and Fig. 2). This specific management target is similar to f_{MEY} in that fishing effort is kept below the level which maximizes gross returns.Thus, $f_{0.1}$ and $F_{0.1}$ take implicitly account of the existence of costs. (Note however, that F_{MEY} and $F_{0.1}$ are similar, but not necessarily equal, contrary to what is stated by Brinca & Santos (1984) in their "Breves Noções Teóricas sobre $F_{0.1}$".

Definitions and Prevention of Overfishing

Another view of fishery management is that it should be mainly reactive and mainly prevent overfishing. Overfishing may be defined in various terms, of which three are commonly referred to the literature:

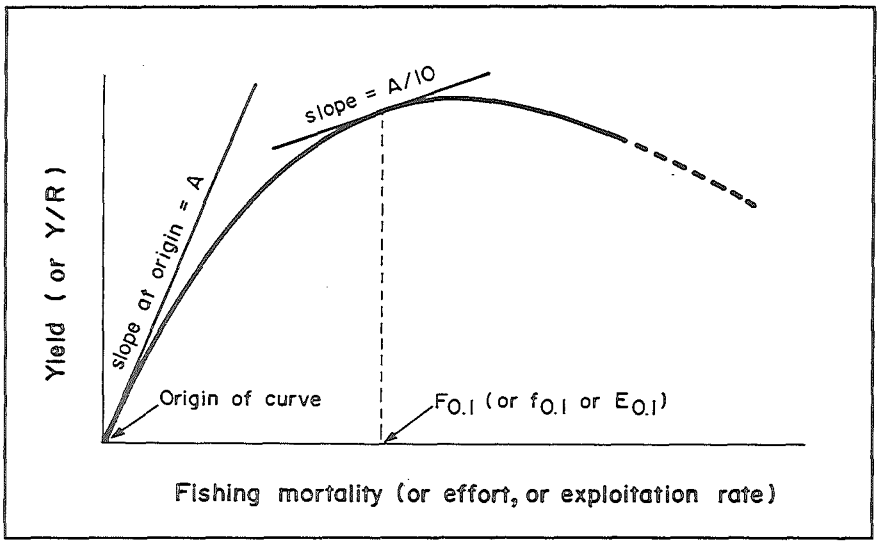

Fig. 2. Definition of $F_{0.1}$ as the fishing mortality at which the slope of the yield curve (or of the Y/R curve) has one-tenth of its value of the origin of the curve. The definition is similar when applied to fishing effort ($f_{0.1}$) or exploitation rate ($E_{0.1}$). Note that $F_{0.1}$ is always less than needed to extract maximum yield (F_{MSY}) and hence is similar to F_{MEY}, which generates Maximum Economic Yield (see text).

1) growth overfishing,

2) recruitment overfishing,

3) economic overfishing.

Growth overfishing is defined in terms of yield-per-recruit, i.e., the catch which can be obtained for each "typical" fish entering the fishery (see below). Growth overfishing occurs when a given combination of mesh size and F-value generates a yield-per-recruit less than targeted (i.e., smaller than it would at F_{MSY}, F_{MEY} or $F_{0.1}$).

Recruitment overfishing may be defined in terms of a stock-recruitment curve such as shown as Fig. 3. Recruitment overfishing, although probably occurring in numerous tropical stocks, e.g., in estuarine bays (Pauly, 1982), is usually difficult to document. Moreover, this form of overfishing usually occurs (in teleosteans at least) at population levels that are very low, i.e., much lower than those at which economic overfishing occurs. A combination of growth and recruitment overfishing is implied in surplus-production models (such as the "Schaefer" and "Fox" models, see Fig. 1); the joint effect of these two forms of overfishing is often called "biological overfishing". This can be contrasted to economic overfishing.

The latter process occurs when fishing goes beyond MEY and the economic rent (or "pure profits") extracted from the fishery (i.e., the difference between gross returns and total costs, see Fig. 1) becomes less than occurs at MEY. Economic overfishing is also called "dissipation of rent". It usually progresses to a point of equilibrium where all rent is dissipated, i.e., total costs equal gross returns (see Fig. 1).

