Venema, S., J. Möller-Christensen and D. Pauly. 1988. Training in tropical fish stock assessment: a narrative of experience, p. 1-15. *In:* S. Venema, J. Möller-Christensen and D. Pauly (eds.) *Contributions to Tropical Fisheries Biology: Papers by the Participants of FAO/DANIDA Follow-Up Training Courses.* FAO Fisheries Report No. 389.

Contributions to Tropical Fisheries Biology: Papers by the Participants of FAO/DANIDA Follow-up Training Courses. Edited by S. Venema, J. Möller-Christensen and D. Pauly. FAO Fisheries Report 389. Rome, 1988.

Training in Tropical Fish Stock Assessment: A Narrative of Experience*

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Abstract

A description is given of training courses in tropical fish stock assessment organized by the FAO/DANIDA project "Training in Fish Stock Assessment" (1983-1987), and specifically of the two follow-up courses which led to the 34 other papers included in this volume. Discussed are goals and methods of such courses, as well as the technical content of the curricula and their implementation via appropriate hard- and software.

Introduction

The present contribution represents a narrative and documentation of two follow-up training courses on fish stock assessment in the tropics, organized by a FAO/DANIDA project (GCP/INT/392/DEN), which led to the 34 other papers included in the present volume. This contribution is also intended to reflect on some of the experiences gained during these courses for the benefit of those with interest in further developing and teaching fisheries biology applied to tropical resources.

*ICLARM Contribution No. 422.

The project "Training in fish stock assessment" is funded by the Government of Denmark through the Danish International Development Agency (DANIDA) and executed by FAO under the FAO/Denmark Cooperative Programme (GCP/INT/392/DEN).

The project started on 1 January 1982 with a total budget of US$1,426,000 for six years. It will continue for another five years, with some modifications in the objectives and geographical areas of operation, and an additional budget of US$2,675,000.

From 1982 to 1987, the project's main objectives were to create nuclei of fish stock assessment specialists in tropical developing countries where English is the main language, and to provide them with the means for international contacts and updating of their skills and knowledge.

These objectives were planned to be achieved mainly through a series of training courses and follow-up activities in the form of consultant visits, fellowships and provision of documentation. However, soon after the start of the project it was decided to make use of the "Network of Tropical Fisheries Scientists" set up in 1982 by the International Center for Living Aquatic Resources Management (ICLARM) and its newsletter "Fishbyte" for aspects concerning communication and information (Munro and Pauly 1982; Pauly and Munro 1982). In 1984 it was decided to use the funds initially intended for fellowships to organize, instead, three follow-up courses for selected participants of the first seven courses organized by the project.

A total of 12 courses were organized: (1) seven basic courses in tropical fish stock assessment, of which two were regional and five national; (2) three follow-up courses, of which two were regional and one national, for selected participants from the seven basic courses; and (3) two mini-courses of one to two weeks duration by one lecturer. A detailed list is presented in Table 1. Other major outputs of the project are a new manual based on the collective experience of the lecturers (Sparre 1985), nine thoroughly documented case studies on tropical fish stock assessment and management, and two volumes with papers produced by the participants of the three follow-up courses. The present document includes those papers produced by the 34 participants of the courses in Hirtshals and Manila. The 11 papers produced by 12 participants during the course in India in November 1987 will be published as a separate volume.

Table 1. Training courses held under the FAO/DANIDA Project "Training in fish stock assessment", 1983-87

Regional Courses

1. Western and northern Indian Ocean, Mombasa, Kenya, 16 May -17 June 1983

2. West Africa and Caribbean, Hirtshals, Denmark, 03 - 30 June 1984

National Courses

3. India, Cochin, 07 November - 09 December 1983
4. Indonesia, Semarang, 05 November - 01 December 1984
5. Malaysia, Penang, 05 November - 01 December 1984
6. Phuket, Thailand, 04 - 29 November 1985
7. Manila, Philippines, 13 January - 05 February 1986

Follow-up Courses (Regional/National)

8. Hirtshals, Denmark, 05 - 30 May 1986
   Participants from courses 1 and 2
9. Manila, Philippines, 12 January - 06 February 1987
   Participants from courses 4 to 7
10. Cochin, India, 02 - 28 November 1987
    Participants from courses 1 and 3

