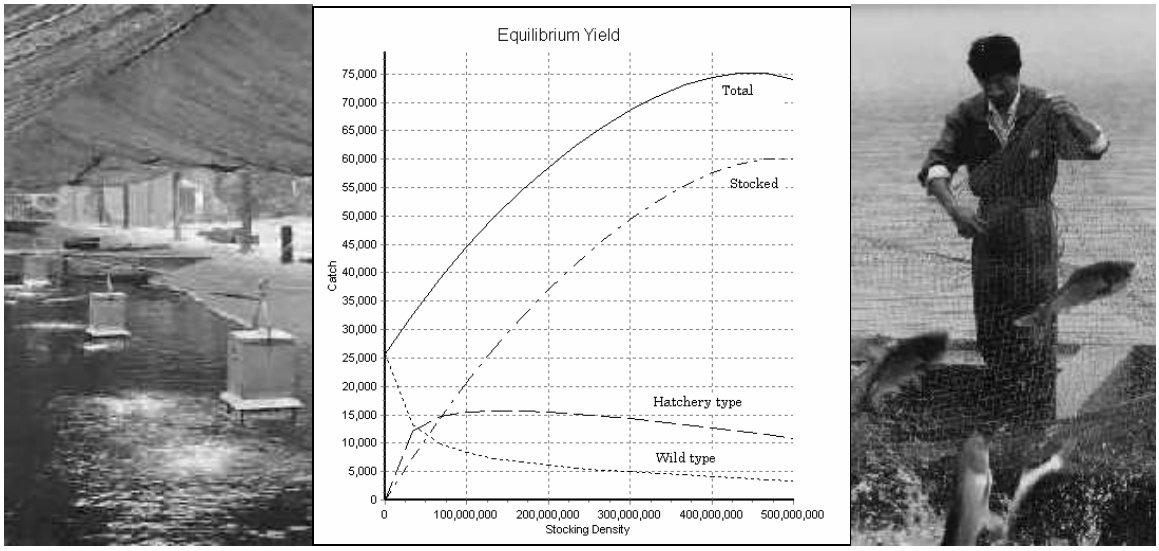
Imperial College London

Enhancefish

Fisheries enhancement decision support tool and toolkit



Final Technical Report

November 2005

DFID Fisheries Management Science Programme
Project R 8469

TITLE OF PROJECT	Fisheries Enhancement Decision Support Tool and Toolkit
PROGRAMME MANAGER / INSTITUTION	MRAG Ltd.

	FROM	TO
REPORTING PERIOD	1 April 2005	31 October 2005

Name and signature of the author of this report

Dr Kai Lorenzen

Project completion summary

DATE SHEET COMPLETED: 20/11/05

TITLE OF PROJECT:	Fisheries Enhancement Decision Support Tool and Toolkit
R NUMBER:	R 8469
DFID RESEARCH PROGRAMME:	Fisheries Management Science Programme
PROGRAMME MANAGER (INSTITUTION):	MRAG Ltd.
SUB-CONTRACTOR (if relevant):	
FMSP OUTPUT:	
PRODUCTION SYSTEM:	Land/Water Interface
COMMODITY BASE:	Freshwater and marine fish and shellfish
BENEFICIARIES:	Poor part-time and full-time fishers in freshwater and marine systems
TARGET INSTITUTIONS:	National fisheries management and research organizations affiliated with the Network of Aquaculture Centers in Asia-Pacific and collaborators of the Mekong River Commission Fisheries Program.
GEOGRAPHIC FOCUS:	Global, in particular Asia

	PLANNED	ACTUAL
START DATE:	1 April 2005	1 April 2005
FINISH DATE:	31 October 2005	31 October 2005
TOTAL COST:	£ 45,000	£ 45,000

1 Project Purpose:	Effectiveness of pro-poor fisheries enhancement initiatives in S and SE Asia improved through development and promotion of a decision support tool enabling a wide range of target end users to apply existing FMSP quantitative assessment methods The purpose has been achieved.
2 Outputs:	1. Decision support tool (DST) for quantitative assessment of aquaculture-based fisheries enhancements available 2. Toolkit to guide use of DST in pro-poor enhancement, and assessment manual available 3. Training course for target end users conducted and evaluated 4. DST and toolkit promoted regionally and globally All outputs have been achieved.

3 Contribution of Outputs to Project Goal:	The project goal is 'benefits for poor people generated by application of new knowledge to fisheries management systems'. The project makes a significant contribution to this goal by making FMSP quantitative assessment methods available to a wide range of target end users who were not previously able to use more advanced methods developed.
4 Publications, reports and other outputs:	<u>Peer-reviewed publications (in press)</u> Lorenzen, K. Population management in fisheries enhancement: gaining key information from release experiments through use of a size-dependent mortality model. *Fisheries Research*, In press. <u>Non peer-reviewed publications, reports and communications materials</u> Lorenzen, K. & Medley, P.A.H. (2005) ***EnhanceFish*** Manual. Imperial College/DFID. Lorenzen, K. (2005) ***EnhanceFish*** Guide. Imperial College/DFID. <u>Verbal presentations, project dissemination and other workshops</u> ***EnhanceFish*** training workshop, 17-21 October 2005. Lorenzen, K. Population dynamics of fisheries enhancement. British Ecological Society Annual Symposium, Hatfield, UK. <u>Other types of project output (software)</u> Medley, P.A.H. & Lorenzen, K. (2005) ***EnhanceFish***: A decision support tool for aquaculture-based fisheries enhancement. Imperial College/DFID.
7 Follow-up indicated/planned.	Continued support for users of the DST is indicated and will be provided. Further development is also planned.
8 Name and Signature of the Author of this Final Report.	Dr Kai Lorenzen

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Enhancefish Policy Brief. STREAM Initiative.

Annex 2
Lorenzen, K. (2005) ***Enhancefish*** Guide. London: Imperial College.

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Lorenzen, K. & Medley, P.A.H. (2005) ***Enhancefish*** Manual. London: Imperial College.

Annex 4
Lorenzen, K. Population management in fisheries enhancement: gaining key information from release experiments through use of a size-dependent mortality model. *Fisheries Research*, In press.

2. Executive summary

(1) Fisheries enhancement through the release of hatchery fish is widely used in inland and increasingly, coastal fisheries. Enhancements can generate significant benefits for the poor, but the approach is often used ineffectively. The reasons for this include institutional issues associated with regulating harvest and sustaining investment in stocking, as well as the technical problem of optimizing stocking and harvesting regimes for local natural, institutional socio-economic conditions

(2) Previous projects supported by the DFID Fisheries Management Science Programme have addressed the full breadth of these issues and developed quantitative methods for optimizing stocking and harvesting regimes as well as adaptive learning approaches that integrate scientific analyses with stakeholder experimentation and learning.

(3) The purpose of the project was to improve the effectiveness of pro-poor fisheries enhancement initiatives in S and SE Asia improved through development and promotion of a decision support tool enabling a wide range of target end users to apply quantitative assessment methods developed in the previous projects.

(4) The project's key output is the ***EnhanceFish*** decision support toolkit for the analysis of aquaculture-based fisheries enhancements. The ***EnhanceFish*** toolkit consists of three parts

a) The ***EnhanceFish*** decision tool: a software package for quantitative assessment of enhanced fisheries
b) The ***EnhanceFish*** manual: a technical manual that explains the scientific principles behind the ***EnhanceFish*** package and its use in assessment
c) The ***EnhanceFish*** guide: practical guidance on how to use ***EnhanceFish*** in the panning and management of enhancements, particularly in developing countries

(5) In addition to developing the main decision support toolkit, the project has developed a number of auxiliary tools, including a methodology for analysing release experiments.

(6) Key elements of the decision tool and toolkit have been tested in a workshop with 20 target end users from seven Asian countries. The workshop has demonstrated that the tool fills an important gap in the suite of assessment tools available to fisheries managers, and meets the requirements of target end users.