Management of Developing Fisheries

In the case of fisheries that are still developing, the role of management is to ensure that the growth of the fishery occurs in small steps, with sufficient lag time between the introduction of new fishing units to assess the impact of the previously introduced units, and to stop the expansion of fishing effort as soon as the stock reaches a critical level (e.g., half of the unexploited biomass when MSY is the target).

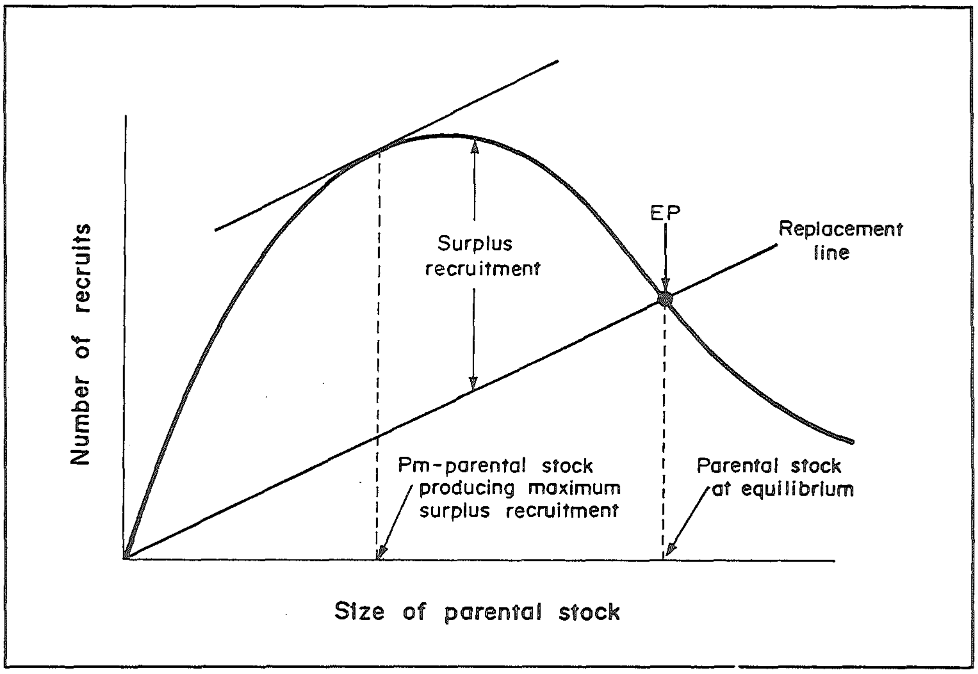

Fig. 3. Schematic representation of a typical stock-recruitment relationship. The model assumes that the unfished stock is in equilibrium (at EP), with fluctuations of parental stock and/or recruitment being dampened by density-dependent mortality (e.g., parental cannibalism, or breakdown of broodcare) or surplus production of recruits. Fisheries use the ability of fish stock to produce surplus recruitment when parental stock is reduced, i.e., it is the fisheries themselves which generate the surplus recruitment upon which it depends (see Baranov, 1976). Note that "recruitment overfishing" occurs when parental stocks are reduced too far, i.e., below P_m (see text).

Also, fishery economists, whenever possible, should work jointly on assessments with fishery biologists to ensure that subsidies (direct or hidden) are injected into the fishery only at the initial stages, when such subsidies may help generate higher catches and resource rent, and not when a resource is overfished (which can only lead to the subsidies being wasted, and to further decline of catches, see Fig.1).

Setting of Research Priorities

Research priorities will differ between fisheries and countries, and here is not the place to discuss the priorities of the IIP. However, one can mention general criteria by which priorities may be evaluated, such as:

i) if a fishery is more or less "unmanageable" (e.g., for specific political reasons), it is a misallocation of resources to devote much emphasis to its investigation;

ii) if a fishery is very small (and/or of little value) then it may be a misallocation of resources to make scarce research time available to study that fishery;

iii) thorough analysis of all available survey and/or of catch data and of historic catch records is generally more cost effective (in terms of information output per research time) than collection of new data; or more precisely,

iv) there is little point in conducting new surveys and/or implementing large data collection schemes if no procedure exists for the timely analysis of data from previous surveys and/or previous data collection drives.

