The Quantitative Training Unit for Fisheries

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NON TECHNICAL SUMMARY

93/117 The Quantitative Training Unit for Fisheries

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OBJECTIVES:

1. To create in a tertiary institution a novel unit for developing course-work for graduate fisheries biologists and fisheries managers to provide world-class training in population dynamics, stock assessment and other aspects of fisheries science.

2. To develop and trial (and, as much as possible, deliver) introductory and advanced course-work on relevant scientific topics.

3. To design and program computer course-modules based on the courses as they were developed to provide an on-going resource for future training of Australia's fisheries scientists.

NON TECHNICAL SUMMARY:

The Quantitative Training Unit for Fisheries is a project funded by the Fisheries Research and Development Corporation in the Institute of Marine Ecology at the University of Sydney. The Unit was set up in February 1995, initially for a period of three years. During that time, up to 3 people have been employed on the project.

The Unit was established to improve the skills of fisheries scientists and fisheries managers in Australia in the area of fisheries modelling. Fisheries modelling embraces a variety of the mathematical techniques used to produce quantitative models of the populations of exploited fish species. These models help scientists monitor changes in fish stocks so that they can provide the necessary information to the managers who are responsible for policies for the sustainable use of these stocks.

Course material was developed using Word, PowerPoint and Excel. Word was used to create reference material for the participants to read in their own time. PowerPoint was used to create presentations for projection during lecture sessions. Excel spreadsheets provided the foundation of the practical sessions

by implementing and demonstrating the mathematical and statistical techniques used in fisheries modelling.

The course material was packaged into 17 modules, so that training course could be tailored to the requirements of the participants. Most of the modules were aimed at fisheries scientists; some were designed for managers. Courses lasted from 2 to 5 days. Eleven courses were held in all Australian States (except Western Australia) and in Canberra. In total, 127 scientists and 25 managers attended.

Seven of the core modules were developed as computer-based, interactive training packages. These were designed as stand-alone software for self-instruction, but they may also be used as presentations. Macromedia Authorware was used as the software vehicle. and the packages can be run on Windows and Macintosh platforms.

It was considered desirable to retain the training unit beyond its initial 3 year period. A successful application for funding at a reduced level was made to FRDC and the unit has started its second 3 year phase. Two part-time positions are being provided to continue both the presentation of training courses and the development of further computer-based packages.

BACKGROUND

Management of renewable resources, particularly ecologically sustainable managed exploitation, requires modelling of populations (Brewer, 1983). Modelling of the dynamics (the temporal trajectories) of numbers, sizes and rates of growth and reproduction of animals is, however, complex (Sissenwine, 1984). This is particularly true where there are numerous overlapping generations, multiple spawnings per seasons (or no clear breeding season), widespread dispersal of some stage(s) of the life-cycle (Sissenwine, 1974). These features of population ecology are shared by numerous animals of commercial importance including many plants, most insects and exploited fish and marine invertebrates (e.g. Fairweather, 1991; Underwood and Fairweather, 1989).

In recent years, there have been two separate developments in the population dynamics of marine fisheries. First has been the growing realization that ecological interactions among species are important for interpretation of patterns of use of resources of food, rates of survival and outbreaks of diseases. This has led to increased needs to understand multi-species fisheries (e.g. Clark, 1984; Newman, 1984), which in turn, has greatly complicated modelling of any single species (FAO, 1978).

Second, there has been a development of dynamical modelling of open or meta-populations. These are typical of marine animals with such widespread dispersal (usually of juveniles but, in some species, of adults) that breeding populations can be scattered widely over the habitat. As a result, dynamics of local populations can only be interpreted in terms of regional, meta-populations (e.g. Roughgarden and Iwasa, 1986; Roughgarden et al., 1985).

NEED

These developments created an urgent need to provide on-going professional training in population dynamics. To ensure that Australia complemented its other areas of excellence in marine ecology and fisheries, a need existed to develop world-class facilities for provisions of training, skills and expertise in the modern management of renewable resources. This is a crucial requirement to fulfil the national responsibilities of Ecologically Sustainable Development.