(7) ***EnhanceFish*** provides the first quantitative assessment tool for aquaculture-based fisheries, as well as the most integrated interdisciplinary framework for analysis. As such the project makes a major contribution to the tools and approaches available to fisheries scientists and managers in the developing world.

(8) Project outputs have been, and continue to be disseminated widely through websites, a discussion forum, policy briefs, the tool with guide and manual, and technical publications.

3. Background

Fisheries enhancement through the release of hatchery fish is widely used in inland and increasingly, coastal fisheries. FMSP projects have demonstrated the potential for enhancement to generate significant benefits for the poor, but the approach is often used ineffectively. The reasons for this include institutional issues associated with regulating harvest and sustaining investment in stocking, as well as the technical problem of optimizing stocking and harvesting regimes for local natural, institutional socio-economic conditions (Lorenzen & Garaway 1998; Garaway et al. 2001). FMSP projects have addressed the full breadth of these issues and developed quantitative methods for optimizing stocking and harvesting regimes as well as adaptive learning approaches (Garaway et al. 2002) that integrate scientific analyses with stakeholder experimentation and learning (Lorenzen 1995; 2000; 2005; Lorenzen et al. 1997; 1998). Currently however, adaptive learning initiatives have used only a subset of the quantitative assessment methodologies developed, mostly those methods that are readily implemented using spreadsheet software (e.g. Excel) or standard statistical packages. Some of the more powerful assessment methods developed under the FMSP are currently accessible only to scientists with good mathematical and programming skills.

The aim of the current project was to make these methods more widely accessible and promote their effective integration into adaptive learning approaches to the development of pro-poor enhancement strategies. The project was developed in direct response to the FMSP strategy for 2005, which specifies a need to: *develop and widely promote a decision support tool, and appropriate teaching and communications materials, enabling a wide range of target end users to apply existing FMSP quantitative assessment methods for fisheries enhancement.*

4. Project purpose

Effectiveness of pro-poor fisheries enhancement initiatives in S and SE Asia improved through development and promotion of a decision support tool enabling a wide range of target end users to apply existing FMSP quantitative assessment methods

5. Outputs

The planned outputs if the project were specified as follows:
1. Decision support tool (DST) for quantitative assessment of aquaculture-based fisheries enhancements available
2. Toolkit to guide use of DST in pro-poor enhancement and assessment manual available
3. Training course for target end users conducted and evaluated
4. Decision support tool and toolkit promoted regionally and globally

All outputs have been achieved, and products will be released for general use following review.

5.1 Decision support tool

EnhanceFish

EnhanceFish is a decision support tool for the analysis of aquaculture-based fisheries enhancements. ***EnhanceFish*** is designed to help users analyse quantitatively many of the key management issues in fisheries enhancement such as:

- Effects of different enhancement measures on fisheries yield
- Impacts of enhancement on natural populations of the target species
- Economic performance of enhancement
- Tradeoffs and synergies between stocking and fishing regulations

At the heart of ***EnhanceFish*** is a mathematical population model that predicts fisheries catch and other biological and production attributes for different management controls such as stocking density and fishing effort. ***EnhanceFish*** also calculates basic economic performance indicators such as fishing income, resource rent or the net present value of enhancement approaches.

The ***EnhanceFish*** software is split into five steps, which guide users through the process of data input, model construction and analysis. These five steps are laid out on the main page of the software (see Figure 1):

(1) Entry of basic information
(2) Set up of parameters
(3) Set up of controls
(4) Economic parameters
(5) Analysis

Each Step has a page associated with it in the software.

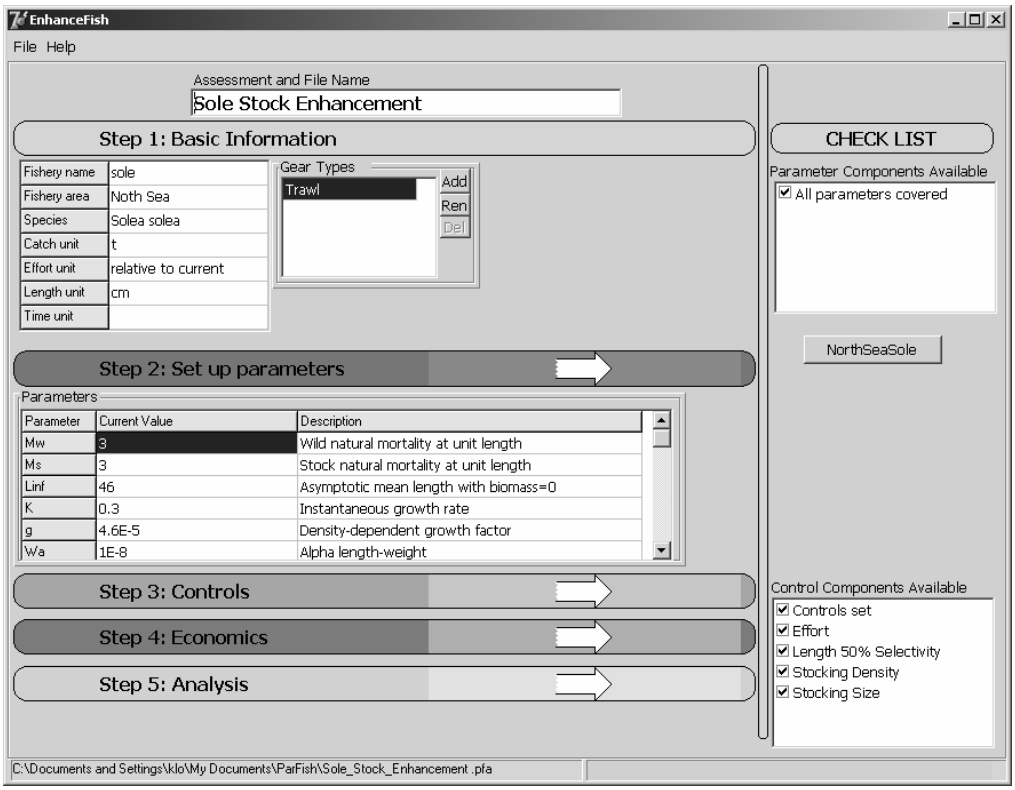

Figure 1. Main page of the EnhanceFish package.

Setting up parameters and controls is a key part of any ***EnhanceFish*** analysis, and one that requires considerable effort and judgement from users who have to draw on multiple sources of system-specific and/or comparative data. To facilitate the setup process, ***EnhanceFish*** represents all process models (e.g. for growth and mortality) graphically at the setup stage (Figure 2). In this way, users can easily understand the process models they set up and judge how the models compare to quantitative information and experience.

