

ICLARM's Activities in Tropical Stock Assessment: 1979-1984, and Beyond

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and
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In March 1977, shortly after ICLARM commenced in Manila, its Program Advisory Committee formulated the guiding principles for the Resource Development and Management Program, which is one of the four program areas of ICLARM (the others are Aquaculture, Traditional Fisheries and Education and Training.) These emphasized research as the basis for managing tropical multispecies fisheries and were translated into a more detailed research program by D. Pauly during a 2-month consultancy at ICLARM in 1978 which laid the foundations for ICLARM's activities in fish stock assessment and management.



Daniel Pauly

The Research Program 1979 to 1983

From June 1979 to February 1982, the Program was staffed only by D. Pauly and emphasis was on the in-house development of appropriate research methodologies, particularly on microcomputer-based methods for the analysis of length-frequency data. Additionally, time was spent on organizing a workshop on tropical multispecies stocks, which would examine the models used to assess such stocks, and prepare a set of recommendations for future research.

The research on microcomputer-based methods yielded its first major result in mid-1980 when the ELEFAN I (Electronic Length Frequency ANalysis) microcomputer program, a radically new approach for the estimation of growth parameters from length-frequency data was completed and first described in the ICLARM Newsletter.

By the end of 1983 an integrated suite of ELEFAN programs was available:

ELEFAN 0: for the creation and maintenance of files for use with the ELEFAN system

ELEFAN I: for the estimation of growth parameters from length-frequency data

ELEFAN II: for estimation of total mortality from a length-converted catch curve, and for the derivation of seasonal patterns of recruitment

ELEFAN III: for performing two different types of length-structured Virtual Population Analysis using monthly catch information and length-frequency data from the fishery, and

ELEFAN IV: for estimation of natural mortality from catch length-composition data and the selection curve(s) of the fishing gear(s).

These programs, including user's instruction and BASIC listings, which have been extensively revised, are now being prepared for publication in book form, along with computational examples. The ELEFAN I and II programs, according to the results of a recent survey, are being used by over 40 users in over 20 countries. Some 15 reports and papers have been published based on the ELEFAN programs (not counting those produced at ICLARM) with a similar number in preparation. Also, several scientists, notably A. MacCall (NMFS, La Jolla, U.S.A.), J.G. Beddington (Univ. of York, U.K.) and J. Majkowski (CSIRO, Australia) have initiated simulation studies on ELEFAN I, II and III with the purpose

of assessing, using rigorous criteria, the various properties of these programs, and their suitability for routine application.

These developments, as well as the increasing realization by the staff of various fisheries laboratories throughout the world of the need to reassess and amplify work on length-based methods, led in 1983 to the concept of an "International Conference on the Theory and Application of Length-Based Fish Stock Assessment Methods", initially planned between ICLARM and the Kuwait Institute of Scientific Research. The proceedings of this conference (February 1985)