It is a goal of many international programmes of cooperative management of exploited fisheries that there should be a core of national expertise able to use existing knowledge of local systems and to adapt procedures of management to local policy-making and required managerial infrastructure (Larkin, 1984).

No current centre of expertise in Australia existed to provide on-going training in interactive management by dynamic modelling of exploited stocks. This

project was therefore established to fill the gap by creating a unit for training in population dynamics.

OBJECTIVES

FRDC has funded the development of the Quantitative Training Unit for Fisheries (QTUF) in the Institute of Marine Ecology (IME), University of Sydney. After its establishment and under the guidance of a National Advisory Committee, the Unit's objectives were designed to achieve 3 things:

(i) to create in a tertiary institution a novel unit for developing course-work for graduate fisheries biologists and fisheries managers to provide world-class training in population dynamics, stock assessment and other aspects of fisheries science;

(ii) to develop and trial (and, as much as possible, deliver) introductory and advanced course-work on relevant scientific topics;

(iii) to design and program computer course-modules based on the courses as they were developed to provide an on-going resource for future training of Australia's fisheries scientists.

METHODS

Development of Course Material

Course material was developed using Word, PowerPoint and Excel. Word was used to create reference material for the participants to read in their own time. PowerPoint was used to create presentations for projection during lecture sessions. Excel spreadsheets provided the foundation of the practical sessions. These spreadsheets implemented mathematical and statistical techniques used in fisheries modelling and these could be directly manipulated and explored by the participants.

Provision of Training Courses

The course material was designed as modules so that training courses could be tailored to the needs of particular groups and research establishments. In all, 17 modules were created (as listed in the Results section). Most of these were aimed at fisheries scientists; some were designed for fisheries managers.

Courses lasted from 2 to 5 days. "Overview" courses for managers typically lasted 2 days while the more intensive courses for scientists were 3 or 5 days. The first two courses were offered at the University of Sydney. Subsequently, courses were held on demand in all Australian States (except Western Australia) and in Canberra. About a dozen participants was found to be the optimal number, though one course contained as many as 28.

Development of Interactive Training Software

The parallel development of computer-based training modules was done to provide an asset that would remain if the Unit did not persist beyond the initial 3 years. Consequently, the modules were designed for self-instruction to be used as an independent training resource.

The software package Authorware, from Macromedia, was chosen as the vehicle for implementation. Authorware is designed specially for the development of interactive training material. It is regarded as one of the leading products in this area. It has the additional advantage of being cross-platform so that Authorware products may be run on both Windows and Macintosh platforms. This was concluded as desirable following a survey by the Unit of fisheries research establishments in Australia in 1995 which showed that both platforms are widely used. Authorware pieces can be distributed as run-time files. This has the important advantage that users do not need Authorware licences and the incidental advantage that the compiled run-time files are protected from unauthorised use of the embedded material.

The development of self-sufficient, interactive training material is, however, labour-intensive and time consuming. The 7 core training modules have been developed in Authorware (these are also listed in the Results section).

Advisory Committee 1995 -1998

These were the members of the National Advisory Committee of QTUF:
Associate Professor H. Beh, Dean, Faculty of Science, University of Sydney.
Professor J.H. Choat, Department of Marine Biology, James Cook University.
Dr M. Haddon, QTUF, Institute of Marine Ecology, University of Sydney.
Mr D. Hall, General Manager Fisheries, Northern Territory.
Mr N. Hall, Western Australian Marine Research Laboratories.
Mr S. Hinge, Commercial Fishing Representative, Port Elliot, S.A.
Ms G. Hood, QTUF, Institute of Marine Ecology, University of Sydney.
Dr R.E. Kearney, Head of School, School of Resource, Environmental & Heritage Sciences, University of Canberra.
Dr I.W. Montgomery, QTUF, Institute of Marine Ecology, University of Sydney.
Dr A. Smith, CSIRO Division of Fisheries, Hobart.
Mr R. Stevens, Managing Director, Australian Fisheries Management Authority.
Professor A.J. Underwood, Director, Centre for Research on Ecological Impacts of Coastal Cities, University of Sydney.