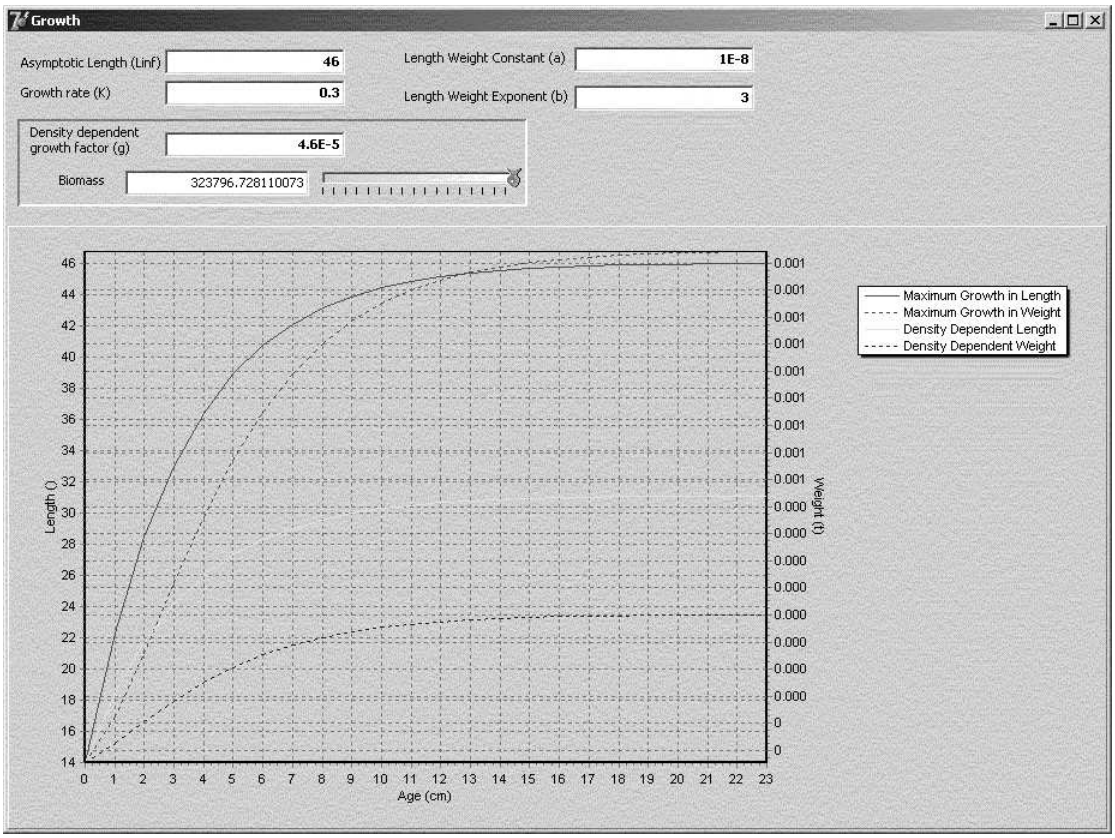

Figure 2. Parameters set up page for the growth model

EnhanceFish analyses allow the prediction responses in:

- Yield from stocked and wild population components;
- Biomass of stocked and wild population components;
- Population age structure;
- Resource rent; and
- Net present value.

To changes in:

- fishing effort;
- gear selectivity;
- stocking density;
- quality of seed fish, and
- stocking size.

EnhanceFish offers a straightforward interface for setting up and running analyses. The analysis page is illustrated in Figure 3, showing the control panel on the right hand side and the output graph on the left.

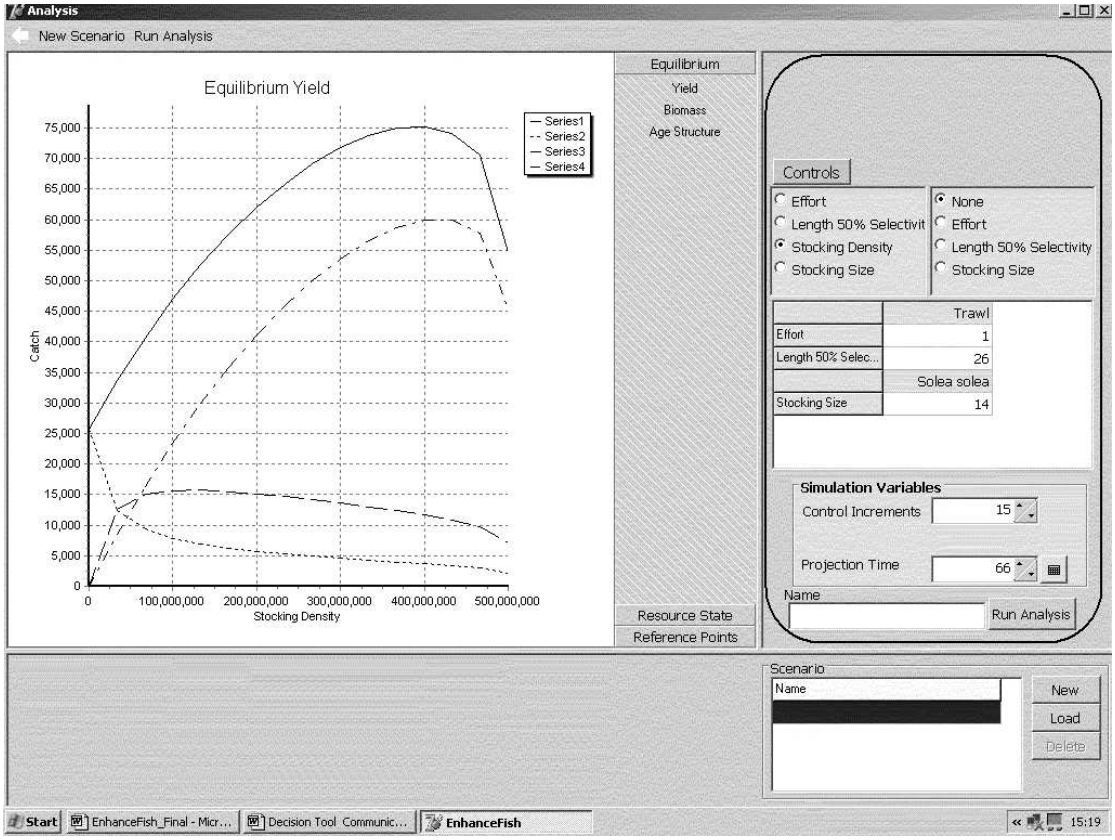

Figure 3. Analysis page of *EnhanceFish*

EnhanceFish is a powerful and general tool for the evaluation of enhancement programmes, from early planning to full-scale operation. Preliminary assessments can be carried out before significant investment in experimental research or production facilities, and before any alternative management options are dismissed or delayed in favour of enhancement. Should a proposed enhancement programme pass the prognostic evaluation and continue to pilot or operational stage, experimental studies may be required to resolve key uncertainties. Close integration of ***EnhanceFish*** population modelling and experimental management is likely to be the most efficient approach to assessing and developing enhancements.

Further details:

Lorenzen, K. & Medley, P.A.H. (2005) ***Enhancefish*** Manual. London: Imperial College. (Annex 3)

Medley, P.A.H. & Lorenzen, K. (2005) ***EnhanceFish***: A decision support tool for aquaculture-based fisheries enhancement. Downloadable from www.aquaticresources.org/enhancefish.

Auxiliary data tools

EnhanceFish is supplied with several auxiliary data tools, currently implemented in an Excel workbook. The tools may used be to

- Estimate growth and mortality parameters from release experiments
- Construct a stock-recruitment relationship

The auxiliary tools support estimation of key input parameters for ***EnhanceFish*** from release experiments of the type commonly carried out in enhanced fisheries (see below for further

details). The tools also allow construction of plausible stock recruitment relationships for fisheries on the basis of life history data and comparative generalisations about the maximum reproductive rate of fish. This allows compensatory responses to enhancement to be gauged even where no population specific stock recruitment relationship is available (a common problem in tropical fisheries).