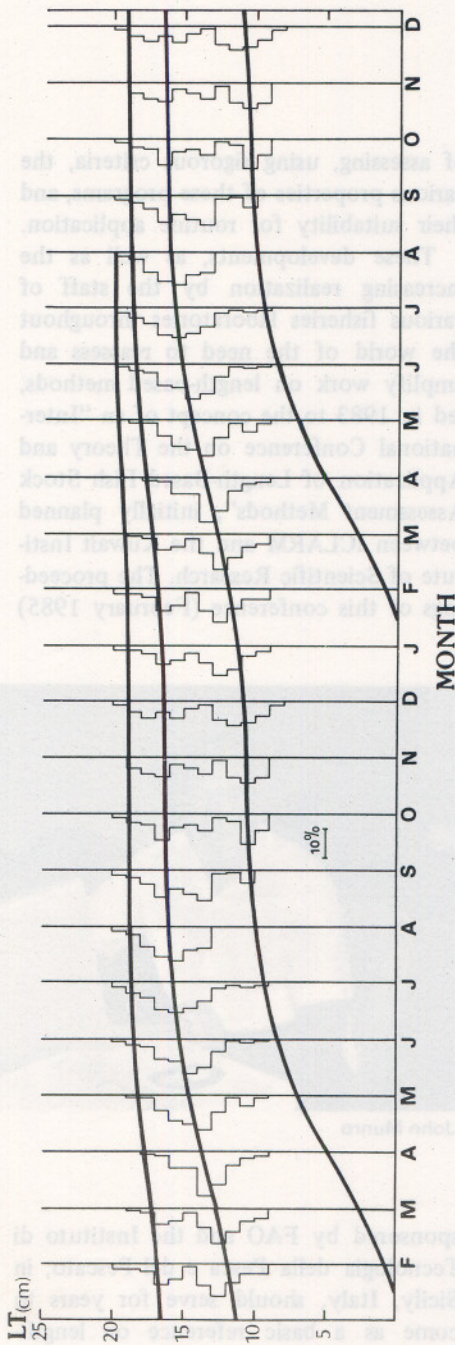


John Munro

sponsored by FAO and the Instituto di Tecnologia della Pesca e del Pescato, in Sicily, Italy, should serve for years to come as a basic reference on length-frequency analysis and length-based stock assessment in both tropical and temperate waters.

Length-frequency analysis, however, is not the only area of stock assessment for which microcomputers can be used. For

example, the filing and manipulation of data obtained during small to medium resources surveys and ecosystem modelling represent other areas where microcomputers can be used with great advantage. ICLARM initiatives on these topics



Seasonally oscillating growth curve, as estimated by ELEFAN I.

included the commissioning of a system of programs in Microsoft BASIC for the filing, maintenance and analysis of fish resources survey data, and the preparation of shorter programs for various purposes, some of which are included in program compilations to be published by FAO.

Throughout, the emphasis has been to show that virtually all aspects of tropical fish stock assessment can be handled with relatively cheap microcomputers and programmable calculators, and that such hardware, judiciously used, can magnify immensely the output of a fisheries laboratory, with a cost: benefit ratio much higher than that of a large computer or research vessels.

A manual by D. Pauly containing 30 fully documented programs for HP 67/97 and HP 41C calculators, has also been published. It embodies the essential parts of the multitude of published methods and models used to assess fish stocks, with emphasis on those approaches that have limited data requirements and can be applied to tropical stocks. The book demonstrates that programmable calculators are sufficient to implement most models used to assess single-species stocks with program listings and computed examples, for which complete keystroke sequences are given.

Participation in various conferences and training courses in 1980-1983, especially the ICLARM/CSIRO conference on the Theory and Management of Tropical Fisheries in January 1981 and the FAO/DANIDA Training Courses in Fish Stock Assessment confirmed the need for simple, robust methods for use when data are scarce, and for a wide dissemination of such methods throughout the intertropical belt, where fishery scientists often work in isolation, and generally have inadequate access to appropriate scientific literature.

The microcomputer- and calculator-based methods mentioned above, plus a number of "paper-and-pencil" methods also developed at ICLARM, do fulfill the criteria of being rather simple, robust and easily applicable to tropical stocks.

The problems linked to the dissemination of these methods to the people who need them was effectively tackled by establishing the Network of Tropical Fisheries Scientists, which has now over

300 members in 65 countries, all linked by *Fishbyte*, the Network's newsletter.

The Network of Tropical Fisheries Scientists, which is presently partly supported by the FAO/DANIDA Fish Stock Assessment Training Project allows for improved communication between individual members, and also enhances the identification of groups of scientists at institutions in various countries who are interested in setting up "country modules" within the framework of the other major project, the "Management-Oriented Fisheries Research Project", also initiated in 1982. There have been four such modules to date:

- a Philippine module, with the College of Fisheries of the University of the Philippines, concerned with the relationship between monsoon wind patterns and the recruitment of Philippine fishes (project now concluded with two scientific papers produced);
- an Indonesian module, with the Marine Fisheries Research Institute in Jakarta in which a microcomputer and ELEFAN programs supplied by ICLARM are being used to analyze the large amount of length-frequency data collected in the last few decades by Indonesian fisheries biologists;
- a Peruvian module, with the Instituto del Mar del Peru and more recently the German Agency for Technical Cooperation as cooperating institutions, in which the ELEFAN programs are being used to derive monthly recruitment estimates, never before available, for the period 1953 to 1982 from the large database available on the Peruvian anchovy and its ecosystem;
- a Zambian module which is assessing the state of the country's major pelagic and demersal fisheries by analyzing accumulated catch and effort statistics and length-frequency data. Most of this work will be accomplished on a microcomputing system supplied by ICLARM, and it includes a visit by a Zambian scientist to ICLARM headquarters in Manila to become familiar with the analytical techniques.