Mini-courses (National) (1 lecturer)

11. Kingston, Jamaica, 25 September - 02 October 1985
12. Port of Spain, Trinidad and Tobago, 05 - 16 October 1987

Courses on Fish Stock Assessment in the Tropics

The seven basic courses in Table 1 were the successors of a series of *ad hoc* courses executed by FAO since 1972 with funds provided by DANIDA, France, CIDA (Canadian International Development Agency) and other organizations, as documented in Venema and Pauly (1982). As such they built on training material already produced for these courses, and a considerable amount of experience gained which led to the identification of the following requirements for the new project:

a) Adaptation of course materials to the specific requirements of fisheries biologists working in the tropics;
b) Training of lecturers through preparatory missions to the tropics and the preparation of case studies. This is necessary because even very experienced fishery biologists from temperate areas are not *ipso facto* qualified to teach tropical fisheries biology;
c) Flexibility with regard to national needs for countries with a larger pool of fishery scientists and regional requirements in the case of grouping of small countries;
d) Adjustment to the different levels of training and experience of the participants;
e) Interactions between trainees and trainers, where possible, before and certainly after the training courses;
f) Continued institutional follow-up after course completion.

The general objective of the seven basic courses was to train fisheries scientists engaged in activities related to stock assessment in the most advanced techniques available for stock assessment in the tropics and to provide them with the means to apply these techniques after the course.

For these purposes it was decided to provide each participant with a programmable scientific pocket calculator (Sharp EL5100S) and to develop a manual with examples from tropical fisheries, containing computational exercises and answers (Sparre 1985). The calculator selected can cope with all calculations needed for the methods taught, while the manual consists of two parts, only one of which contains answers, thus providing a means for self-study and extension.

While the manual was used for a brief introduction in the methods during the first two or three weeks of each four or five week course, actual training in stock assessment was provided in the form of case studies on aspects of tropical fisheries written and selected according to the needs and interest of the participants. A total of nine case studies is now available or in preparation on subjects such as: trawl surveys, coral reef resources, shrimp stock assessment, gillnet selection and data collection and management aspects of a small-scale fishery.

Follow-up Courses

Three follow-up courses were organized by the project, in Hirtshals, Denmark (May 1986, see Appendix I), Manila, Philippines (January 1987, see Appendix II), and Cochin, India (November 1987). Of these, only the first two are considered in this paper.

The objective of the follow-up courses was to assist selected participants from the earlier courses in carrying out a complete scientific (fish stock assessment) study. This comprised processing of data collected in the participants' countries, writing a scientific paper, presenting and discussing it with lecturers and fellow participants, and finally preparing it for publication.

The invited participants were selected by the lecturers of the previous training courses in close collaboration with local course directors or immediate supervisors. The criteria for selection were the following, the participants should: a) be currently engaged in assessment work; b) have a set of data available, preferably collected by themselves; and c) master the techniques taught at the previous training courses.

After selection, but prior to the issuing of invitations, the participants (and their institutions) were visited by one of the lecturers, and the selection of data for analysis was finalized during such a visit. This enabled the majority of participants to arrive at the course with data considered to be suitable for analysis and the subsequent production of a scientific paper.

Use of Microcomputers

The rapid development and sharp drop in the costs of microcomputers, combined with the increased availability of user-friendly menu-based programs for fish stock assessment of tropical resources, logically led to the decision to make this hard- and software available to the participants at the courses.

An important consideration for this decision was that the number of microcomputers available to fishery scientists in developing countries was increasing rapidly and that the leading scientists should therefore be trained in their use as soon as possible. The courses also formed excellent opportunities to test the user-friendliness and other aspects of the various program packages.

Details on computer use in Hirtshals and Manila are given below:

Hardware

HIRTSHALS COURSE

Five microcomputers and one minicomputer (of the Danish Institute for Fisheries and Marine Research) were used as follows:

(i) Four Apple IIc (128K each): three used to run a test version of the program package for Apple II developed by Sparre (1987), while the fourth equipped with a CP/M card, was used to run the ELEFAN package of Brey and Pauly (1986).

(ii) One Hewlett-Packard HP87 with a two-pen plotter, used to run the graphics-oriented ELEFAN package of Saeger and Gayanilo (1986), and/or to generate graphs of curves estimated using other programs.