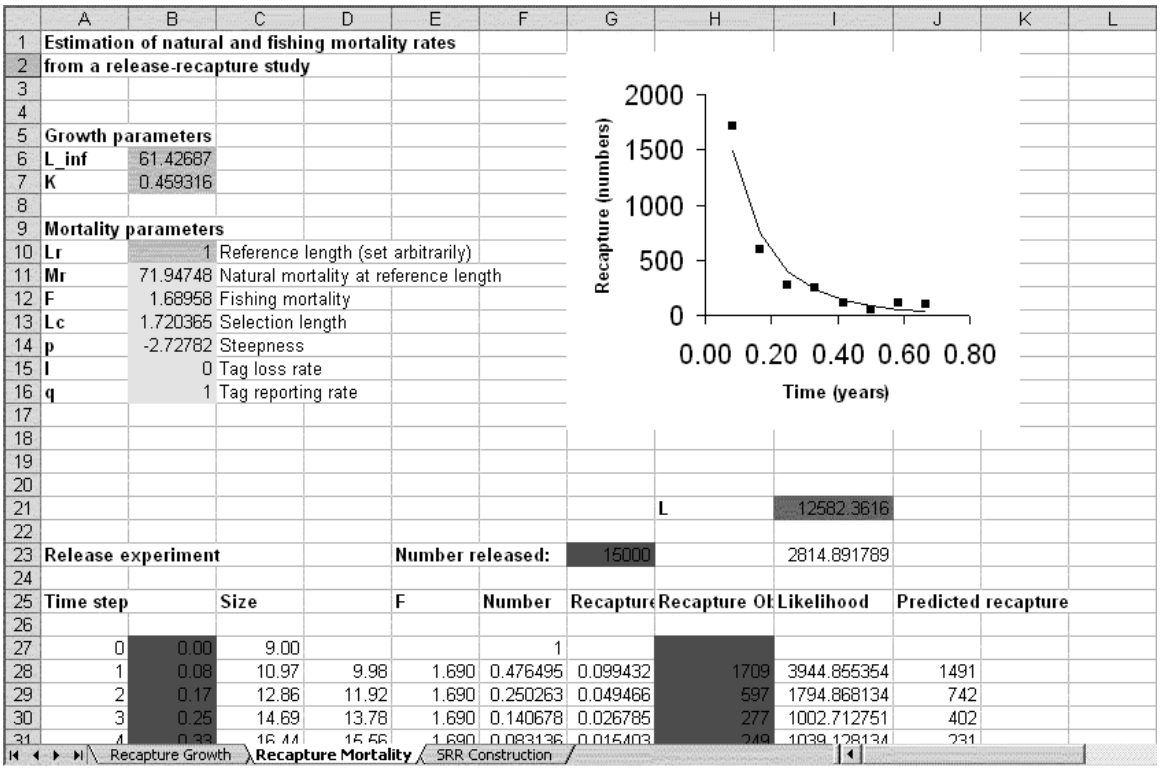

Figure 4: Recapture analysis of a cohort on *Barbodes gonionotus* released in a Cambodian reservoir

Further details:

Lorenzen, K. & Medley, P.A.H. (2005) ***Enhancefish*** Manual. London: Imperial College. (Annex 3)

EnhanceFishDataTools.zip downloadable from www.aquaticresources.org/enhancefish.

Primary research in support of decision tool development

Release experiments are carried out in many enhancement programmes, but are rarely analysed beyond a purely statistical treatment of recapture ratios. This is unfortunate because much useful management information remains hidden unless experiments are analysed within a population dynamics framework. Where such analyses have been carried out, they often involve *ad hoc* assumptions to deal with the problem that natural mortality rates vary over the duration of the experiment. This problem may be overcome, and the analysis simplified and unified through use of a size-dependent mortality model. Such a model has two main functions. First, it allows to model survival and recapture of a released cohort throughout its lifetime even if fish are released as juveniles. Second, it unifies the analysis of cohorts released at different size, which are linked through a common mortality process. The analysis provides direct estimates of size-dependent natural mortality and

fishing mortality patterns, which can then be used to predict recaptures and yield under alternative release and harvesting regimes. Furthermore, the size-dependent natural mortality parameter allows comparative analyses of post-release performance between experiments that differ in release size and fishing patterns. The model, which describes natural mortality as an inverse function of fish length, has been derived in an earlier study and enjoys strong empirical support.

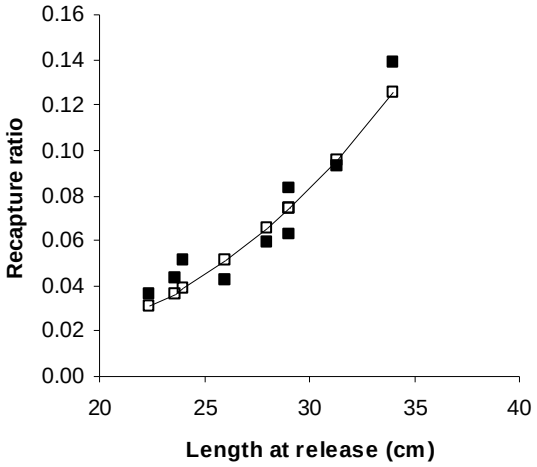

Figure 5. Predicted and observed total recapture ratio as a function of length at release.

By expressing size-dependent mortality in terms of a single parameter, the mortality rate M_r at reference length L_r, the model facilitates comparative analyses of data from experiments in which mortality rates have been measured for different fish sizes. A preliminary comparative analysis shows that natural mortality is more variable and substantially higher on average in released hatchery fish (median M_r = 13.3 year^{-1}) than in wild fish (median M_r = 3.3 year^{-1}) for the same reference length (L_r = 5 cm). Such comparative information provides a benchmark against which the effectiveness of releases may be evaluated. Application of the approach is illustrated through the analysis of published data from a cod (*Gadus morhua*) release experiment in Norway (Figure 5).

Further details:

Lorenzen, K. Population management in fisheries enhancement: gaining key information from release experiments through use of a size-dependent mortality model. *Fisheries Research*, in press. (Annex 4)

5.2 EnhanceFish guide and manual

Guide

The ***EnhanceFish*** guide provides the link between the ecological-technical analyses supported by the decision tool and participatory development of enhancements. The guide covers approaches to the integrated analysis of enhancement systems, communicating with primary stakeholders in the course of analysis and development, and use if the ***EnhanceFish*** tool within the wider development process (Box 1).

Box 1. Contents of the *EnhanceFish* guide

A participatory, integrated process for analysing and developing fisheries enhancements is proposed (Figure 6). The process has five steps, four of which may be iterated repeatedly throughout the development process.

Step 1: Engage stakeholders

In this initial step, stakeholders are identified and engaged in the development and analysis process. Baseline information required for a broad, integrated analysis of the enhancement system is obtained from a variety of sources including the stakeholders. An important output of this step should be the creation of institutional arrangements (formal or informal) that allow effective two-way interaction between analysts and other stakeholders.

Step 2: Understand the enhancement system

A broad, integrated analysis of the enhancement system is conducted. This is best done by an interdisciplinary team in direct interaction with stakeholders. The process should foster a joint and integrated understanding of the system, problems affecting its effectiveness and sustainability, and realistic options for improving the system.

Step 3: Conduct ***EnhanceFish*** analysis

EnhanceFish analysis is carried out by qualified resource management professionals. It involves translating the broad and often qualitative system properties and development options identified in Step 2 into quantitative parameters and controls used in ***EnhanceFish***, and vice versa.

Step 4: Initiate management action and monitoring

Outcomes of the ***EnhanceFish*** analysis are communicated to stakeholders. Stakeholder decision making on management and development options is facilitated as required, and a monitoring programme set up to allow subsequent evaluation of development outcomes. Depending on the level of uncertainty in predicted outcomes and associated risks, explicitly experimental management options may be implemented in order to reduce uncertainties.

Step 5: Evaluate outcomes

Outcomes are evaluated jointly by analysts and other stakeholders. If outcomes are judged to be unsatisfactory or sub-optimal, the analysis process may be re-iterated. Knowledge gained is incorporated into the understanding of the enhancement system (Step 2), the ***EnhanceFish*** analysis refined (Step 3) etc.