The advisory committee met on the following dates:

1 May 1995
28 August 1995
25 March 1996
16 September 1996

20 June 1997

RESULTS

Development of Training Courses

Since 1995, training material in Word, PowerPoint and Excel have been developed for the following course modules:

1 Introduction to Fisheries Modelling
- Why use mathematical models and what are their strengths and limits?
- How have models been used in fisheries science?
- The distinction between descriptions and explanations in modelling.

2 Simple Population Models
- Non-aged structured models, their uses and limits.
- The underlying structure of virtually all fishery models.
- Fundamental properties of exploited populations and their simulation.

3 Model Parameter Estimation
- Model fitting, the use of disparate data types, and sources of error.
- A comparison of least squares, maximum likelihood, and Bayesian methodology.

4 Stock-Recruitment Relationships
- The influence on stock-production - yield per recruit
- Density-dependence and the effects of measurement error
- Empirical versus realistic models.

5 Growth of Individuals
- Growth as a contribution to stock production
- Models and descriptions of growth - size and weight
- The comparison of growth curves

6 Biomass-dynamic Models
- The use of catch-per-unit-effort data
- The impact of alternative harvesting strategies.
- Non-equilibrium fitting of biomass dynamic models

7 Standardised Indices of Abundance
- Should one standardize the data or the outputs?
- Using general linear modelling to produce standardized indices of abundance from CPUE data.

8 Stratified Random Survey Design
- Stratified random surveys and subsequent analyses.

- The need for consistency with survey methods through time.

9 Introduction to Computer Intensive Methods

- What does computer intensive really mean?
- What do Monte Carlo, randomization, jackknife, and bootstrap methods all have in common?
- A brief characterization and comparison of Monte Carlo, randomization, jackknife, and bootstrap methods.

10 Randomisation Tests

- What is a randomization test?
- Why use randomization tests?
- The use of randomization methods to create confidence limits around a parameter.
- The comparison of complex data (eg. growth curves) using randomization tests.

11 Bootstrap Methods

- What does bootstrapping entail?
- What are the limits of bootstrapping?
- Bootstrap confidence intervals around parameter estimates.
- Probability density functions of estimated parameters.
- Using Monte Carlo methods with biomass dynamic models.

12 Introduction to Age-structured Models

- Age-structured modelling.
- Incorporating catch in weight into the model.
- Modelling stock-recruitment.
- Modelling a constant rate of harvest with age-specific vulnerability.
- Age-plus age-classes.

13 Yield-per-recruit

- Optimizing yield from cohorts.
- The objectives of yield-per-recruit analyses
- Model structure and assumptions

14 Development of Fisheries Management

- A brief history of fisheries assessment and management.
- The problems of fishery management.
- The use of fisheries performance indicators.

15 Fisheries Assessment Jargon

- Communication between fisheries managers and fisheries scientists.
- Terms used in fisheries assessments.

16 Major Stock Assessment Techniques

- Matching analytical methods and data.
- What sorts of data are available in Australia?

- The need for risk assessment and the determination of uncertainty of assessments.
- Strengths and weaknesses of different techniques.

17 Computer Simulations of Fisheries

- Practical experience with the influence of uncertainty on the outcomes of management decisions using simulations of fin-fish, crustacean, and molluscan fisheries.

Provision of Training Courses

Each course was structured by assessing the skills and requirements of the participants and then integrating the appropriate modules. The computer modules were then presented using a tutorial approach with extensive feedback and appropriate ancillary material.

Since 1995 the following training courses have been provided:

Start Date	Days	Location	Participants	Audience
14 Aug 95	5	Sydney	12	Scientists
6 Mar 96	3	Sydney	12	Scientists
27 Mar 96	3	Hobart	11	Scientists
6 May 96	5	Townsville	12	Scientists
23 Sept 96	5	Adelaide	13	Scientists
7 Oct 96	5	Hobart	14	Scientists
21 Oct 96	5	Queenscliff, Vic	12	Scientists
16 Dec 96	2	Canberra	12	Managers
12 May 97	2	Brisbane	13	Managers
14 May 97	3	Brisbane	28	Scientists
2 June 97	5	Adelaide	13	Scientists

The total number of people trained in these courses is 152.