The country modules of the "Management-Oriented Fisheries Research Project"

have several objectives. Foremost is the training of fishery scientists in the interpretation of fishery data. They will provide the basis for future in-country training of additional workers, for improvement of university curricula and for interaction with fisheries administration. Thus, the capabilities of participating countries in fisheries management should be improved through better dialogue between biologists and managers, and between the fisheries departments of governments and universities.

The country modules should also help determine the basic information requirements for stock assessment and fisheries management in participating countries and produce well-documented reviews of the various fisheries investigated as well as original studies on tropical fish population dynamics.

Other training activities have included national training courses in the Philippines to international training courses, such as the FAO/DANIDA courses mentioned above, and from supervising M.Sc. students to assisting numerous colleagues on extended visits to ICLARM.

Additionally, reports and books ranging from the "Theory and Management of



Research assistant Deng Palomares at computer analyzing data for the Tropical Fish Stock Assessment Project and Management-Oriented Fisheries Research Project—Peru module.

Tropical Fisheries" (D. Pauly and G. Murphy, eds.) to "Caribbean Coral Reef Fishery Resources" (J.L. Munro, ed.), and to a series of reports on the fisheries of San Miguel Bay in the Philippines, have provided well documented examples of the theory and practice of tropical fish stock assessment. They are now used as a basis for parts of the FAO/DANIDA Fish Stock Assessment Training Project. Some are listed on the next page.

1984 and Beyond

The various methodological advances outlined above, particularly the calculator and microcomputer-based approaches have led to a situation very different from that prevailing a decade ago when the authors, working on a variety of fisheries projects had difficulty in identifying straightforward methods which could be applied to the data which had been gathered. In fact the situation has almost reversed itself, and there is now an urgent need to accelerate the dissemination of the new methodologies that have emerged in the last decade.

For this reason, much of ICLARM's future activities in stock assessment will consist of dissemination of appropriate methodologies, organizing training courses,

helping with the development of curricula, and training scientists through stays at ICLARM.

Future ICLARM research, as far it can be now anticipated, will concentrate on three major areas: assessment of specific resources, recruitment problems and comparative studies of the growth and mortality of fish and aquatic invertebrates.

Feedback

The continued relevance of ICLARM's work in stock assessment depends critically on feedback by colleagues; we hope that this essay will encourage colleagues to write, and to comment on how to make our work and theirs more effective.

We believe that one way that this can be achieved is by increasing the membership in the Network of Tropical Fisheries Scientists. Membership, which is free and includes subscription to *Fish-byte* and other benefits, is personal (*not* institutional) and readers who are, or wish to be, actively involved in stock assessment and management are encouraged to seek nomination by writing to the Director, Resource Development and Management Program, ICLARM, MCC P.O. Box 1501, Makati, Metro Manila, Philippines. ●



Pauly, D. 1979. Theory and management of tropical multispecies stocks: a review with emphasis on the Southeast Asian demersal fisheries. ICLARM Studies and Reviews No. 1, 35 p.

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Pauly, D. and N. David. 1980. A BASIC program for the objective extraction of growth parameters from length-frequency data. I.C.E.S. C.M. 1980/D:7 Statistics Cttee. 14 p.*

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Pauly, D. and J. Ingles. 1981. Aspects of the growth and mortality of exploited coral reef fishes, p. 89-98. In E. Gomez, C.E. Birkeland, R.W. Budde-meier, R.E. Johannes, J.A. Marsh, Jr. and R.T. Tsuda (eds.) Proceedings of the Fourth International Coral Reef Symposium, Manila, Philippines. Vol. 1.*

Pauly, D. and J.L. Munro. 1982. On the development and dissemination of new methodologies for tropical stock assessments, p. 79-87 (Annex 3). In Indo-Pacific Fishery Commission (IPFC)

**Selected Publications on
Tropical Stock Assessment from
ICLARM's Resource Development
and Management Program
1979-1984**

Single copies of articles followed by an asterisk are available free of charge from the address at the foot of p. 9. The others may be purchased from ICLARM or its overseas distributors. See p. 11 for ordering procedure.