REVIEW OF SOME STOCK ASSESSMENT MODELS

Synthetic Models

The models (=equations, usually) used by fishery biologists to predict fish catches (or other interesting quantities) as a function of fishing effort may be broadly separated into two classes: 1) synthetic (or holistic) models, and 2) analytic models. The former group consists of those models which describe processes but do not attempt to explain them with reference to deeper, underlying processes.

Examples of holistic models used in fishery biology are the empirical relationship between fish yield and morphoedaphic index (MEI) in freshwater lakes and reservoirs, the stock-recruitment model of Ricker (1975), or more importantly, the various surplus-production models used routinely for stock assessment throughout the world (Schaefer, 1954, 1957; Fox, 1970; Gulland, 1983; Pauly, 1984).

Of these, the Schaefer and Fox models are likely to be the most useful in the Mozambican context, along perhaps with Munro's space-structured model (Munro, 1980) which could possibly be used for some artisanal fisheries, e.g., along the shore of Lake Niassa/Malaŵi.

The theory behind these models is not discussed here (but see Munro, 1980 and Pauly, 1984). Rather, emphasis may be given to some practical aspects of model fitting and of interpretation of results:

i) when fitting a regression line to a plot of C/f *vs*. f data, a geometric mean (GM, or "functional") regression should be used, rather than a normal ("predictive") regression;

ii) plots such as in (i) must always have axes with a zero origin, such as to allow easy visualization of the actual range of C/f, f-values included in the plot, and of the effect of fishing on the C/f values.

The rationale for (i) is given in Pauly (1984); it refers to the uncertainty associated with the plot, which is expressed by the absolute value of the correlation between C/f and f (r). The parameters of a GM regression (a', b') are obtained from those of a predictive regression from

$$b' = b/r$$

and

$$a' = \overline{Y} - b'\overline{X}$$

and hence directly reflect the uncertainty alluded to above. In case of uncertainty, management advice should be conservative. Now, since we have

$$MSY = a^2/(4 \cdot |b|)$$

and

$$f_{MSY} = a/(2\,|b|)$$

MSY and f_{MSY} are lower when estimated using a GM than when using a predictive regression, with the difference increasing with the difference between 1 and r.

Another important item that must be considered when fitting a regression line to C/f, f points is that these points are assumed (in terms of the logic of surplus-production models) to reflect equilibrium conditions.

Some sophisticated methods exist (e.g., Pella & Tomlinson, 1969, or the Prodfit program of W.W. Fox, in Sims, 1984) to account for the fact that available C/f, f values usually do not reflect equilibrium conditions. However, for a number of theoretical and practical reasons which cannot be discussed here, the most appropriate correction for non-equilibrium conditions appear to be that proposed by Gulland (1983), where C/fi values are plotted against values of $(f_i+f_{i-1})/2$. This amounts to assuming that the previous year's effort influences contemporary C/f as much as contemporary effort, which is a reasonable proposition when the fish spend more than one year in the fishery.

For the specific context of Mozambique, this implies that, except in the case of the short-lived shrimps (and with any future fishery for stolephorid anchovies), the above correction should be applied routinely, which also will have the effect of reducing MSY and f_{msy} estimates (see Pauly, 1984, Chapter 10).

Analytical Models

The analytic models discussed during the course were

1) yield-per-recruit analysis (Y/R), and

2) length-structured virtual population analysis (VPA).

The presentation of these models followed Chapters 8 and 7, respectively of Pauly (1984), except for the discussion of the effect of the knife-edge assumption (see Beverton & Holt, 1966) on Y/R estimates in small fish and shrimp, recently shown by Pauly & Soriano (1986) to lead to considerable biases.

