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FAO-ICLARM stock assessment tools

User's manual



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8

FISAT

FAO-ICLARM stock assessment tools

User's manual

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Preparation and use of this document

The FAO-ICLARM Stock Assessment Tools (FiSAT) presented herein is a program package consisting of robust methodologies for use with microcomputers, enabling users to formulate management options for fisheries, especially in data-sparse, tropical contexts. FiSAT did not evolve overnight. Indeed it took years of experience from many scientists throughout the world, with both LFSA and the Compleat ELEFAN, for a software to emerge that would go beyond these two packages. The functionality and flexibility, thus ease of use of both LFSA and the Compleat ELEFAN software, from which FiSAT was developed, provided the criteria which determined the final form taken by FiSAT.

This User's Guide was designed and written for use together with both the software, and the FiSAT reference manual - hence the absence of screen displays and graphs. Moreover, the chapters are arranged as presented in FiSAT. The following are summaries of the six chapters of this User's Guide:

Chapter 1. Getting Started

Contains information on system requirements, on installing the package, on how to respond to FiSAT prompts, and on how to access FiSAT functions and menu options;

Chapter 2. HELP Facilities

Potential users of this software, especially novice computer users, are advised to read this short chapter, which contains information on how to use the HELP facilities included in the system;

Chapter 3. FILE Menu

Contains information on the different routines available in the FILE menu which deals mainly with data creation, editing and other data manipulation routines;

Chapter 4. ASSESS Menu

The heart of FiSAT: contains a description of the different modules available to assess/analyze data; their requirements, and the expected outputs;

Chapter 5. SUPPORT Menu

Contains a description of the different modules available in FiSAT to prepare or complement data analyses as performed through the "ASSESS" menu;

Chapter 6. UTILITIES Menu

Contains information on various utilities, e.g., import and export facilities, the FiSAT calculator, printer configuration, etc.;

Appendices

A. Editing and Function Keys

Contains tables summarizing the keys and their function in the software;

B. Terms and Variables

Contains a list of terms and variables used in this manual and their definition(s);

C. Error Messages

Contains a list of error messages used by the software and suggested solution(s);

D. References

Lists all references cited in this User's Guide.

We emphasize that users of FiSAT must read the manual presenting the background of the methods included therein (Gayanilo and Pauly in press), manuals such as Pauly 1984 and Sparre and Venema 1993, and the suggested reading(s) specified as a model/method is presented, and do their best to understand the spirit of these methods if they want to use FiSAT optimally to extract reliable information from their data.

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Also, we thank the scientific staff of DIFMAR (Danish Institute of Fisheries and Marine Research) for their comments on various aspects of FiSAT, David Die (formerly with FAO) for his valuable inputs, Francisco Torres, Jr., and especially Maria Lourdes Palomares for testing the package, and Merly Medina for assisting in typing the manuscript.

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ABSTRACT

FiSAT (FAO-ICLARM Stock Assessment Tools) is the software that resulted following the merging of its two predecessors, the Compleat ELEFAN (Electronic Length Frequency ANalysis) package developed at ICLARM (International Center for Living Aquatic Resources Management) and LFSA (Length-based Fish Stock Assessment) developed by FAO, and the addition of some new routines found useful in the analysis of length frequencies.

FiSAT was developed for an IBM PC (or compatible) with a minimum of 512K of RAM and 7.5 MBytes of free disk space, and takes advantage of the high resolution-graphic capabilities of microcomputers. Other key features of the software are (i) a spreadsheet-like "feel", with the file being processed at most one click of a button away; (ii) pop-up windows, with concise help messages describing available functions, and (iii) support of various graphic cards and of standard dot matrix and HP PCL supported laser printers.

FiSAT was developed mainly for the detailed analysis of length-frequency data, but also enables related analyses, of size-at-age, catch-at-age, selection and other data typically collected for tropical fish stock assessment.