Report of the Third Session of the Standing Committee on Resource Research and Development. Sydney, Australia. April-May 1982. FAO Fish Rep. 275. 135 p.*

Pauly, D. and G.I. Murphy, editors. 1982. Theory and management of tropical fisheries. ICLARM Conference Proceedings 9, 360 p. International Center for Living Aquatic Resources Management, Manila, Philippines and Division of Fisheries Research, Commonwealth Scientific and Industrial Research Organisation, Cronulla, Australia.

Pauly, D. and A.N. Mines, editors. 1982. Small-scale fisheries of San Miguel Bay, Philippines: biology and stock assessment. ICLARM Technical Reports 7, 124 p. Institute of Fisheries Development and Research, College of

Fisheries, University of the Philippines in the Visayas, Diliman, Quezon City, International Center for Living Aquatic Resources Management, Manila, and the United Nations University, Tokyo, Japan.

Munro, J.L., editor. 1983. Caribbean coral reef fishery resources. ICLARM Studies and Reviews 7, 276 p.

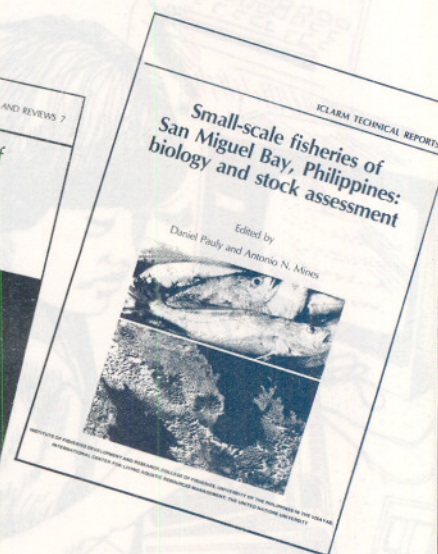
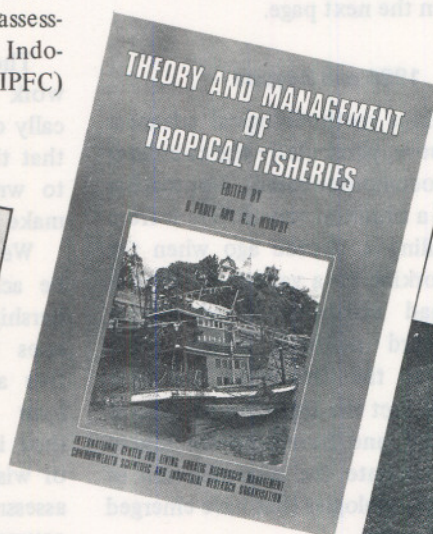
Munro, J.L. 1983. A cost effective data acquisition system for assessment and management of tropical multispecies, multigear fisheries. Fishbyte 1(1): 7-12.*

Pauly, D. and I. Tsukayama. 1983. On the seasonal growth, monthly recruitment and monthly biomass of the Peruvian anchoveta from 1961 to 1979, p. 987-1004. In G.D. Sharp and J. Csirke (eds.) Proceedings of the expert consultation to examine changes in abundance and species composition of neuritic fish resources. San José, Costa Rica, 18-29 April 1983, FAO Fish. Rep. No. 291, Vol. 3.*