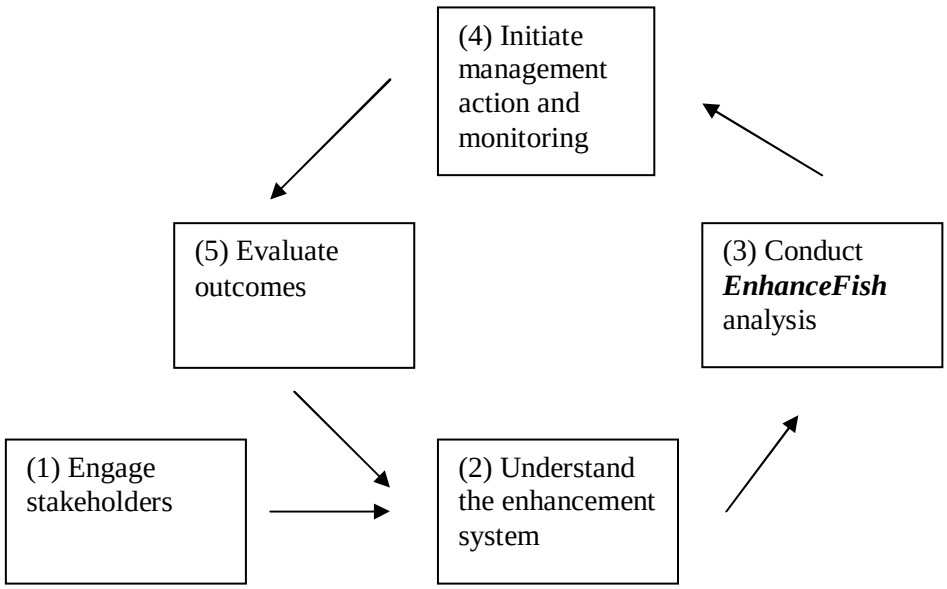

Figure 6. Process framework for using *EnhanceFish* in the development of fisheries enhancements.

The framework used in the integrated analysis of fisheries enhancement systems is shown in Figure 2. The framework has been extended and modified from a general 'institutional analysis' framework for common pool resources (Oakerson 1992; Pido et al. 1996). There are three main types of attributes:

- **Situational variables**, which influence the outcome of fisheries enhancement either directly or through the incentives they provide for resource user action
- **Patterns of interaction**, the aggregated actions of resource users as influenced by incentives provided by the situational variables
- **Outcomes** of resource use as influenced by the physical and biological characteristics of the resource, and its use (patterns of interaction).

Between the attributes, there are two types of **interactions: Operational interactions** (solid lines) determine outcomes in the short term when the situational variables are fixed. In **dynamic interactions** (dashed lines) situational variables are modified in response to the outcomes of operational interactions. Both types of interactions may involve direct physical-biological effects, and interactions mediated by stakeholder action. For example, life history characteristics of the target fish population will directly affect yield through ecological processes. Life history characteristics such as migratory behaviour will also influence the incentives for fishers to restrict exploitation (in anticipation of future benefits), thus influencing yields via the resulting pattern of exploitation. Similarly, dynamic interactions could involve direct biological feedback (such as a decline in wild stock productivity due to competition with stocked fish), or modification by stakeholders of harvest rules or aquaculture production techniques in the light of outcomes seen as undesirable.

The **situational variables** are structured in six groups:

1) Physical and biological attributes of the resource
   - The physical environment
   - The ecology of aquatic resource production

2) Technical attributes of fishing
   - Efficiency and selectivity of fishing techniques

3) Biological and technical attributes of aquaculture production
   - Techniques used in aquaculture production and release for enhancement

4) Attributes of stakeholders
   - Livelihoods of primary stakeholders: resource users and seed producers
   - Interests and influence of other stakeholders

5) Market (supply and demand) attributes
   - The economic environment
   - The state and accessibility of markets for labour, and input and outputs of the fishery

6) Institutional arrangements
   - Operational rules for resource use (rules that determine by whom, where, when and how resources may be used)
   - Conditions of collective choice, which are the set of rules which determine how operational rules can be made
   - External arrangements pertaining to rules and conditions of collective choice.

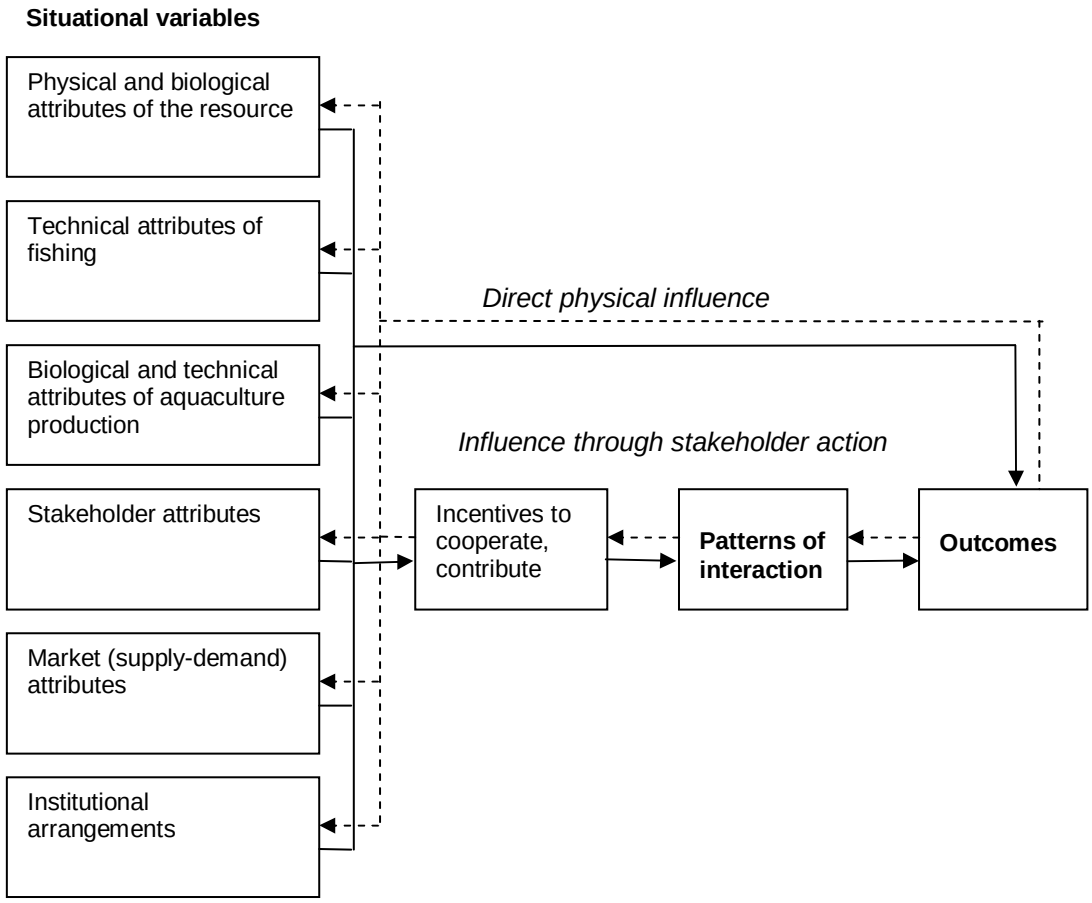

Figure 7 Framework for analysing fisheries enhancement systems. Adapted from Oakerson (1992) and Pido et al. (1996).

Patterns of interaction are the aggregation of all the actions taken by individual resource users, in the light of situational attributes, over a period of time. For example, individual fishers will decide how much effort to expend on fishing in the light of the status of stocks (biological attribute), the value they place on fishing compared to alternative activities (stakeholder attributes), the market price of fish (economic attributes), and the rules for resource use as well as the expected penalty for breaking these (institutional attributes). Aggregated over all fishers and a period of time, these decisions define the level of harvesting effort in the fishery.

Outcomes of resource use are physical (e.g. stock abundance or production) at the most basic level. Stakeholders attach values to physical outcomes according to their own objectives and situations, and thereby translate physical outcomes into benefits and costs.

Use of the framework is fully explained in the ***EnhanceFish*** Guide.

Further details:

Lorenzen, K. (2005) ***Enhancefish*** Guide. London: Imperial College. (Annex 2)

Manual

The ***EnhanceFish*** manual guides users through quantitative assessment using the software package. The manual includes a brief introduction to the population dynamics of fisheries enhancements, use of the software package, and guidance on conduction analyses including cases studies (Box 2). The manual is a 'living document' that will be updated regularly in response to user feedback and further development of the software.