Development of Interactive Training Software

Interactive modules for use on Macintosh and PC platforms have been developed in Macromedia Authorware. These modules cover the following topics:

1 Simple Population Models
2 Parameter Estimation
3 Stock-Recruitment Relationships
4 Growth of Individuals
5 Biomass Dynamic Models
6 Stratified Random Surveys
7 Standardised Indices of Abundance

The modules use a variety of interactive techniques such as menus and buttons for navigation, as shown in Figure 1.

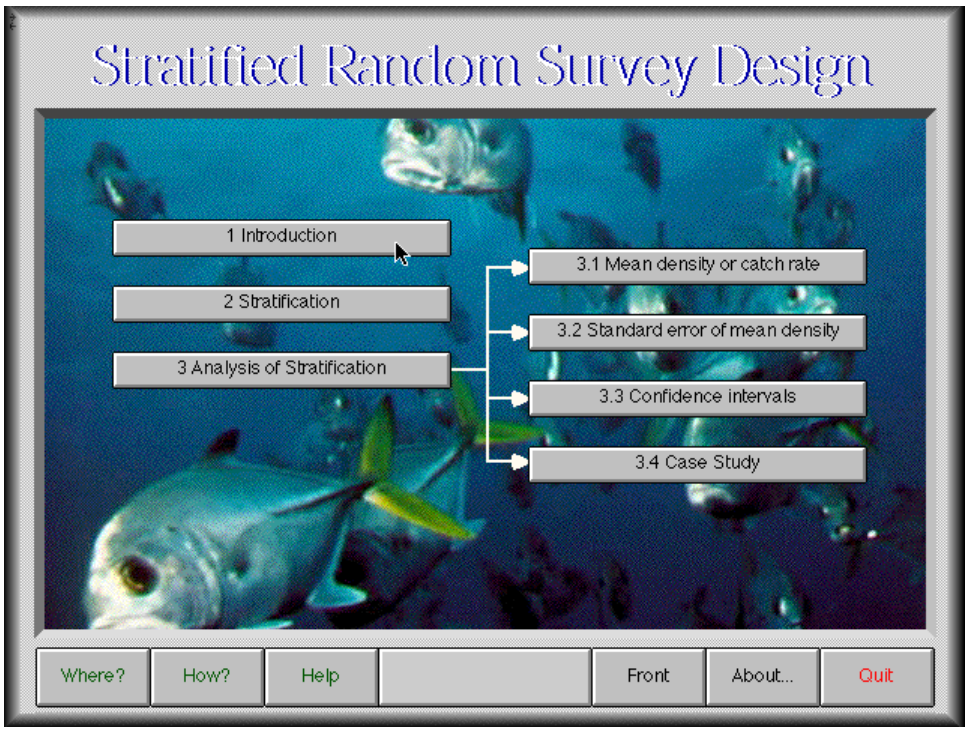

Figure 1. Navigation in the Authorware modules.

The modules contain many graphs to illustrate different equations and types of models. The user can enter new parameter values and redraw the graphs as shown in Figure 2.