(iii) One minicomputer VAX 11/75 was only used to run a very fast version of the ELEFAN I program written by P. Sparre (pers. comm. to Sims 1984), and improved during the course by D. Thiam and P. Sparre (see Thiam 1986).

At this course, there were therefore about three participants per computer.

MANILA COURSE

(i) Five IBM PC's (or compatibles) with printers, on loan from ICLARM, used to run a test version of the graphics-oriented package "The Compleat ELEFAN" (see Pauly and Morgan 1987).

(ii) One mainframe computer of the University of the Philippines, used for a discriminant analysis of the morphometrics of two fish species (Soriano et al., this vol.).

Five participants were assigned per PC, the fifth PC was used mainly for additional programming activities.

Software

Since the first course held in Mombasa in 1983, where an early version of ELEFAN was used with an Apple III computer, great progress has been made in the development of software for fish stock assessment, based mainly on length-frequency data sets. Three packages were available and used in Hirtshals, *viz.*, a) the ELEFAN version of Brey and Pauly (1986) for Apple II with CP/M; b) the graphics-oriented ELEFAN package for Hewlett-Packard 86/87 (Saeger and Gayanilo 1986), and c) the Length-Based Fish Stock Assessment (LFSA) program package developed by Sparre (1987) for Apple IIc.

The diversity of these computer systems was the cause of significant loss of time during the course; the need to re-enter files into different computers proved particularly frustrating. It was therefore decided that the subsequent course would use only one type of computer, and that files created for one type of analysis should be transferable between programs.

The LFSA package was still being developed and numerous interventions and program changes were needed. It is obvious that a course of this type was one of the best testing opportunities for this new software, but that, on the other hand, too much time had to be dedicated to this activity.

For the Manila course the situation was simpler, since only one package was used, a test version of the Compleat ELEFAN package for IBM PC and compatibles. Also, this program package underwent thorough testing during the course, but this time two programmers, Ms. Mina Soriano and Mr. Felimon Gayanilo, Jr. (ICLARM), were present to make the necessary changes and/or to help the participants in making proper use of the package.

During the Hirtshals course the bulk of the duplication in re-entering files was caused by the need for different files for the ELEFAN package on the one hand, and the Bhattacharya (1967) and Gulland and Holt (1959) plot method, which forms the key steps in the FAO package (Sparre 1987), on the other hand. For this reason it was decided that the latter two routines should be incorporated into the Compleat ELEFAN package. Another considerable improvement was that the Compleat ELEFAN package runs in compiled BASIC, hence the problem of extended computing time, such as occurred in Hirtshals, has been resolved.

Overall, the problems related to the software used were:

- Lack of detailed documentation (the manuals provided made numerous tacit, but sometimes, questionable assumptions, see below);
- Participants not reading manuals, and generally ignoring the instructions provided through the program (e.g., via the "instruction box" of the Compleat ELEFAN package).

While the latter is explainable largely by the lack of familiarity of many participants with the use of computers, the former is a serious problem with potentially harmful implications.

Thus, for example, in the case of the method of Wetherall (1986), which is, in slightly modified form (Pauly 1986a) incorporated in the Compleat ELEFAN package, the points used in the linear regression are - as suggested by Wetherall (1986) - weighted by the cumulated frequencies. This gives, however, an enormous weight to the first point included in the regression, i.e., to the very point whose selection (by the participant) is generally very problematic. Thus, the method, although in principle correct, can produce completely misleading results - even when well-sampled data are used - if only one point is not well chosen. The software, it was felt, should therefore (i) provide alternative weighting modes and (2) flash special warnings about the dangers and consequences of erroneous selection of point(s).

Preparation of the Papers

Pre-course

In order to produce the highest efficiency in accomplishing the objectives of the follow-up courses, each participant was given a tutor. For the Hirtshals course, one tutor each was assigned

to the four participants from the Caribbean area; the five participants from West Africa and the five participants from East Africa and the South-West Indian Ocean region. (By coincidence, none of the three participants assigned to the fourth tutor came to Hirtshals).

For the second course one tutor was assigned to each of the three largest national groups and one to a group representing all countries.

Prior to the courses, each participant was visited by his/her tutor who stayed for some days and assisted in the selection and presentation of data, and discussed aspects of the work relevant to the preparation of the paper.