FiSAT has four main groups of routines, FILE, ASSESS, SUPPORT and UTILITIES. FILE deals with the file creation, editing and various data manipulation routines. ASSESS contains the models and methodologies used in the analysis of the different types of data which FiSAT supports, and ranges from growth and mortality parameter estimation to prediction using either the Beverton and Holt yield-per-recruit analysis or the Thompson and Bell yield and stock prediction model. SUPPORT was developed to facilitate data analysis. It contains routines to simulate length frequencies, display bar graphs, estimate (unsampled) maximum lengths, and sample weights, and perform regression analyses. UTILITIES contains functions for importing and exporting data files, configuring output options and managing some DOS functions; a simple calculator is also included. A separate manual is available from FAO, and by the same authors, which documents the routines in ASSESS and SUPPORT.

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D. References

- Abrahamson, N.J., 1971. Computer programs for fish stock assessment. FAO. Fish. Tech. Pap. 101. pag. var.
- Appeldoorn, R., 1987. Modification of a seasonally oscillating growth function for use with mark-recapture data. J. Cons. CIEM, 43: 194-198.
- Ault, J.S. and N.M. Ehrhardt, 1991. Correction to the Beverton and Holt Z-estimator for truncated catch length-frequency distributions. ICLARM Fishbyte, 9(1): 37-39.
- Beverton, R.J.H. and S.J. Holt, 1956. A review of methods for estimating mortality rates in exploited fish populations, with special reference to sources of bias in catch sampling. Rapp.P.-V.Réun. CIEM, 140:67-83.
- Beverton, R.J.H. and S.J. Holt, 1966. Manual of methods for fish stock assessment. Part II. Tables of yield function. FAO Fish. Biol. Tech. Pap., (38) 10 + 67 pp. (ver. 1).
- Beyer, J.E., 1987. On length-weight relationships: Part I: Computing the mean weight of the fish in a given length class. ICLARM Fishbyte, 5(1): 11-13.
- Bhattacharya, C.G., 1967. A simple method of resolution of a distribution into Gaussian components. Biometrics, 23: 115-135.
- Del Norte, A.G.C. and D. Pauly, 1990. Virtual population estimates of monthly recruitment and biomass of rabbitfish, *Siganus fuscescens* from Bolinao, Northern Philippines, p. 851-854. In R. Hirano and I. Hanyu (eds.). The Second Asian Fisheries Forum, Asian Fisheries Society, Manila, Philippines, 991 p.
- Ehrhardt, N.M. and J.S. Ault, 1992. Analysis of two length-based mortality models applied to bounded catch length frequencies. Trans. Amer. Fish. Soc. 121(1):115-122.
- Fabens, A.J., 1965. Properties and fitting of the von Bertalanffy growth curve. Growth, 29: 265-289.
- Formacion, S.P., J.M. Rongo and V.C. Sambalay, 1991. Extreme value theory applied to the statistical distribution of the largest lengths of fish. Asian Fisheries Science, 4(1992): 123-135.
- Gayanilo, F.C. Jr., M. Soriano and D. Pauly, 1989. A draft guide to the Compleat ELEFAN. ICLARM Software 2. 70p.
- Gulland, J.A., 1965. Estimation of mortality rates. Annex to Arctic fisheries working group report ICES C.M./1965/D:3. (mimeo). Reprinted as p. 231-241. In P.H. Cushing (ed). Key papers on fish populations. Oxford. IRL Press. 1983.
- Gulland, J.A. and S.J. Holt, 1959. Estimation of growth parameters for data at unequal time intervals. J. Cons. CIEM, 25(1): 47-49.

