APPENDIX 3 : EXISTING EXPERT SYSTEMS IN FISHERIES

A thorough literature search was commissioned via the 'Dialog' on-line computerized search facility offered at Imperial College. This has access to over 200 bibliographic databases held on computer in Europe and America.

The most suitable databases were first chosen from a description of each in A catalogue and from background knowledge of likely sources.

* Aquatic Sciences and Fisheries Abstracts.
* Oceanic Abstracts.
* Enviroline (environmental science reference database).
* Inspect (computing and physics reference database).
* U.S.A. Government Reports Database.

Combinations of 'Expert System?' and 'Fish?' were used as key words in searches. Output was to paper, disc or electronic mail. Charges were according to connect time, number of references chosen and output medium. Further searches were also made using the CD-ROM version. This is cheaper, though not as extensive and is only updated periodically.

This rigorous search confirmed the results of earlier manual searches that there are very few references for this specific topic. These are marked * in the reference list. Several of these cross referenced from the different databases.

* **Steinbach, C., Pereira, C.**, 1989. SALMEX: An Intelligent Knowledge Based System for the Diagnosis of Salmonoid Fish Diseases. Proceedings of the Scandinavian Conference on Artificial Intelligence 1989.

This work is of no direct relevance to the project. Details have been passed to colleagues with interests in aquaculture.

* **Froese, R., Schofer, W.** 1987. IDEXSYS: Computer Aided Identification of Fish Larvae. ICES, Copenhagen (Denmark) 1987. 10pp.

Such a system could be used as a sub module when one of a main expert recommendations is to carry out a larval study. Details have been passed to colleagues proposing a new expert system aid for field taxonomy.

* **Bielawski, L. & Lewand, R.** 1989. REGIS: Regional Information System for African Aquaculture. F.A.O. and National Agricultural Library, USA Dept. of Agriculture.

A demonstration copy of this software was obtained from an expert systems exhibition. It has been written using 'KnowledgePro' software, and illustrates the capabilities of this software. REGIS is an hypermedia information document on aspects of aquaculture in Africa. It uses 'hypergraphics' and 'hypertext' to form the 'threads' that link sections of the document together on various conceptual bases. For example, sections can be called up by selecting their headings from the table of contents. Sections referring to particular countries can be retrieved by making a graphical choice from a map of the continent. Alternatively sections can be accessed according to species through a graphical or textural choice. The Aquatic Sciences and Fisheries Abstracts are available on line or on CD-ROM. Should you have access to either

of these a search technique can be employed on the document to assemble paragraphs containing the key words used in the search. The expert system component is limited. It is a short rule based module giving simple advice for establishing an aquaculture enterprise. Though REGIS is not directly relevant to ocean fisheries management it serves as an excellent demonstration of potential uses, especially for the use of hypermedia in conjunction with an expert system. REGIS serves to demonstrate how a computer can be used to harness information that would otherwise overwhelm us by its sheer volume.

* **Anon.** 1987 CATCUV 1: Fishery Management Expert System. Proceedings of ORIA '87: Artificial Intelligence and the Sea. Inst. Robotique & Intelligence Artificielle, Marsille, France.

The proceedings were received after a long search but unfortunately this paper had been removed. Another search should be made for this reference.

* **Petit, M. & Stretta, J.M.** 1989. Two Tools Available for an Operational Tuna Fishery: Aerospatial Teledetection and Expert Systems Models. CICAA vol 30, no 2, pp 500-505

This study has expert systems as an addendum to work on teledetection for tuna. It is proposed that more use can be made of satellite imagery for estimating fish location from oceanographic characteristics and that this should be combined with existing methods of airborne (plane) radar detection. It further proposes a framework for co-operation between countries and sectors, (i.e. fishing industry, govt. fisheries dept etc.) to use such information.

* **Ryan, J.D. & Smith, P.E.** 1985. An expert system for fisheries management. in Oceans '85. Proceedings: Ocean Engineering and the Environment. Vol 2, pp. 1114-1117 San Diego CA. USA. Nov. 1985.

A promising paper but on closer study is more a statement of intent. It addresses none of the basic issues of knowledge engineering. It contains proposals that concentrate on organizing data from the fishery and analyzing it to estimate parameters, and using these in simulation models and statistical considerations. It does not make clear what aspects of knowledge are to be used or how these will be used.