Between these preparatory missions and the actual course, tutors and participants maintained close contact through correspondence, while searches for relevant literature were carried out upon request. As a consequence of these activities, some participants arrived at the actual courses with semi-processed data sets and/or draft papers with reference material. Despite this preparatory work several others, however, arrived with large quantities of raw data, sometimes collected at the last moment, which required a lot of processing time.

Course

As the courses reported upon here represented a new form of training for the project, no detailed program was made in advance of the Hirtshals course, i.e., only a rough outline was established within which it developed in the following four phases:

i) In plenum sessions during the first two days the participants presented their data sets and intended methodologies to be followed. Some instructions were given on the use of the microcomputers;

ii) The remaining part of the week one, plus week two were used for data sorting, input and analysis, in close cooperation with the respective tutor;

iii) During the third and fourth week first drafts of the papers were actually written, entered in the word processor and copied to all. The authors then presented their papers at "mini symposia". Lecturers and participants usually offered a number of suggestions for additional data processing and improvement.

iv) After the mini symposia most papers were partly or completely rewritten, reproduced and distributed for final comments.

A number of lectures were given on topics related to problems encountered during the preparation of data and papers, e.g., on the assumptions behind each method.

The Manila course, with a larger number of participants (20), of which about 50% had difficulties in speaking and writing English fluently, the production of a first draft was delayed by about one week. Very few participants had therefore an opportunity to produce a revised second draft of their papers. However, some modifications were made towards the end of the course in close collaboration with the tutors and editors.

Some 17,000 photocopies were made during each course, which indicates clearly the amount of work involved in the production and reproduction of these papers.

Post-course

Subsequent to both courses the papers were reviewed by the tutors and, where necessary, edited versions were sent to their author(s) for comments and/or additional work. The editors, in cooperation with ICLARM's technical staff, notably Mrs. Letty Dizon, then prepared the camera-ready version.

Contents of the Papers

The 34 papers prepared by the participants of the two courses cover a variety of studies, generally closely linked to length-frequency analysis. The papers presented in this volume range from full-fledged assessments, including catch predictions, to preliminary analyses, indicating serious gaps in sampling programs or other constraints, e.g., relatively large mesh sizes used for surveys. All papers contain the basic data which enable the reader to repeat the data analysis, for example, with the help of improved versions of the program packages. The papers can therefore be used straightforwardly as case-study material for training purposes, in addition to their obvious contribution to our knowledge on the various resources. The papers have been arranged in four groups: "dynamics of tropical invertebrates", "dynamics of tropical demersal fish" and "dynamics of tropical pelagic fishes", dealing with estimates of growth parameters and assessments of specific resources, respectively, and "biological and technical interactions in tropical multispecies stocks and fisheries". As might be seen from Fig. 1, the 34 papers included here cover a large part of the intertropical belt.

Basic Structure of Analysis

The bulk of the papers in the first three groups follows this outline:

(*i*) Presentation of basic (length-frequency data), including as needed, their regrouping in space and time, and ponderation (usually by the catch instead of catch/effort, as would probably have been more appropriate);

(*ii*) Estimation of growth parameters using either the ELEFAN I program of Pauly and David (1981), or the Bhattacharya (1967) method of separation of composite distribution, with subsequent linking of mean length and estimation of growth parameters using the method of Gulland and Holt (1959). Also, use of the ϕ' concept (Pauly and Munro 1984, and see below);

(*iii*) Estimation of mortality (Z) under the assumptions of steady state, using a length-converted catch curve (Pauly 1984; Sparre 1985) or mean length(s) in catch samples using the equation of Beverton and Holt (1956) or the method of Wetherall (1986);

(*iv*) Subtraction from Z of an estimate of natural mortality (M) usually based on the empirical equation of Pauly (1980a) to obtain an estimate of fishing mortality (F), through $F = Z - M$ and computation of the exploitation rate $E = F/Z$;

(*v*) Assessment of state of the stock based on the values obtained in *(iv)*, complemented, as permitted by the available data, by additional analyses, e.g., length-cohort analysis (Jones 1984), yield-per-recruit analysis (Beverton and Holt 1966; Pauly and Soriano 1986); surplus production models (Schaefer 1957; Fox 1970; Munro 1980).