Box 2. Contents of the *EnhanceFish* manual

Further details:

Lorenzen, K. & Medley, P.A.H. (2006) ***Enhancefish*** Manual. London: Imperial College. (Annex 3)

5.3 Training course for target end users

A regional training course on the use of the tool and toolkit was held in collaboration with NACA/STREAM and the Mekong River Commission Fisheries Programme. The course had two major, linked components

- an e-workshop on broad analysis of enhancement systems in preparation for ***EnhanceFish*** analysis,
- a residential one week training course focusing on ***EnhanceFish*** analysis and its application to participant's case studies

The full training course was attended by 20 participants from 7 Asian countries. A number of other aquatic resources professionals participated in e-workshop activities.

E-workshop

The electronic workshop was run for about one month prior to the residential course. It involved information on ***EnhanceFish*** being made available through websites and direct e-mailing to participants, a public discussion forum (Figure 8), and direct e-mail contact with and among participants.

The e-workshop as successful in raising awareness of ***EnhanceFish***, and the need for and approaches to integrated analysis of enhancement systems. Most workshop participants were already engaged in participatory management activities with fishers, and would draw on these ongoing activities to conduct the broad-based analysis suggested as part of applying the ***EnhanceFish*** tool. Direct e-mail contact proved more effective in creating and maintaining momentum for the activity than the public discussion list, which nonetheless created substantial public awareness of the course. The discussion list is being maintained and will be re-invigorated upon public release of ***EnhanceFish***.

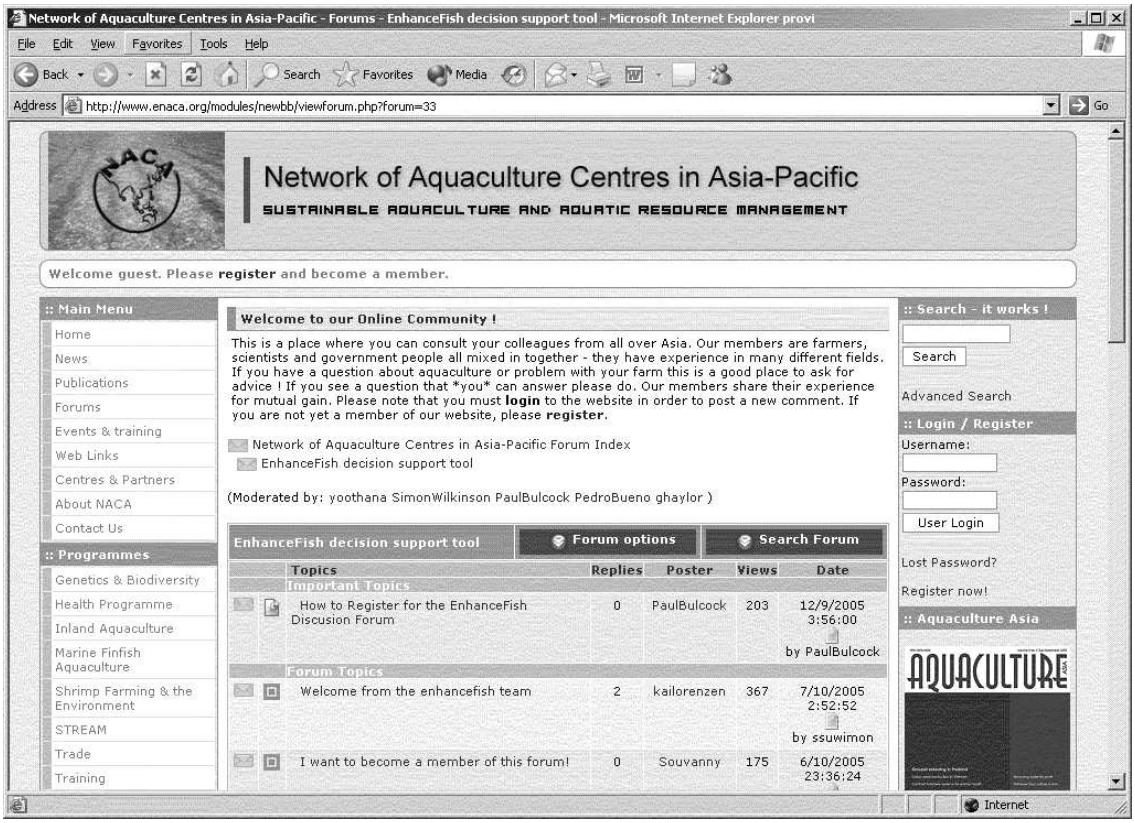

Figure 8. EnhanceFish discussion forum, launched in advance of the training course and to be maintained for at least another 6 months.

Residential course

The residential training course was held from 17 to 21 October at NACA/STREAM in Bangkok. Participants included fisheries management staff and applied and strategic research scientists from government departments, universities and regional organisations (Table1, Figure 9). During the residential course, participants completed the broad-based integrated analysis of case study systems initiated during the e-workshop, and conducted quantitative analyses of these systems using ***EnhanceFish*** (see schedule in Box 3).

Figure 9. Participants of the EnhanceFish training course at NACA, 17-21 October 2005.

Much of the work during the workshop was carried out in groups focusing on three case study systems:

- Developing a culture-based fishery for *Barbodes gonionotus* in Thmorda reservoir in Cambodia
- Enhancing natural fish populations in Ubolratana reservoir, Thailand
- Sturgeon enhancement in the Caspian Sea.

The workshop was very successful: participants were able to conduct both the broad-based integrated analysis and quantitative assessments for the case study systems. Two of the case studies have been incorporated into the ***EnhanceFish*** installation package as example analyses.

Box 3. *EnhanceFish* workshop schedule

Monday 17 October 2005

- Welcome and introduction of participants
- Introduction to ***EnhanceFish*** and workshop objectives
- Presentations by participants on 'their' enhancement fisheries
- Formation of case study groups and group work to provide broad-based analysis of case study systems
- Group presentations in case study systems and discussion on key issues

Tuesday 18 October 2005

- Overview of the scientific basis of to ***EnhanceFish***
- Using ***EnhanceFish*** (interactive demonstration)
- ***EnhanceFish*** practical
- ***EnhanceFish*** practical continued

Wednesday 19 October

- How to get the input data needed for ***EnhanceFish***
- Analysing data to estimate parameters for ***EnhanceFish*** (with exercises)
- Group work on case studies: questions for analysis and sources of information
- Presentations and discussion on proposed analyses and data sources

Thursday 20 October

- Group work: analyses of case study fisheries
- Group work: analyses of case study fisheries
- Group work: analyses of case study fisheries
- Group work: analyses of case study fisheries

Friday 21 October

- Synthesis of group work for presentation
- Presentations on group work
- Evaluation of ***EnhanceFish*** and workshop

Monitoring of workshop proceedings and outcomes by facilitators, and feedback from participants identified a variety of mostly minor issues with the preliminary versions of project outputs used in the workshop. These have been addressed in subsequent modifications.

All participants considered ***EnhanceFish*** a tool that will be useful to their future work. It was clear that ***EnhanceFish*** fills a major gap in the suite of assessment tools available to fisheries professionals, which does not yet include any tools for the analysis of enhancement.

Figure 10. Group work during the *EnhanceFish* workshop: applying the tool to participant's case studies.

5.4 Regional and global promotion of the EnhanceFish toolkit

The ***EnhanceFish*** decision tool and toolkit were, and continue to be promoted in the Asia-Pacific region and globally. Details are reported in Section 7.

6. Research activities

Research activities were largely desk-based and most have been implicitly reported in the outputs section (Section 5). Hence only a very brief account is given here.

6.1 Development of EnhanceFish decision support tool

Population dynamics models for aquaculture-based fisheries enhancements developed under previous FMSP projects were synthesized and implemented in a software package. The package is designed to support analysis and decision making in relation to fisheries enhancement at all stages in the project cycle. A number of auxiliary data analysis tools were also developed, in particular for the analysis of release experiments.