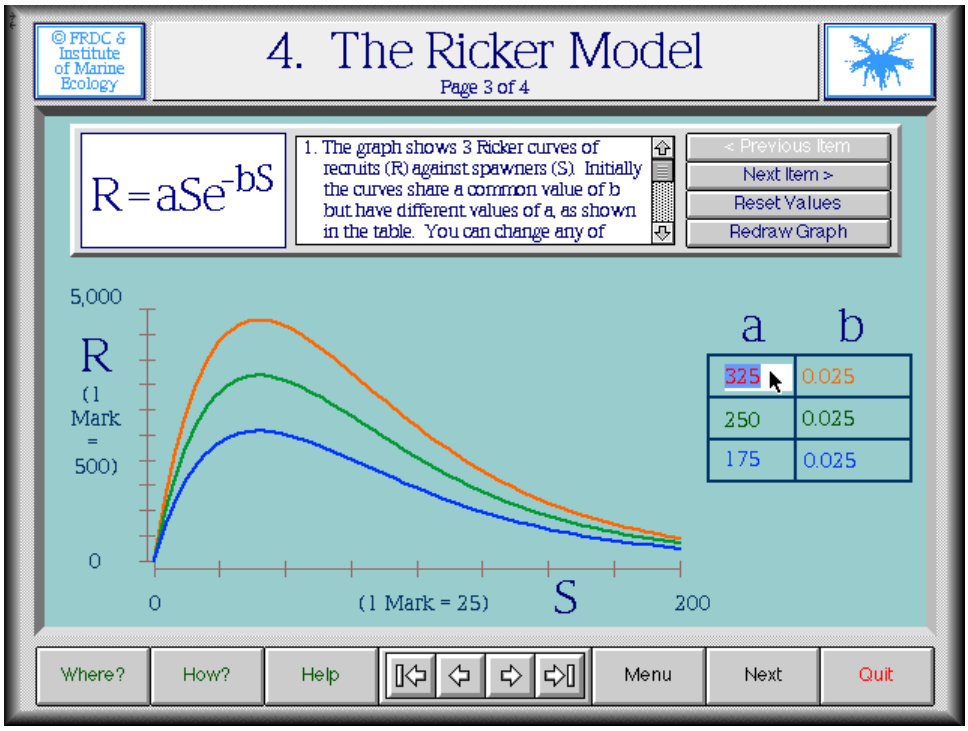

Figure 2. Interactive graphs.

The modules use hot text to provide additional information, definitions and references to publications, see Figure 3.

Figure 3. Hot text used for explanations.

An extensive help system is provided to make the modules easy to use. A Where? button allows easy navigation to any section in the module. A How? Button takes the user to a Navigation Tutorial to explain the conventions used in the pieces. Each page has a context-sensitive help facility to show the options that are available, as shown in Figure 4.

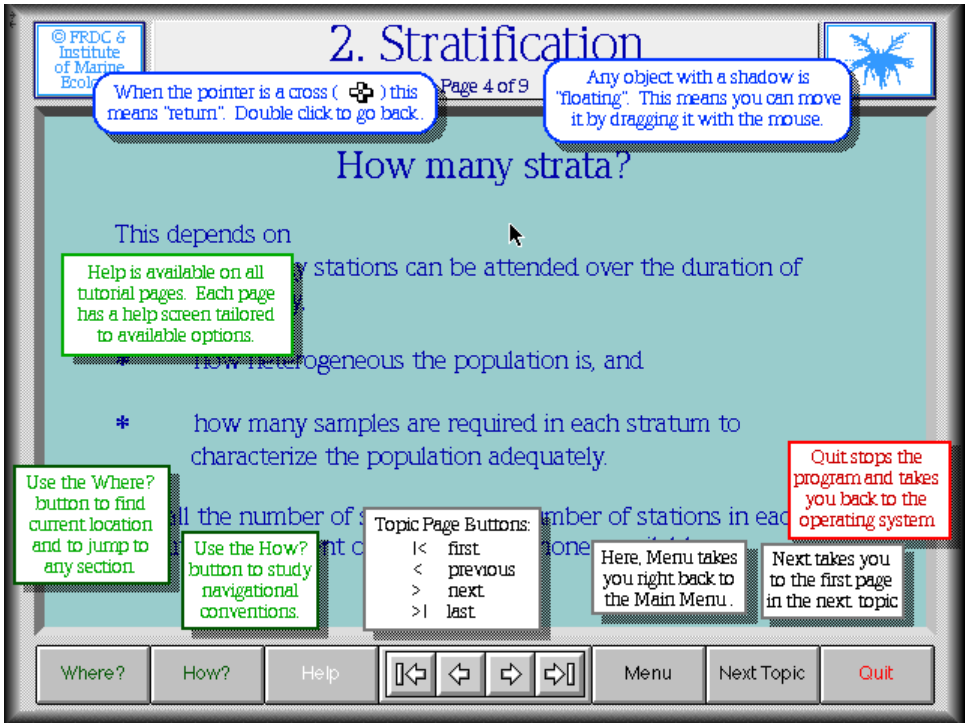

Figure 4. The help facility.