A number of participants had insufficient data for all items, from *(i)* to *(v)* to be performed. Some had more, or different data, notably on mesh selection, enabling different analysis to be performed. These may be found in this volume under the section on "Biological and Technical Interactions in Tropical Multispecies Stocks and Fisheries".

The ϕ' concept alluded to above, refers to the fact that given constant units (i.e., with the parameter L_∞ and K of the von Bertalanffy growth function being expressed as total length in cm and $K = year^{-1}$, respectively) and base for the logarithm (we used Log_{10}), the quantity ϕ' defined by:

$$\phi' = \log K + 2 \log L_\infty$$

is normally distributed within a given fish species with different populations, each of which may have different but mutually compatible values of L_∞ and K (Pauly 1979, 1980b; Pauly and Munro 1984). Thus, growth parameter estimates for a given stock can be usefully compared via

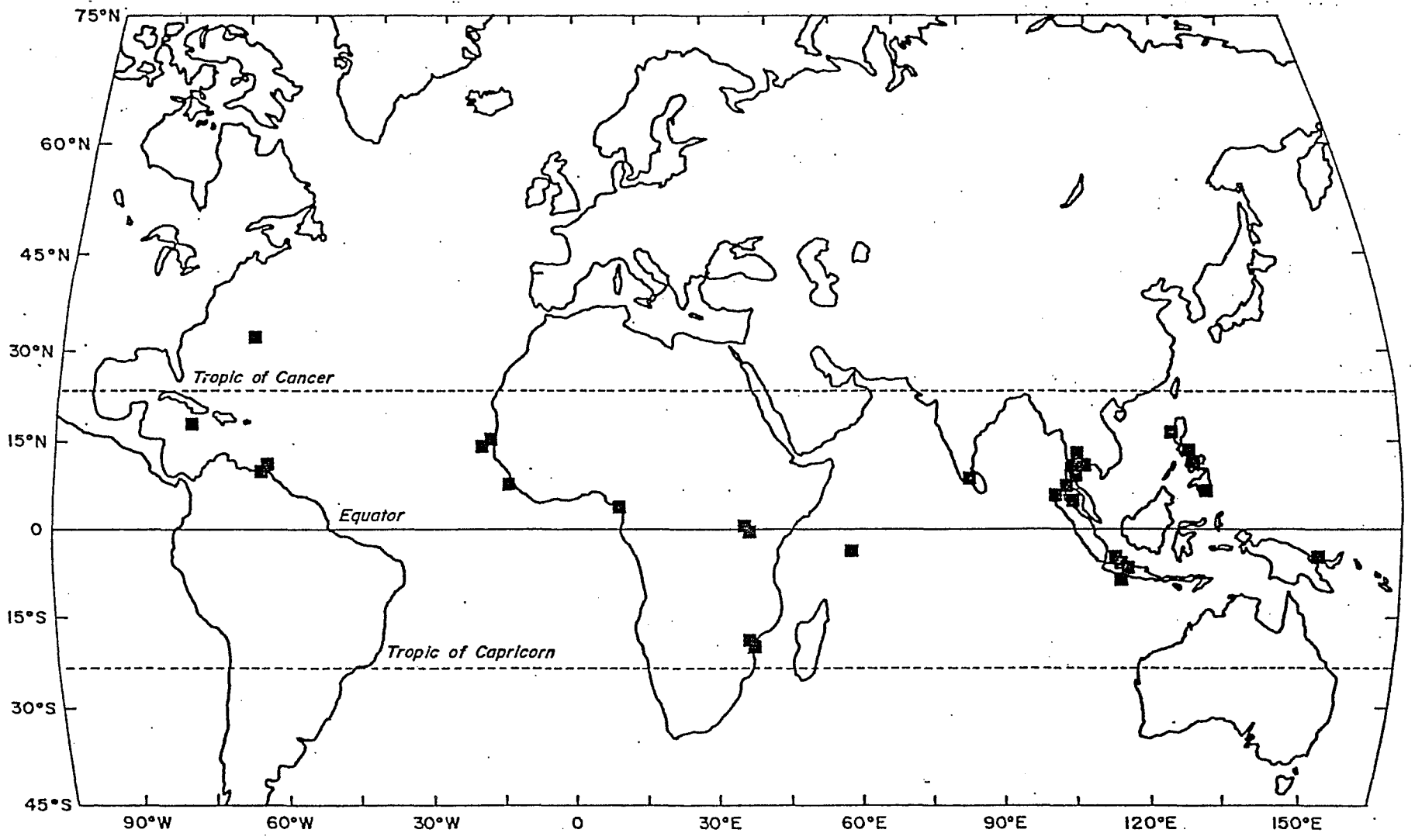

Fig. 1. Geographical distribution of sampling sites for the data analyzed in the 34 other contributions included in this book. Note extensive coverage of the intertropical belt.