Thus, emphasis was given during the course on the sequence of routines of the Compleat ELEFAN package which can be used to bypass the knife-edge assumption, as follows:

1) create a length-frequency data file using ELEFAN I (e.g., "A");

2) use file A to obtain preliminary estimates of growth parameters via ELEFAN I;

3) use the catch curve routine of ELEFAN II and some preliminary estimate of M (e.g., M = 2K) to obtain approximate probabilities of capture, by length class, from the ascending left side of the catch curve;

4) use estimated probabilities of capture to correct A using ELEFAN 0 ("Probability Entry Routine"), leading to a new file, corrected for selection (e.g., "ACORR");

5) obtain final estimates of growth parameters from ACORR using ELEFAN I; and

6) estimate Z and M using final estimates of growth parameters and reestimate probabilities of capture. (Usually, a second iteration will not be necessary).

Then Y/R analyses can be performed, based on the growth parameters estimated in (5), the probabilities estimated in (6) and the appropriate routine of ELEFAN II.

Length-structured VPA are incorporated in the contribution of some participants, and the reader is referred to these (Torstensen, this vol., and B. Sousa, this vol.) for details (see also Jones, 1984 and Pauly, 1984).

One item which came as a surprise to several participants was this author's insistence that, given the seasonal oscillations of water temperature ocurring off Mozambique (see Table 1), the growth of fish and invertebrates sampled in the southern half of the country should be highly seasonal. A discussion of seasonal growth in tropical fish is given in Longhurst & Pauly (1987).

Table 1. Monthly mean sea surface temperature (°C) off different parts of the Mozambique coast.

Month\Location	Maputo Bay[a]	Above a depth of 100 m[b] Maputo	Beira	Angoche
January	(28.4)	25.5	29.1	27.2
February	(28.1)	26.3	29.2	26.5
March	(26.7)	26.8	29.0	26.2
April	25.1	24.2	26.5	27.5
May	22.8	23.5	26.3	27.0
June	20.3	23.1	24.2	25.8
July	19.8	22.5	24.0	25.0
August	21.8	22.5	24.0	24.8
September	21.7	22.2	25.0	25.0
October	23.8	22.0	25.5	26.0
November	24.6	22.5	26.1	27.0
December	26.	25.7	27.0	27.5
Max. temp. difference (°C)	8.6	4.8	5.2	2.7
Annual mean	24.1	23.9	26.3	26.3

[a]Values for 1969 from Martins & Costa (1972, station C7); values in brackets based on measurements from Inhaca Island (January-February 1988) or interpolated (March).
[b]Rough estimates based on data on file at the IIP, Maputo and compiled by T. Gammelsrφd (pers. comm.).

A modification of the von Bertalanffy growth equation which can capture such seasonal growth oscillations is presented in Pauly (1984, Chapter 4) and is also incorporated into the Compleat ELEFAN package.

The various growth analyses conducted using this software during the course confirmed that, indeed, growth of fishes and invertebrates off Mozambique is highly seasonal, with growth reductions occurring during the coldest season (July to September) and ranging from 50 to 100% below average annual growth (see contributions in this vol.).

Neglecting such seasonal growth oscillations must, thus, invariably result in considerable bias of growth and hence mortality parameter estimates. Indeed, some earlier estimates of growth parameters from Mozambique, as well as estimates from neighboring countries, used to date as reference, now appear questionable, not being based on explicit consideration of seasonal growth oscillations.

Moreover, explicit consideration of seasonal growth oscillations is not only important when estimating growth parameters, but also when estimating total mortality by way of a length-converted catch curve.

The standard approach for constructing such curves involves the assumption of a one-to-one relationship between the time needed for the fish of a given length class (i) to grow through that length class (Δt_i) and the (mean) length of the fish in that class (L_i) (Pauly, 1984). However, as pointed out by Sparre (1990) the one-to-one relationship between L_i and Δt_i is absent when growth is seasonal; rather the value of Δt_i depends both on the value of L_i *and* the time of the year. One result of this is that Z is overestimated when a standard length-converted catch curve is used when growth is seasonal, the effect being stronger when $C >> 0$, and K is high (Sparre, 1990).