Borch, O.J., Hartvigsen, G. 1990. STRATEX: A Knowledge Based System for Strategic Market Planning in Small Firms (fish export). A.I. Communications, March 1990 vol 3, no 1, pp 12-24.

Though such a system is not immediately relevant to fisheries management per se it definitely has potential to work as a complementary module within the architecture of a future expert system. If for example it decided that an objective to expand a country's marketing industry was viable or that such a move was complementary to another objective e.g. increase employment, then a something similar to STRATEX could be assigned to a list of plans to be carried out in order to achieve the objective. Co-operation with a system like STRATEX is worth investigating. Co-ordination would be required in the amalgamation of this or any other application, so that it would work within a uniform framework e.g. hardware platform, user interface etc. This paper describes the results of the pilot system development via the goals and decision making procedure of the system. The authors describe the different planing stages in STRATEX from a users point of view.

Golden, B.L. & Rothschild, B.J. 1987. A Microcomputer Based Decision Support System For Multispecies Fishery Management. Technical Report No. 1. The University of Maryland.

This aims of this work (nicknamed CANOFISH) are similar to those stated by Ryan and Smith except they are proposed to work for a multispecies fishery. However in this system at the time of publication, all of the modules with one important exception were operational. Unfortunately the exception was the expert system module, 'ADVISOR', which was being worked on. CANOFISH looks like a very disciplined approach to integrating the various

existing computing tools used for fisheries management into a single integrated Decision Support System (DSS). It is envisaged that the expert system module ADVISOR will both provide expert knowledge and use this to drive and co-ordinate all of the other modules making up the DSS. The knowledge content stated for ADVISOR is vaguely defined, with no analysis of the kinds of problem that are likely to be met in the process of knowledge engineering. An update of this work might provide further useful information.

The impetus for producing CANOFISH, came from the inapplicability of most standard assessments to small scale fisheries. Large scale fisheries typically have comparatively few fishing units, few landing sites and concentrate on a few species and single species models are used for stock assessment. However in a small scale fishery there are often thousands of small fishing units, scattered landing sites and many different species landed. These types of fishery take a significant proportion of the world catch and exist in the developed, as well as the developing world. The authors argue that simplification of fisheries systems for ease of management ignore species interaction which may be critical for good system performance i.e. production, so that management of the fishery tends towards a classic sub optimal state.

Summary of the CANOFISH Decision Support System :

MONITOR	- data input	- commercial
		- biological
	- data manipulation	- to a standard format
		- derived measures
		- detect outliers
		- statistical tools

OPTIMIZER - would contain the assessment programs and the method of choosing between them.

SIMULATOR - uses system dynamics for modelling and simulating interacting systems. e.g. causal loops.

ADVISOR - expert system heart of DSS. drives and co-ordinates the other modules.

Potential contributions of the proposed DSS :

(i) Better and more frequent data handling will reveal new information e.g. migration and result in better decision making. (MONITOR)

(ii) Will identify outliers (MONITOR)
(iii) Will provide powerful but easy to use routines for assessment.
(iv) Will include multispecies optimization models. (OPTIMIZER)
(v) Simulation. There will be simple focusing on single questions asked by ADVISOR so that the interpretation of the simulation results is guided by the expert system (SIMULATOR)
(vi) Encoding of existing knowledge into an expert system which can be modified.

The development team developing prototype system reached the following conclusions :

* The resources required to develop such a system should not be underestimated. It took three people one year to get a prototype up and running (without a functional expert module).

* Simple module linkages are best to begin with, these can be made more sophisticated.

* The underlying methodology used in the fisheries domain is not clearly understood. Expert systems must evolve as new insights are gained.

* Jones, J.C. 1989. Expert Systems for Fisheries Management. Biological Computation, University of York. & R.R.A.G.

This study is the basis of work presented here. It presents a briefer simpler summary of both fisheries management and expert systems. Basic concepts and terminology are clearly explained. It concentrates on the analysis of problems and places a strong emphasis on the data modelling approach. The general design solution arrived at by a different route, is the same as the conclusion of this report, which was obtained from greater practical experience of developing prototypes and the application of rigid formal systems design and analysis. In this early study there is limited flexibility for the user as it requires that all procedures are followed in strict sequence regardless of their time requirements, itself a time consuming process.