ϕ' with those of another stock, and their compatibility assessed. Conversely, when growth data are not available for a specific stock of a given species, a mean value of ϕ' can be estimated from other stocks of that same species, and ϕ' used in conjunction with an estimate of L_∞ obtained through the method of Wetherall (1986) to indirectly obtain an estimate of K (see Pauly 1986b for a first discussion of this approach, proposed at a training course held in Algeria in November 1985). These approaches, as illustrated in a large section of the contributions included in this volume, suggest that the situation should become rare, where an assessment cannot be carried out for lack of growth parameters - at least as far as the most common tropical fish and invertebrate species are concerned.

This matches the situation concerning the estimation of the natural mortality coefficient (M), for use in various models (yield per recruit, cohort analysis). This difficult task was essentially resolved through use of the empirical equation of Pauly (1980a) also used extensively during this course.

Since the papers were considered to be useful training material for future courses and/or self-study, it was decided to expand the methods section of some papers by incorporating descriptions of some of the methods and to make cross references to these sections in other papers, e.g., effects of migration (Sousa), ELEFAN (Thiam), seasonality (Samb), Bhattacharya (Asila and Ogari), swept-area method (Jones and Jones), raising factors (Djama), etc.

Evaluation of the Follow-up Courses and their Output

Generalities on the Courses' Contents

There were some major and minor questions regarding principles which attracted attention during the discussions:

- What to do with incomplete data sets and less than perfect assessments: Should one wait until the "right data" become available, or publish what is there, analyzed in the best possible fashion?
  At the course the second option was chosen in view of the fact that publishing and working should be for fisheries scientists a continuing process rather than a "once-in-a-lifetime-event". Also, the specific situation of many developing countries (problems with publishing, staff fluctuation, difficulties in safe-keeping of data) makes it mandatory to write one's results before opportunities are lost (Pauly 1986c).
- Another example is the variation of methods. The computer programmes are often more sophisticated than the basic method as described in available manuals or textbooks. Example: The length-frequency catch curve normally has $\ln N/\Delta T$ as the ordinate. The ELEFAN package available at the courses had something more complicated, which required an iterative procedure. The results become less biased (P. Sparre, pers. comm. to Pauly 1984). The users, however, did not know the method, but accepted it. The question is: what are the implications of this attitude, should the instructors be worried about this?
- In general, the scientists of developing countries are not sufficiently motivated by their institutes to write scientific papers. They should be remedied.
- Major problems were observed with regard to insufficient knowledge of relevant literature.

Evaluation of the Hirtshals Course

An evaluation based on a questionnaire filled by the participants of the first course (at Hirtshals) was conducted at the Hirtshals course in order to optimize planning for the second course (in Manila). The results of the evaluation may be briefly summarized as follows.

i) All 14 participants thought that the follow-up course was an excellent (10) or a good (4) way to give high level training following an introductory training course in fish stock assessment.

ii) The tutors' visit prior to the course was very much appreciated and all but one participant found that they had received sufficient guidance on preparation of the data and were given a clear understanding of what was expected of them.

iii) Everybody found it a good idea to start the course with a presentation of each case. All but one liked the "mini-symposium" approach. However, many would have liked to have more time to read the papers before each discussion. The working facilities were (i.e., the North Sea Center, Hirtshals) found to be all right. Half of the participants had sufficient time for the work, the other half did not. Computer facilities were found to be just right by eleven and insufficient by two participants.

iv) Several participants suggested that more data processing (e.g., raising length-frequency data to catch or catch/effort) should be done prior to the course, such as to allow more time for more sophisticated analyses and discussions.

v) A direct question asking for suggestions for improvements was answered as follows (random order):

- More and better instruction in the use of computers;
- More lectures on the implications for management;
- More time for preparation of mini-symposia;
- More tutors, or rather, the time of the tutors should not be taken up for computer programming and debugging.

vi) A specific problem that arose in a few cases was that of conflicting advice or rather different approaches to solve a specific problem being given by the tutor on the one hand and one or more of the other lecturers on the other. This was quickly solved when recognized, but unfortunately not without having caused some stress to the participants. On the other hand, it was a good demonstration of the fact that different approaches are usually equally acceptable in the process of finding out what is happening to a fish stock.