- Gumbel, E.J., 1954. Statistical theory of extreme values and some practical applications, a series of lectures. National Bureau of Standards, Applied Mathematics Series, 33. US Govt. Printing Office, Washington. USA.
- Hasselblad, V., 1966. Estimation of parameters for a mixture of normal distributions. Technometrics, 8:431-444.
- Hoening, J.M., 1982. Estimating mortality rate from the maximum observed age. ICES. C.M./1982/D:5 10p. (mimeo).
- Hoening, J.M. and W.D. Lawing, 1982. Estimating the total mortality rate using the maximum-order statistic for age. ICES C.M./1982/D: 7. 13p. (mimeo).
- Isaac, V.J., 1990. The accuracy of some length-based methods for fish population studies. ICLARM Tech. Rep. (27):81p.
- Jones, R., 1984. Assessing the effects of changes in exploitation pattern using length composition data (with notes on VPA and cohort analysis). FAO Fish.Tech.Pap. (256): 118p.
- Jones, R. and N.P. van Zalinge, 1981. Estimations of mortality rate and population size for shrimp in Kuwait waters. Kuwait Bull. Mar. Sci., 2: 273-288.
- Kvalseth, T.O., 1985. Cautionary note about r^2 . American Statistician, 39: 279-285.
- Laurec, A. and B. Mesnil, 1987. Analytical investigations of errors in mortality rates estimated from length distributions of catches. p.239-282. *In* D. Pauly and G.R. Morgan (eds.). Length-based methods in fisheries research. ICLARM Conf. Proc. 13.
- Mesnil, B., 1985. Computer programs for fish stock assessment. ANACO: Software for the analysis of catch data by age group on IBM-PC and compatibles. FAO Fish. Tech. Pap., 101 (Suppl. 3): 78p. + 2 diskettes.
- Moreau, J., 1988. Estimation of natural mortality from selection, and catch length-frequency data: a modification of Munro's method and application example. ICLARM Fishbyte, 6(2): 10-12.
- Moreau, J. and F.X. Cuende, 1991. On improving the resolution of the recruitment patterns of fishes. ICLARM Fishbyte, 9(1): 45-46.
- Munro, J.L., 1982. Estimation of the parameters of the von Bertalanffy growth equation from recapture data at variable time intervals. J.Cons. CIEM, 40: 199-200.
- Munro, J.L., 1984. Estimation of natural mortality rates from selectivity and catch length-frequency data. ICLARM Fishbyte, 2(1): 11-14.
- Munro, J.L. and D. Pauly, 1983. A simple method for comparing the growth of fishes and invertebrates. Fishbyte. 1(1):5-6.
- Pauly, D., 1979. Gill size and temperature as governing factors in fish growth: a generalization of von Bertalanffy's growth formula. Berichte des Instituts für Meereskunde an der Univ. Kiel. No. 63, xv + 156 p.

- Pauly, D., 1980. On the interrelationships between natural mortality, growth parameters and mean environmental temperature in 175 fish stocks. J.Cons. CIEM, 39(3):175-192.
- Pauly, D., 1981. The relationships between gill surface area and growth performance in fish: a generalization of von Bertalanffy's theory of growth. Meeresforsch., 28(4): 251-282.
- Pauly, D., 1982. Studying single-species dynamics in a tropical multi-species context, p. 33-70. *In* D. Pauly and G.I. Murphy (eds.). Theory and management of tropical fisheries. ICLARM Conf. Proc. 9.
- Pauly, D., 1983. Some simple methods for the assessment of tropical fish stocks. FAO Fish. Tech. Pap. (234): 52 p.
- Pauly, D., 1984. Fish population dynamics in tropical waters: a manual for use with programmable calculators. ICLARM Stud.Rev. (8):325p.
- Pauly, D., 1986. On improving operation and use of the ELEFAN programs. Part II. Improving the estimation of L_{∞} . ICLARM Fishbyte, 4(1):18-20.
- Pauly, D., 1990. Length-converted catch curves and the seasonal growth of fishes. ICLARM Fishbyte, 8(3): 33-38.
- Pauly, D. and N. David, 1981. ELEFAN I, a BASIC program for the objective extraction of growth parameters from length-frequencies data. Meeresforsch., 28(4):205-211.
- Pauly, D. and J.L. Munro, 1984. Once more on the comparison of growth in fish and invertebrates. Fishbyte. 2(1):21.
- Pauly, D. and J.F. Caddy, 1985. A modification of Bhattacharya's method for the analysis of mixtures of normal distributions. FAO Fish.Circ. (781): 16p.
- Pauly, D. and G.R. Morgan (eds.), 1987. Length-based methods in fisheries research. ICLARM Conf. Proc. (13): 468p.
- Pauly, D., M.L. Palomares and F.C. Gayanilo, Jr., 1987. VPA estimates of the monthly population length composition, recruitment, mortality, biomass and related statistics of Peruvian anchoveta, 1951 to 1981, p. 142-166. *In* D. Pauly and I. Tsukayama (eds) ICLARM Stud. Rev. 15.
- Pauly, D. and M.L. Soriano, 1986. Some practical extensions to Beverton and Holt's relative yield-per-recruit model, p. 491-496. *In* J.L. Maclean, L.B. Dizon and L.V. Hosillo (eds.). The First Asian Fisheries Forum. Asian Fisheries Society, Manila, Philippines.
- Pauly, D., J. Moreau and N. Abad, 1995. Comparison of age-structured and length-converted catch curves of brown trout *Salmo trutta* in two French rivers. Fisheries Research, 22:197-204.
- Pauly, D., M. Soriano-Bartz, J. Moreau and A. Jarre, 1992. A new model accounting for seasonal cessation of growth in fishes. Austr. J. Mar. Freshwat. Res., 43:1151-1156.