Pauly (1990) developed an approach for constructing length-converted catch curves when growth is seasonal which Gayanilo (1991) turned into a computer program that can be used to analyze L/F files created using the Compleat ELEFAN package. This program, not available when the drafts of the other paper in this volume were written, was used to reestimate Z where appropriate. As it turned out, however, these corrections and the small textual changes they entailed did not affect the basic thrusts and conclusions of these papers.

It may be expected that similar results would have been obtained, had the effect of seasonal growth on length-structured VPA also been followed up.

Another problem which required some discussion during the course is the estimation of natural mortality (M), particularly in invertebrates such as shrimp and lobsters.

Methods to estimate M discussed in Pauly (1984) are:

1) estimating Z in an unexploited population;

2) plotting Z *vs*. f, based on data from a fishery in which effort has varied greatly;

3) plotting catch *vs*. Z and estimate M from the intercept on the Z-axis of the resulting parabolic plot (Csirke & Caddy, 1983);

4) using an empirical relationship between M and other, easy to estimate parameters.

The last of the three approaches is illustrated by the empirical model of Pauly (1980) of the form

$$\log_{10} = -0.0066 - 0.270 \log_{10}L_\infty + 0.6543 \log_{10}K + 0.463 \log_{10}T$$

where M and K are expressed on an annual basis, L_∞ in cm total length and T is the mean water temperature in°C (see, e.g., Table 1).

This equation is built into the "catch curve" routine of ELEFAN II and hence allows, following estimation of Z, the rough estimation of F from Z-M. However, several participants used data referring to the carapace length of crustaceans, in mm, which led to three common questions:

i) Is it necessary to reenter L/F data with length expressed in cm?

ii) What is the effect of using carapace length (CL) instead of total length (TL)?

and more generally,

iii) Can an equation based on growth and mortalities of fish be used to infer M in, e.g., crustaceans?

The answers are simple: (1) the Compleat ELEFAN keeps track of length units used, and hence can and does convert mm or inches to cm when estimating M; (2) carapace length being about 3.5 times shorter than total length should lead to an overestimation of M by a factor of $10^\wedge(0.279^*\log_{10} 3.5)$ = 1.4, i.e., a 40% overestimation of M; (3) recent work on shrimp suggests that they have natural mortality comparable to those of fish with comparable growth parameters (Pauly & Neal, 1985) and this should also apply to lobsters.

However, to avoid misunderstanding, this author suggested, when problems arose, to use $M \approx 2K$ (Beverton & Holt 1959; Pauly & Soriano, 1986; Ralston, 1986; Longhurst & Pauly, 1987), a suggestion implemented in several contributions in this volume.

Either way, it must be realized that the estimates of M needed to assess Mozambican stocks should be derived from data sampled in Mozambique. At present, this author sees the possibility of deriving such estimate of M only in the case of shallow-water shrimps, for which longer time series of catch, effort and of length-frequency data exist, or could be reconstructed.

There are situations, particularly when the available length-frequency samples consist of too few samples and/or specimens and/or cover too narrow a range of sizes, when ELEFAN I fails to provide credible values of asymptotic length ("credible" means here similar to maximum sizes reported from the taxonomic literature, which should always be consulted).

In such cases, independent methods may be used to identify a value of "L_∞" for use as fixed input value in ELEFAN I. Such values may be maximum sizes taken from the literature, e.g., from Fischer & Bianchi (1984) for fishes, or from Holthuis (1980) for shrimps.

If the gear used to sample the available L/F data was not a gear which selected against larger fishes (as occur, e.g., with beach seines) a Wetherall plot (Wetherall, 1986; Wetherall et al., 1987) can be used to estimate L_∞ independently of growth data. A modified version of this plot, based on Pauly (1986a) is incorporated in the ELEFAN II program of the Compleat ELEFAN, and was found useful by the course participants.