6.2 Development of EnhanceFish guide and manual

The ***EnhanceFish*** guide and manual were developed by synthesizing research results of previous FMSP projects with a particular reference to providing general guidance on the analysis and development of fisheries enhancements. Key elements of the guide and manual were tested in the training course for target end users, and subsequently modified in the light of workshop outcomes.

6.3 Training course for target end users

A regional training course on the use of the tool and toolkit was held through NACA/STREAM and in collaboration with the Mekong River Commission Fisheries Programme. The course had two major, linked components: a three months e-workshop on the use of the toolkit, and a residential one week course focusing on the decision tool while building on, and evaluating use of the toolkit by participants during the e-workshop. Training outcomes were monitored and evaluated to identify and address problems encountered with the practical use of the decision tool.

6.4. Promotion of EnhanceFish Toolkit

The ***EnhanceFish*** decision tool and toolkit were, and continue to be promoted in the Asia-Pacific region and globally. Dissemination and promotion was and is being carried out through established channels and means of NACA/STREAM and FAO. Further details are given in Sections 7 and 8.

7. Contribution of outputs

7.1 Contribution to development goals

EnhanceFish provides the first quantitative assessment tool for aquaculture-based fisheries, as well as the most integrated interdisciplinary framework for analysis and development. As such the project makes a major contribution to the tools and approaches available to fisheries scientists and managers in the developing world.

Fisheries enhancements offer particular opportunities for fishers to increase production and/or productivity of their resources (Lorenzen et al. 2001, Garaway et al. 2001). Enhancement can improve the livelihoods of fishers by increasing the productivity of fisheries resources, fostering institutional change that can lead to a more equitable and sustainable use of resources, and building of social capital. However, to be successful enhancements must involve far more than stocking. For example, stocking and harvesting practices must be coordinated and tailored to the physical and socio-economic environment in order to achieve good production, seed fish be produced so that they perform well after release, and management institutions must be capable of coordinating these activities. ***EnhanceFish*** aids the planning and management of aquaculture-based fisheries enhancements: assessing whether enhancement is beneficial at all in a particular situation and if so, how the enhancement should be managed in order to achieve its objectives.

The ultimate beneficiaries are aquatic resource users in inland (and coastal) areas of South and Southeast Asia who are involved in, or may have opportunities to become involved in aquaculture-based fisheries enhancements. The direct beneficiaries are research and extension specialists in government departments and NGOs who are involved in promoting and improving fisheries enhancements. It is unlikely that any groups would be disadvantaged by the application of research findings.

7.2 Promotion of outputs

Dissemination and promotion to a wide range of communication stakeholders was and is being carried out through a variety of channels and means as outlined in the communication matrix (Table 1).

The main planned communication products (Table 1) have been developed and promoted:

- The Training course (e-workshop and residential course)
- The ***EnhanceFish*** decision tool
- The ***EnhanceFish*** guide and manual
- A policy brief
- Professional publications

The workshop has been reported on under Section 5.3. The other communication products are listed under Section 8, and appended to this report.

Monitoring and evaluation

Monitoring and evaluation of the communications strategy was based primarily on records from the e-workshop, results from case study assessments carried out by participants of the residential workshop, and structured feedback provided by participants. This was reported under Section 5.3, and more detailed feedback is documented in the ***EnhanceFish*** Training workshop outputs (CD ROM). A full list of workshop participants is given in Table 2.

By the end of October 2005, project websites have registered 'hits' as follows:

- NACA ***EnhanceFish*** page: 137
- Lorenzen Lab ***EnhanceFish*** pages: 82
- ***EnhanceFish*** discussion forum: up to 418 viewings per message

7.3 Planned further promotion of outputs

The main outputs (tool, manual and guide) will be made publicly downloadable by the end of 2005, following continued testing by collaborators and review by FMSP programme management. The outputs are already well publicized, and a news release on key web sites and discussion lists at the time of release will ensure rapid uptake.

The ***EnhanceFish*** discussion forum on the NACA/STREAM website will remain open and is expected to become very lively once the outputs are downloadable. Support for users will be provided via this forum and the dedicated ***EnhanceFish*** email help. (enhancefish@aquaticresources.org).

A professional outreach paper for Aquaculture Asia, and a technical paper on the EnhanceFish package are in preparation.

Table 1: Project Communications Matrix.

Communication stakeholders	Research Product / message to be communicated	Current knowledge, attitude, practice of stakeholders	Communication objectives: Desired outcome of communication / promotion	Communication channels and media in which research product will be communicated	Approach to monitor and evaluate implementation of communications plan
Poor fishers and their organizations in India, Laos, Thailand & Vietnam	Adaptive learning approaches and assessment methods implemented in partnership with fisheries management personnel can improve performance of enhancements	Knowledge of stocking and harvesting strategies limited, practice determined by seed availability or (occasionally) ad hoc experimentation	Stakeholders appreciate that performance of enhancements can be improved through adaptive learning, and seek advice from management personnel	Direct communication with fisheries management personnel guided by toolkit as training course (e-workshop activities)	Monitoring and evaluation of training course outcomes,
Fisheries management personnel in government departments and NGOs in India, Laos, Thailand & Vietnam and regionally	Practical use of assessment methodology for fisheries enhancements in partnership with fishers	Limited knowledge of assessment methods, keen to provide advice but reliant mostly on non-scientific information	Stakeholders understand principles of assessment and interaction with fishers and seed producers, and are enabled to carry out assessments using tools developed	Training course (e-workshop and residential course); tool, toolkit and manual, professional publications	Evaluation of training course outcomes, downloads of DST and toolkit
Applied researchers in NARS and IARCs in India, Laos, Thailand & Vietnam and regionally/globally	Scientific basis and practical use of assessment methodology for fisheries enhancements	Limited knowledge of assessment methods, interested in assessment but unable to use advanced methods due to lack of tools	Stakeholders understand underlying principles and are enabled to carry out assessments using tools developed	Training course (e-workshop and residential course); tool, toolkit and manual, professional publications.	Evaluation of training course outcomes, requests for downloads of DST and toolkit , personal professional contacts
Strategic researchers in NARS and IARCs in	Scientific basis, application and	Limited knowledge of scientific basis and tools	Stakeholders appreciate that	Training course (e-workshop and	Evaluation of training course outcomes,

India, Laos, Thailand & Vietnam and regionally/globally	opportunities for further development of assessment methodology for fisheries enhancements	for assessment of enhancements, focus research on details of biology rather than strategic assessment	scientific methods for strategic assessments are available and can inform management decisions	residential course); tool, toolkit and manual, professional and scientific publications.	requests for downloads of DST and toolkit , personal professional contacts
National and international policy makers in India, Laos, Thailand & Vietnam and regionally/globally	Benefits of using quantitative assessment in the development of enhancements	Knowledge of potential for assessment low, enhancement seen as inherently positive or negative, low willingness to request assessments despite substantial funding for implementation of enhancements	Stakeholders appreciate need for objective and quantitative assessments and request scientists/managers to conduct such work	Policy briefs including case studies	Inclusion of assessment requirements in national policies
National and international development planners and consultants in India, Laos, Thailand & Vietnam and regionally/globally	Benefits of using quantitative assessment in prognostic evaluation of enhancement proposals	Potential for quantitative prognostic evaluation is poorly appreciated	Stakeholders appreciate potential for prognostic evaluation to support decision making about potential enhancement projects and request scientists/managers to conduct such work	Policy briefs including case studies	Prognostic evaluation conducted prior to decisions to invest in enhancement projects

Table 2. Participants of the EnhanceFish training course at NACA, 17-21 October 2005.