As far as possible, these suggestions and criticisms were used to improve the planning and execution of the second course.

Evaluation of the Manila Course

To a large extent the Manila course went more smoothly than the Hirsthals course among other reasons due to uniformity in the computers and programs, the continuous presence of two additional programmers and easy access to the specialized library of ICLARM.

However, there were two major problems which required a lot of extra inputs from the participants and staff *viz.*, the limited English language skills of about half of the participants and a number of large sets of raw data requiring a large amount of processing time. However, these problems were gradually solved and the papers were eventually produced during the course as scheduled.

The Data and the Outputs

After many years of despair because the age of tropical fish could rarely be read from their hard parts, such as scales and otoliths, a new era began when the implications of the fact became fully realized that most l[illegible]uency distributions of tro[illegible]h contain peaks, each representing fish of app[illegible] the same age. More [illegible]icated methods of length-

frequency analysis were rapidly presented often in the form of further development of concepts initially proposed by earlier generations of researchers working on length-frequency analysis. They were applied in numerous papers published in the last decade, most of them showing promising results and based on data which had been collected but not published for obvious reasons. This has delayed the development of rigorous criteria for assessing the suitability of data sets for use of methods of length-frequency analysis (but see contribution in Pauly and Morgan 1987).

Some data sets used during the courses were clearly deficient because of inadequate sampling. The papers based on such sets would normally not be given a wide distribution, e.g., as formal publications. They have been incorporated here because they serve as a clear illustration of cases when sampling programs fail and of what needs to be done to improve them. The discussion of these papers may be considered of great importance for training purposes.

Where assessments of stocks of temperate waters are usually based on long series of data collected under national or international sampling programs, data collection in tropical developing countries has been much more limited in time and area due to lack of means and/or long-term planning. Data are often collected under short-term, local projects rather than through national or international sampling schemes. This is an immediate problem but hopefully not a lasting one.

Another problem associated with data collection is that in many cases additional data on total landings and effort of a particular fishery, sample weights and total catch of the vessel sampled were not collected, thus preventing the use of proper raising factors. However, this problem can, of course, be avoided in future sampling schemes to be set up by the participants and their colleagues.

More serious is the fact that some species have length-frequency data with cohorts that are difficult to identify, with one or two modes appearing to remain in the same position for the major part of the year. We assume this is due to an inflow of juveniles from a nursery ground and an outflow of young maturing adults to a different location. These phenomena occurred in several data sets treated at these courses (see e.g. Sousa, this vol.).

Most participants brought data sets for one or two reasonably abundant species. In fact, the "multispecies" problem of tropical demersal fisheries was approached explicitly in only a few papers.

There were also few papers on stock and yield assessment. Does this indicate that most scientists are still busy estimating the basic parameters of growth and mortality, or is it an indication of a still poor relationship between biological research and management needs? The situation will differ from one country to another. During the courses, however, the important role of the fishery scientist *vis-à-vis* the authorities responsible for management and development has been repeatedly emphasized.

Despite the above-mentioned limitations the bulk of the papers included here do represent significant advances, either in terms of assessing specific stocks or at the conceptual level, as in the case of the papers grouped in the section on "Biological and Technological Interactions".

It is thus with considerable pride that we present this volume of contributions to tropical fishery biology.

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Appendix I

FAO/DANIDA FOLLOW-UP TRAINING COURSE IN TROPICAL FISH STOCK ASSESSMENT HIRTSHALS, DENMARK, 5-31 MAY 1986

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Appendix II

FOLLOW-UP TRAINING COURSE ON FISH STOCK ASSESSMENT IN THE TROPICS MANILA, PHILIPPINES 12 JANUARY-6 FEBRUARY 1987

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