When a fixed value of L_∞ is used with ELEFAN I, it is K (plus C, WP and starting point) which will be estimated from the L/F data. Such constrained estimation of parameters are usually more reliable than unconstrained ones, and should be used whenever appropriate, i.e. when the quality of the available L/F data is questionable.

Furthermore, the reliability of estimates of K can be assessed, when at least one set of growth parameters (L_∞ and K) are available from (another) stock(s) of the species in question, or on closely related species, using

$$\phi' = \log_{10} K + 2\log_{10} L_\infty$$

where L_∞ is expressed, e.g., in cm, total length, and K is put on an annual basis.

Empirical studies (see, e.g., Moreau, 1986 for tilapias; Longhurst & Pauly, 1987 on skipjack tuna) show that ϕ' has, within any given species, a rather narrow distribution, with a coefficient of variation

(CV = s.d. * 100/mean) < 10%. Thus, given a set value of L_∞ (as obtained, e.g., from a Wetherall plot) and a (mean) value of ϕ' derived from data in the literature, one can estimate a reasonable value of K for one's stock in the absence of growth data, or validate one's preliminary estimate of K. This approach is illustrated in several of the contributions in this volume.

Several methods used during the course, and which are part of the Compleat ELEFAN package, require the available L/F data to represent a steady-state population, i.e., a population in which mortalities are constant, or vary in random fashion.

This was usually approximated here by grouping time series of 2-3 years' worth of catch-at-length data, or of catch data raised to C/f into an "artificial year" in which the January data from different years are pooled, as well as the data for February, March, etc. Then, the 12 months of the artificial year were pooled, with each of the 12 "monthly" samples given the same weight. This method should work when years are pooled during which no rapid change of fishing effort or of fishing pattern occurred (see various contributions in this volume).

ON PUBLISHING FISHERIES RESEARCH

The job of a fisheries research institute is to conduct research such that the resources can be optimally exploited and managed for the benefit of society at large.

However, the research work must be documented to have any impact, and research work that is not documented may as well be considered not to have been conducted. Thus, performing and documenting one's research are part of the same process, not separate activities. This is particularly obvious when one thinks of large-scale sampling schemes which, when they have no end-users to examine the accumulated information, quickly degenerate into machines that produce nonsense data.

The general public and especially government entities and the fishing sector have a right to expect to be informed about an institute's activities—if only because they pay for the research—directly or indirectly. Fisheries research is conducted using scientific methods. The key aspect of science, distinguishing it from other human adventures (e.g., running a business or a church) is that it is a "public" activity in which the "public", however, consists of other scientists. Without such "public", a scientist may never know whether her or his work is scientifically sound, nor be able to improve her or his analytic skills. Hence, fishery research scientists must write both for the public-at-large (inclusive of government entities and the fishing sector) *and* for other fishery scientists. This is generally achieved throughout the world by fisheries research institutes producing two types of publications (see also Table 2), of which the first group, addressed to lay persons, usually consists of:

i) An Annual Report, documenting the institute's projects, activities, personnel movements, etc.;

ii) Extension literature (e.g., the IIP's "Boletim de Divulgação") and/or a newsletter (e.g., "Naga, the ICLARM Quarterly");

iii) Informal, confidential memos and internal reports relating to management decisions and/or to negotiations with representatives of the fishing sector.

The publications addressed to the scientific community usually consist of:

i) The above-mentioned Annual Report, which fulfills a double role, because it also lists any institute's scientific results;

ii) Technical Reports;

iii) Data Reports; and

iv) Scientific papers in international journals, and leading to an annual or biannual compilation of an institute's "Collected Reprints".

The Publications of IIP cover much of the range of documents listed here as (i) to (iii), with item (iv) being, however, conspicuously missing. Some suggestions are given below, therefore, on why and also how some IIP staff should, respectively, could contribute to the international literature.

The first set of points to be adressed is why IIP staff should spend time and resources to publish in the international literature which, after all, is not going to increase fishery catches on Mozambique.