The scripting language which forms part of Authorware permits the use of techniques such as 3-dimensional graphics, as shown in Figure 5.

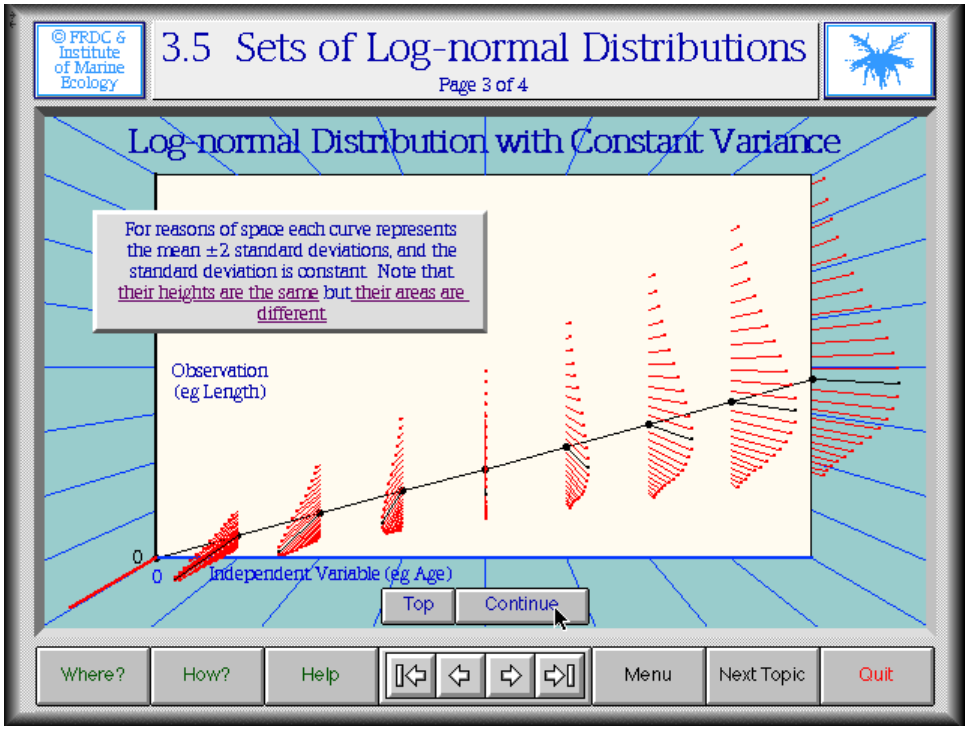

Figure 5. Three-dimensional graphics.

The language also permits the implementation of sophisticated numerical methods. Figure 6 illustrates parameter fitting by the motion of a triangular simplex object through a likelihood space to the region of maximum likelihood.