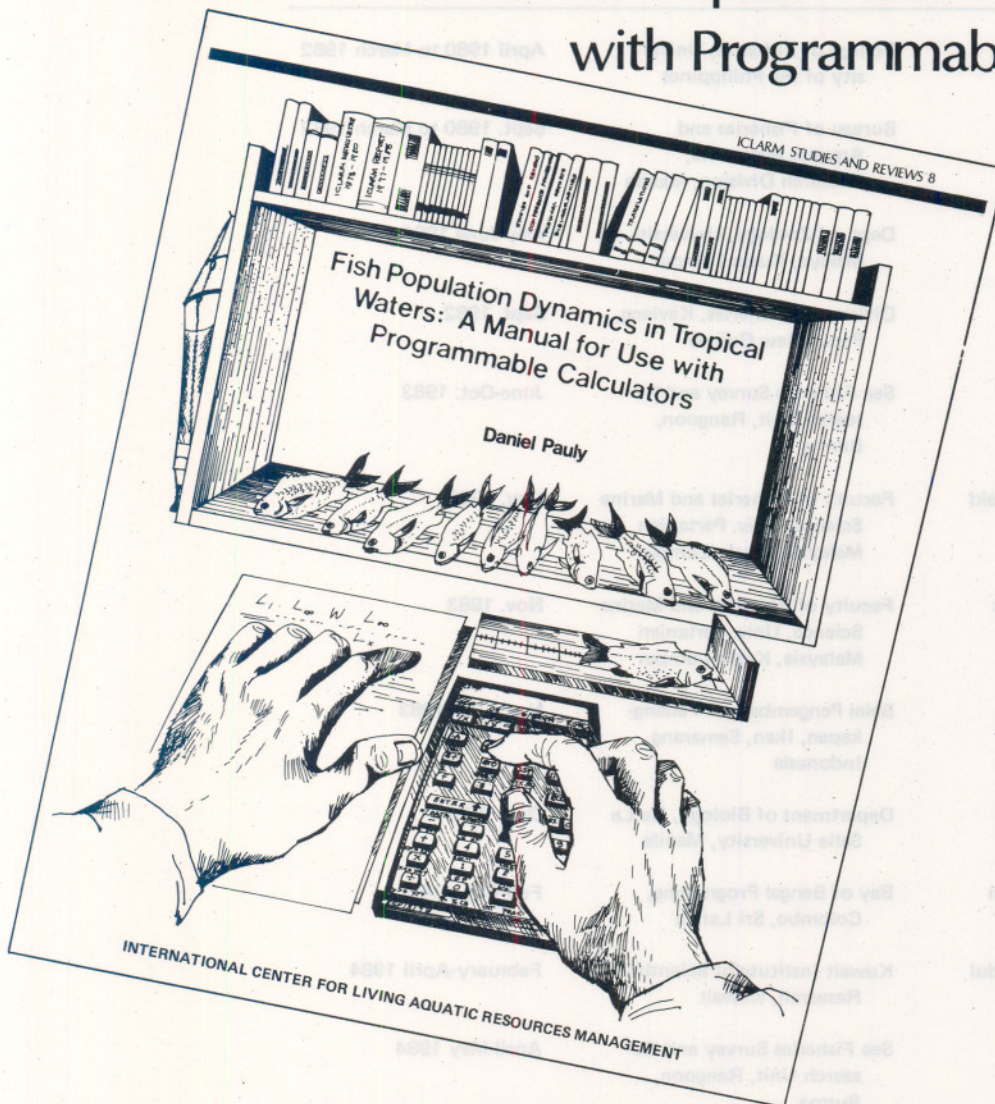
Munro, J.L. 1984. Estimation of natural mortality rates from selectivity and catch length-frequency data. Fishbyte 2(1): 11-14.*

Munro, J.L. and I.R. Smith. 1984. Management strategies for multispecies complexes in artisanal fisheries. Proc. Gulf and Caribbean Fish. Inst., 36.*

Pauly, D. 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Studies and Reviews 8, 325 p.



Introducing a New Manual for Fisheries Science: "Fish Stock Assessment in Tropical Waters: A Manual for Use with Programmable Calculators"



Fish population dynamics in tropical waters: a manual for use with programmable calculators. D. Pauly. 1984. ICLARM Studies and Reviews 8, 325 p. US\$14.00 surface, \$17.50 airmail (paper); \$25.00 surface, \$29.50 airmail (cloth); 30 preprogrammed HP 67/97 cards, \$10.00. Peso price: P200 (paper); P250 (cloth).

This manual challenges the widely-held notion that fish stock assessment, being based on mathematical models, should remain accessible only to a minority of scientists working in the research institutions of developed countries.

Starting with explicit definitions of even the simplest concept, this book presents a variety of methods for stock assessment, all of which have been tested for their applicability to tropical fish.

The methods selected cover the following areas: length/weight relationships,

mesh selection, fish growth, mortality, population size estimation by various methods (e.g., tagging, virtual population analysis), yield-per-recruit assessments, stock-recruitment relationships, surplus-yield models, fish population increase and aspects of multispecies stocks and fisheries. Emphasis was given to methods based on length-frequency and other data that are readily collected from tropical fisheries.