Table 2. Some suggestions toward increasing the scientific output of a fishery research institution (adapted from Pauly, 1987).

i)	Produce an Annual Report, with brief accounts of the work in each research group, their findings and published output;
ii)	Give active support to young scientists to publish the results of studies they have carried out under their own names;
iii)	Give adequate credit to supervisors and scientific administrators for the scientific output of their subordinates, not only their own;
iv)	Delay as long as possible the promotion of recent MSc or PhD recipients to administrative positions;
v)	Always build reporting and publication costs into the budget of a proposed study;
vi)	Encourage scientific staff to learn the international language of science (English)[a] and to read scientific literature as widely as possible;
vii)	Encourage scientific staff to submit at least one contribution (however short) a year to an international journal, and use these to produce an annual set of "Collected Reprints" for exchange with other institutions;
viii)	Make sure that the library has at least one of the current awareness journals (e.g., "Aquatic Sciences and Fisheries Abstracts" or "Current Contents") - cancelling other subscriptions to save costs if necessary - and use the titles and addresses in this journal to obtain (free) reprints, which are then circulated to staff;
ix)	Avoid the production of anonymous reports, which give no credit to their author(s);
x)	Release confidential data and reports as soon as they have outlived their usefulness to real-time management decisions;
xi)	Encourage cooperation, within and between institutions, of individual staff working on similar or related topics;
xii)	Cooperate with other institutions, e.g., Universities within the country and abroad, partner institutions in other countries, etc.

[a]The author's first language is French.

Here are some reasons:

1) Writing one's paper in a form that is acceptable by international standards and responding to the comments of anonymous, rigorous reviewers improves one's analytical and writing skills and must be seen as a form of training, i.e., a "free consultancy" to IIP by the referees and the editors of the journals to which contributions are sent;

2) Publishing in the international literature puts one in touch with the "invisible college",

i.e., with the colleagues one has (often unknowingly) throughout the world. These colleagues will send IIP staff sets of their own reprints, often useful contribution not available in the IIP library - again a "free consultancy";

3) Publishing in the international literature is free (except for some North American journals with charges of up to 50 US$ per published page), and hence such journals could actually be used to *reduce* the cost of documenting the research of IIP;

4) The time needed to prepare a brief manuscript for submission to an international journal can be reduced (to at most 1-2 days per paper) if such manuscripts are extracted from larger documents prepared simultaneously, e.g., for the Revista de Investigação Pesqueira: such parallel publications will not represent cases of (ethically unacceptable) double publications because:

   i) The "Rev. Invest. Pesq." not being an externally reviewed journal, the contributions published therein do not preclude publications in such journals;

   ii) The manuscript to be submitted to international journals would be much shorter, usually document data in graphic form (as opposed to tabular form) and present only salient points of general scientific interests (as opposed to complete assessments).

With regard to *how* to publish a scientific paper in an international journal, the following can be said:

1) Do not think that *you* cannot do it - every publishing scientist had papers rejected - even Nobel prize winners. [One of the many papers I submitted which was not accepted was rejected with the (anonymous) comment "Rubbish, may apply in the tropics, but not here!"].

2) Read the essay on why "Fisheries scientists must write" (Pauly, 1986b), the excellent book on "How to write and publish a scientific paper", by Day (1983) and the book by Barrass (1978) of which the IIP Library has both the Portuguese and the original English versions.

3) Read several issues of the journal to which you would like to submit a manuscript (MS), and learn to imitate its style and form. Also, read and closely follow its "Guide to Authors", usually reprinted on the back cover of every third or fourth issue.

4) Submit your MS and be ready to consider the often extremely nasty, but sometimes useful comments of 2-3 anonymous "referees". Follow their suggestions as far as you can, and recommend specific changes. Resubmit MS if it was provisionally accepted, or submit to another journal if it was rejected and you still think your paper is sound. (Never send an MS to more than one journal at once, always work sequentially).

Everything else will follow. Good luck!

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