- Pope, J.G., 1972. An investigation of the accuracy of virtual population analysis using cohort analysis. ICNAF Res. Bull., (9): 65-74.
- Powell, D.G., 1979. Estimation of mortality and growth parameters from the length-frequency in the catch. Rapp. P.-V. Réun. CIEM, 175: 167-169.
- Rikhter, V.A. and V.N. Efanov, 1976. On one of the approaches to estimation of natural mortality of fish populations. ICNAF Res.Doc., 79/VI/8, 12p.
- Saila, S.B., C.W. Recksiek and M.H. Prager, 1988. Basic fishery science programs: a compendium of microcomputer programs and manual of operation. Elsevier Science Publishing Co. New York, USA. 230p.
- Sainsbury, K.J., 1980. Effect of individual variability on the von Bertalanffy growth equation. Can. J. Fish. Aquat. Sci., 37: 241-247.
- Seber, G.A.F., 1982. The estimation of animal abundance and related parameters, 2nd ed. MacMillan, New York, USA.
- Shepherd, J.G., 1987. A weakly parametric method for estimating growth parameters from length composition data, p. 113-119. *In* D. Pauly and G.R. Morgan (eds). Length-based methods in fisheries research. ICLARM Conf. Proc. 13.
- Silvestre, G.T., M.L. Soriano and D. Pauly, 1991. Sigmoid selection and the Beverton and Holt yield equation. Asian Fisheries Science 4(1):85-98.
- Soriano, M.L. and A. Jarre, 1988. On fitting Somers' equation for seasonally oscillating growth, with emphasis on t-subzero. ICLARM Fishbyte, 7(2): 13-14.
- Soriano, M.L. and D. Pauly, 1989. A method for estimating the parameters of a seasonally oscillating growth curve from growth increment data. ICLARM Fishbyte, 7(1): 18-21.
- Sparre, P., 1987. Computer programs for fish stock assessment. Length-based fish stock assessment for Apple II computers. FAO Fish Tech. Pap., (101) Suppl. 2: 218 p. (+ 3 diskettes).
- Sparre, P. and S.C. Venema, 1993. Introduction to tropical fish stock assessment. Part 1-manual. FAO Fish. Tech. Pap. (306.1) Rev. 1: 376 p.
- Sparre, P.J. and R. Willmann, 1992. Software for bio-economic analysis of fisheries. BEAM 4. Analytical bio-economic simulation of space structured multi-species and multi-fleet fisheries. FAO Computerized Information Series (Fisheries). No. 3. Vol. 1:186p. Vol. 2:46p.
- Strømme, T., 1992. NAN-SIS: Software for fishery survey data logging and analysis. User's manual. FAO Computerized Information Series (Fisheries), No. 4, Rome, FAO. 103 p. (+ 1 diskette).
- Thompson, W.F. and F.H. Bell, 1934. Biological statistics of the Pacific halibut fishery. 2. Effect of changes in intensity upon total yield and yield per unit of gear. Rep. Int. Fish. (Pacific Halibut) Comm., (8):49p.

Wetherall, J.A., 1986. A new method for estimating growth and mortality parameters from length-frequency data. ICLARM Fishbyte 4(1): 12-14.