The full program listings and user instructions of thirty programs for use with HP 67/97 programmable calculators

are included, while the translation of these programs for use with other types of calculators, especially HP 41 and TI 59, is discussed in an appendix. Sixty computational examples including complete keystroke sequences are provided to illustrate the methods presented in the text. These examples are drawn exclusively from subtropical and tropical stocks and fisheries.

Preprogrammed cards for HP 67/97 can be purchased from ICLARM along with the book, which includes a page with holders for 30 cards.

A supplement to this book will also be available from ICLARM, which provides complete translations of the original listings for HP 67/97 for use with HP 41 C calculators. These translations, prepared by J.M. Vakily and D. Pauly, make full use of the advanced capabilities of the HP 41 C.

Altogether, this manual and the calculator programs which go with it should make fish stock assessment much easier for its practitioners than has been the case to date.

This latter feature should also allow for use of this manual as a teaching tool, both in the context of shorter-term training courses for fisheries officers and in universities, where it can serve as background to courses in population dynamics.

Enquirers in the U.S.A. should order directly from our exclusive distributor there, International Scholarly Book Services, Inc., P.O. Box 1632, Beaverton, Oregon 97075, to whom payment should be directed using the airmail price. Persons in Canada and Central and South America may also find ISBS a convenient source.

Indian readers can avail of the surface price in rupee equivalent from Pioneer Publishers, D/9 Vanshree, L.T. Road, Borivli (West), Bombay 400 092, India.

Enquirers elsewhere should address orders and payment (payable to ICLARM) in US\$ by check (from U.S.-based banks only), international money order, bankdraft or UNESCO coupons to The Editor, ICLARM, MCC P.O. Box 1501, Makati, Metro Manila, Philippines.

Fisheries biologists trained at ICLARM in the use of the ELEFAN programs and other methods for tropical stock assessment (April 1980 to June 1984).

Visitor	Institution	Dates of visit
Mr. J. Ingles	College of Fisheries, University of the Philippines	April 1980 to March 1982
Mr. R. Regalado	Bureau of Fisheries and Aquatic Resources, Research Division, Manila	Sept. 1980 to March 1982
Dr. Yap Siaw-Yang	Dept. of Zoology, Universiti Malaya, Kuala Lumpur	May-June 1981
Mr. Paul Dalzell	Division of Fisheries, Kavieng, Papua New Guinea	Sept. 1982
Dr. Sann Aung	Sea Fisheries Survey and Research Unit, Rangoon, Burma	June-Oct. 1983
Mr. Mohd Zaki Mohd Said	Faculty of Fisheries and Marine Science, Univ. Pertanian Malaysia, Kuala Lumpur	Nov. 1983
Mr. Mohd Azmi Ambak	Faculty of Fisheries and Marine Science, Univ. Pertanian Malaysia, Kuala Lumpur	Nov. 1983
Mr. G. Tampubolon	Balai Pengembangan Penangkapan, Ikan, Semarang, Indonesia	Nov.-Dec. 1983
Mr. L. Pinto	Department of Biology, De La Salle University, Manila	Dec. 1983
Dr. K. Sivasubramaniam	Bay of Bengal Programme, Colombo, Sri Lanka	February 1984
Mr. Abdul Rehman Abdul Ghaffar	Kuwait Institute of Scientific Research, Kuwait	February-April 1984
Mr. Aye Pyo	Sea Fisheries Survey and Research Unit, Rangoon, Burma	April-May 1984
Ms. Anette Junio	Marine Sciences Center, University of the Philippines, Manila	May 1984
Ms. Chan-Eng Heng	Faculty of Fisheries and Marine Science, Univ. Pertanian Malaysia, Kuala Lumpur	June 1984
Mr. Liew Hock Chark	Faculty of Fisheries and Marine Science, Univ. Pertanian Malaysia, Kuala Lumpur	June 1984
Mr. R. Matipa	Department of Fisheries, Chilanga, Zambia	June 1984
Ms. A.S. Cabanban Ms. E. Cortes-Zaragoza Mr. I.D. Mangaoang Mr. C.R. Pagdilao Mr. N.A. Navaluna and Ms. D.P. Tandog	M.Sc. students, University of the Philippines, Manila	Various dates