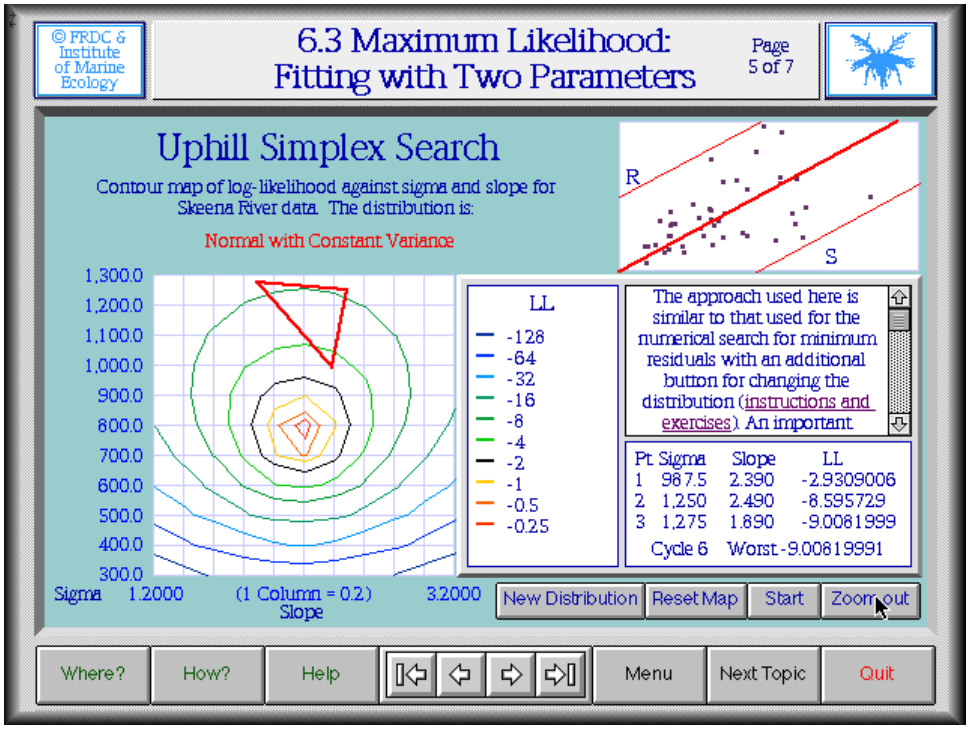

Figure 6. Numerical techniques.

Modules 1, 3 and 4 were distributed to participants after being evaluated during the course in Adelaide in June 1997. It is planned that future training courses will be delivered using the computer-based modules, starting with the next course in June 1998.

BENEFITS

The establishment of the Unit has meant increased professional capacity throughout the fisheries laboratories and managerial agencies in Australia. Immediate benefits are demonstrable through the personnel who have attended courses. It does, however, take time for this to be translated and amplified to measurable improvements in scientific outcomes for specific fisheries projects. It is generally recognised that it takes 5 - 8 years from inception to publication to identify a change in a scientific sub-discipline due to novel methodology. Experience with teaching professional courses in experimental design suggests a similar, or longer, time-scale for measured improvements in outputs of trainees. There is no reason to suppose that training in fundamental aspects of theory, dynamics and methodology for fisheries science would appear more quickly. The purpose of the Unit was to raise general levels of training. The basic premise - reflecting FRDC's major aims - was to improve potential for a

profitable, sustainable industry by ensuring scientific best practice in all areas of the industry.

The sectors of the industry that benefit directly are primarily the management and research components. In addition, better and more specifically trained personnel in various State and Commonwealth organizations greatly increase the entire industry's capacity to manage, to predict and to sustain its productivity.

A specific, immediate benefit is a major increase in sources of professional, scientific advice for management agencies (State and Commonwealth). These have been limited in the past.

FURTHER DEVELOPMENT

The National Advisory Committee of the Unit considered that it would be desirable to maintain an on-going QTUF for 3 years in order to:

1. Continue to provide training in the population dynamics of exploited stocks.
2. Assure the future of the training material by integrating it into the postgraduate programs of the University of Sydney.
3. Develop additional computer-based modules.
4. Disseminate the products of QTUF.

There was clearly a need for continuing provision of training courses in the introductory and core material. Further, to maximise the benefits of the existing investment in computer-based material, there was a need to provide a mechanism for the distribution of software. In addition, the value of the computer-based material can be increased by developing further modules for which a requirement has been identified by the Advisory Committee.

As a result, a successful application was made to FRDC to continue funding QTUF, at a reduced level, for another 3 years. The Unit (Phase 2) now consists of 2 part-time (50%) positions. One of these is for the provision of training courses and the integration of the training material in postgraduate programs. The other half position is for the development of additional computer-based modules and the distribution of software. The Unit is now housed in the Centre for Research on Ecological Impacts of Coastal Cities in the University of Sydney.

For further information contact:

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APPENDIX 1

Intellectual Property

Intellectual property rights to training material and software produced by the Unit belong jointly to the Fisheries Research and Development Corporation and to the University of Sydney.

APPENDIX 2

Staff

The following staff were engaged in the project:

Person	Position	Period
Professor A.J. Underwood	Principal Investigator	Feb 95 - Jan 98
Dr M. Haddon	Senior Research Fellow	Feb 95 - Sept 97
Dr I.W. Montgomery	Research Fellow	Apr 95 - Jan 98
Dr S. Richards	Research Fellow	May 96 - Feb 97
Ms G. Hood	Software Developer	Mar 97 - Jan 98