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Paul Bulcock	Research Associate NACA STREAM	paul.bulcock@enaca.org
Christopher Keating	M and E Advisor NACA STREAM	Chris.j.keating@gmail.com

8. Publications and other communications materials

Peer-reviewed publications (in press)

Lorenzen, K. Population management in fisheries enhancement: gaining key information from release experiments through use of a size-dependent mortality model. *Fisheries Research*, In press.

Non peer-reviewed publications, reports and communications materials

Lorenzen, K. & Medley, P.A.H. (2005) ***Enhancefish*** Manual. London: Imperial College.

Lorenzen, K. (2005) ***Enhancefish*** Guide. London: Imperial College.

Anon. (2005) ***EnhanceFish*** Project Briefing. 4 pp.

Anon. (2005) ***EnhanceFish Policy Briefing*** 2pp. STREAM Initiative.

Anon. (2005) Workshop on the fishery management tool ***EnhanceFish***. NACA Newsletter October-December 2005, p. 4.

Verbal presentations, project dissemination and other workshops

Verbal conference presentation:

Lorenzen, K. Population dynamics of fisheries enhancement. British Ecological Society Annual Symposium, Hatfield, UK.

Workshop:

EnhanceFish Training Workshop at NACA/STREAM in Bangkok, 17-21 October 2005.

Other types of project output

Software:

Medley, P.A.H. & Lorenzen, K. (2005) ***EnhanceFish***: A decision support tool for aquaculture-based fisheries enhancement. Imperial College.

Website and discussion forum:

Main ***EnhanceFish*** site (main download site)
www.aquaticresources.org/enhancefish.htm

NACA/STREAM ***EnhanceFish*** discussion forum
www.enaca.org/modules/newbb/viewforum.php?forum=33

Workshop outputs:

Enhancefish Training workshop outputs (CD ROM)

9. References

Garaway, C., Arthur, R. & Lorenzen, K. (2002) Adaptive learning in inland fisheries enhancement. Final Technical Report of R7335, MRAG Ltd.

Garaway, C., Lorenzen, K. & Chamsingh, B. (2001) Developing fisheries enhancements in small waterbodies: lessons from Lao PDR and Northeast Thailand. ACIAR Proceedings 98: 227-234.

Lorenzen, K. (1995) Population dynamics and management of culture-based fisheries. *Fisheries Management and Ecology* 2: 61-73.

Lorenzen, K. (1996) A simple von Bertalanffy model for density-dependent growth in extensive aquaculture, with an application to common carp (*Cyprinus carpio*). *Aquaculture* 142: 191-205.

Lorenzen, K. (1996) The relationship between body weight and natural mortality in fish: a comparison of natural ecosystems and aquaculture. *Journal of Fish Biology* 49: 627-647.

Lorenzen, K. (2000) Allometry of natural mortality as a basis for assessing optimal release size in fish stocking programmes. *Canadian Journal of Fisheries and Aquatic Sciences* 57: 2374-2381.

Lorenzen, K. (2005) Population dynamics and potential of fisheries stock enhancement: practical theory for assessment and policy analysis. *Philosophical Transactions of the Royal Society B*. 360: 171-189.

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Lorenzen, K., Juntana, J., Bundit, J. & Tourongruang, D. (1998) Assessing culture fisheries practices in small water bodies: a study of village fisheries in Northeast Thailand. *Aquaculture Research*. 29: 211-224.

Lorenzen, K., Xu, G., Cao, F., Ye, J. & Hu, T. (1997) Analysing extensive fish culture systems by transparent population modelling: bighead carp, *Aristichthys nobilis* (Richardson 1845), culture in a Chinese reservoir. *Aquaculture Research* 28: 867-880.

Lorenzen, K. & Garaway C.J. (1998) How predictable is the outcome of stocking? *FAO Fisheries Technical Paper* 374: 133-152.

10. Project Logframe

Narrative summary	Objectively verifiable indicators	Means of verification	Important assumptions
Goal			
Existing FMSP research outputs relating to: the contribution of capture and enhancement fisheries to the livelihoods of the poor; fisheries management tools and strategies that could benefit the poor; and, the means to realise improved management, further developed, disseminated and promoted to relevant stakeholders at all levels	1. By 31 March 2006, at least three fisheries information products developed to inform management research and influence policy (in target countries, international knowledge systems and DFID). 2. Pro-poor enhancement fisheries management strategies actively promoted into at least four target institutions in two target countries and widely promoted (nationally and internationally) by 31 March 2006.	• Programme Management review • Project FTRs • Programme highlights • Publications and other communications materials • Teaching materials • Fisheries management tools • Quarterly and annual reports • FMSP project database • FMSP Website • Requests for manuals and guidelines received • Uptake of research products by target institutions monitored and reported in Annual Report • National statistics and publications • International networks, databases and publications	1. Policy makers remain receptive to information on fisheries management 2. Stock enhancement process cost effective and socially appropriate.
Purpose			
Effectiveness of pro-poor fisheries enhancement initiatives in S and SE Asia improved through development and promotion of a decision support tool enabling a wide range of target end users to apply existing FMSP quantitative assessment methods	Target institutions use decision tool and toolkit, have established linkages with primary stakeholders, and are providing improved management advice	Monitoring of use of toolkit during e-workshop, use of tool on information gathered during residential workshop, and continuation of activities following end of project through NACA/STREAM	Target institutions remain committed to, and are adequately resourced to support pro-poor enhancement strategies
Outputs			
1. Decision support tool (DST) for quantitative assessment of aquaculture-based fisheries enhancements available 2. Toolkit to guide use of DST in pro-poor enhancement, and assessment manual available 3. Training course for target end users conducted and evaluated 4. DST and toolkit promoted regionally and globally	1 Tool available by September 2005 2 Toolkit available as draft by July 2005, final version by October 2005 3 Training course for at least 10 target end users completed by October 2005 4 Professional publications, and policy briefs published by October 2005	Quarterly and final reports, including evaluation of communication strategy	Target end users remain interested in assessment methodology for enhancements and participate actively in the training course

Activities	Milestones	
1.1 Review of existing models 1.2 Development of assessment procedures 1.3 Implementation of models and procedures in software package 2.1 Toolkit for use of decision tool within adaptive learning approaches developed 2.2 Synthesis of assessment principles 2.3 Case study assessments conducted and documented 2.4 Guide to use of software written 3.1 Training materials developed from toolkit and manual 3.2 Toolkit training e-workshop 3.3 DST training course 3.4 Evaluation of training course outcomes 4.1 Communications plan fully developed and implemented 4.2 Project publicised via policy briefs, professional publications and electronic resources 4.3 Decision support tool and manual made available for downloading 4.4 Monitoring and evaluation of communications plan	1.1 Review completed by May 2005 1.2 Assessment procedures developed by June 2005 1.3 Models and procedures implemented in software package by August 2005 2.1 Draft toolkit available by July 2005 2.2 Synthesis of principles completed by May 2005 2.3 Case study assessments completed by July 2005 2.4 Guide to use of software completed by August 2005 3.1 Toolkit training materials available by July 2005, DST training materials by September 2005 3.2 E-workshop outputs available by August 2005 3.3 Training course held September 2005 3.4 Training course outcome evaluated by September 2005 4.1 Communication plan available 4.2 Information on project available regionally by April 2005; professional publications describing decision tool and benefits of using it available by September 2005 4.3 Decision support tool and manual available for downloading by October 2005 4.4 Evaluation of communications plan and uptake available by October 2005.	

11. Keywords

Fisheries, enhancement, decision analysis, model

12. Annexes

Annex 1:
Enhancefish Policy Brief. STREAM Initiative.

Annex 2
Lorenzen, K. (2005) ***Enhancefish*** Guide. London: Imperial College.

Annex 3:
Lorenzen, K. & Medley, P.A.H. (2005) ***Enhancefish*** Manual. London: Imperial College.

Annex 4:
Lorenzen, K. Population management in fisheries enhancement: gaining key information from release experiments through use of a size-dependent mortality model. *Fisheries Research*, In press.