APPENDIX A

LIST OF PARTICIPANTS IN THE BIO-ECONOMIC MODELLING WORKSHOP

Thai demersal fisheries in the Gulf of Thailand
31 May - 8 June 2000
Melia Hua Hin hotel, Hua Hin, Thailand

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APPENDIX B

LIST OF PARTICIPANTS IN THE POLICY DIALOGUE MEETING

Management of the demersal fisheries in the Gulf of Thailand
9 June 2000
Melia Hua Hin hotel, Hua Hin, Thailand

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Ms Atchara Vibhasiri Senior Biologist	See Appendix A
Ms Pismorn Isara Senior Biologist	See Appendix A
Mr Wirat Sanitmajjaro Biologist	See Appendix A
Mr Kanit Chuapun Biologist	See Appendix A

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Ms Waraporn Dechboon Biologist	See Appendix A
Mr Suthep Juala-ong Biologist	See Appendix A
Ms Amporn Lawapong Economist	See Appendix A
Ms Wacherapranee Claithong Economist	See Appendix A
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APPENDIX C

OPENING REMARKS

by

Mr.Somsak Chullasorn
Senior Marine Fishery Advisor
Department of Fisheries

31 May 2000, Melia Hua Hin Hotel, Hua Hin, Thailand

Distinguished Guests
Ladies and Gentlemen,

On behalf of the Thai Department of Fisheries, I would like to express our great pleasure to welcome our participants from abroad both from countries far away as well as from our neighboring countries to the Bio-Economic Modelling Workshop on the Thai Demersal Fisheries in the Gulf of Thailand.

This workshop is of particular importance for the future of the demersal fisheries in the Gulf of Thailand. Most of you are aware of the serious biological and economic conditions, which these fisheries are facing. The level of resources exploitation has increased significantly during the last three decades. This has resulted not only in a substantial increase in fish harvest but also in a large decline of the Catch per Unit of Effort. As a consequence, the economic performance of the fisheries has been suffered and conflicts among different groups of fishermen have increased. There is definitely a need to rationalize these fisheries activities and the findings from this workshop are expected to be valuable to guide the Department of Fisheries in this task.

One area of priority is to find a means of reducing the trawling effort in the Gulf of Thailand. Such a fleet reduction or decommissioning programme will have social and economic implications that require a careful analysis.

Another priority of the Department of Fisheries is to effectively curb and ban push-net fishing in the entire Gulf of Thailand. This was subject of recent discussion in the National Fisheries Policy Committee that re-iterated the importance of expeditious cessation of push-net fishing.

This workshop offers a unique opportunity for the Department of Fisheries to analyse, in an integrated fashion, the biological and socio-economic effects of the transition to more responsible fisheries. This is in line with our commitment to implement the FAO Code of Conduct for Responsible Fisheries and the International Plan of Action on the Management of Fishing Capacity. In this endeavour, we are very glad to be able to draw upon the expertise and experience from all of you.

This workshop benefits greatly from the financial and technical support of FAO, especially its FAO/NORWAY FISHCODE Project, and the support of ICLARM. The workshop also benefits from prior work done by the Danish Institute of Fisheries Research in the area of bio-economic modelling and software development.

During your stay in this beautiful part of the Gulf of Thailand, Hua Hin/ where there are a variety of tourist attractions, you should take the opportunity to observe some of our rich fisheries traditions by yourself and enjoy its culinary fruits.

Ladies and Gentlemen,

I wish you a very fruitful workshop and a pleasant stay in Kingdom of Thailand. Finally, on behalf of the Department of Fisheries and the Thai Royal Government, I would like to formally declare open this workshop.

Thank You

APPENDIX D

AGENDA BIO-ECONOMIC MODELLING WORKSHOP

Thai Demersal Fisheries in the Gulf of Thailand
31 May - 8 June 2000

Wednesday 31 May

9.00	Opening (Mr Somsak Chullasorn)
9.20	Introduction of workshop objectives & agenda and participants (Mr Rolf Willmann and Mr Pongpat Boonchuwong)
9.40	An overview of the regional fisheries management in Asia (Dr Mahfuzuddin Ahmed)
10.45	An overview of the fisheries management issues in the Gulf of Thailand and of existing and planned fisheries management regulations (Mr Somsak Chullasorn and Dr Mala Supongpan)
11.30	Introduction to bio-economic modelling

- The Gordon-Schaefer model (Dr Mahfuzuddin Ahmed)
- Past application of the Gordon-Schaefer model to the Gulf of Thailand (Dr Rungrai Tokrisna)
- Thompson and Bell model: the BEAM 5 model (Mr Per Sparre and Mr Rolf Willmann]
- ECOPATH model (Dr Villy Christensen)

14.45 An overview of the available data on the fisheries of the Gulf of Thailand

- Biological and ecological data (e.g. time series of catches, catch composition, CPUE, estimates of stock sizes and of F and M, changes of fish habitats, data gaps) (Dr Mala Supongpan)
- Technological data (e.g. historical evolution of fishing methods, number and sizes of vessels and gear, on-board equipment, modes of fishing operations, types and numbers of fish processing firms) (Mr Pongpat Boonchuwong)
- Economic and social data (e.g. time series of fish prices, numbers of fishermen, fixed and variable harvesting costs, fixed and variable fish processing costs, crew income, return on investment of different vessel

types and vessel sizes, fishing subsidies, factors affecting labour mobility; fisheries management costs) (Mr Pongpat Boonchuwong and Dr Somying Piumsombun)

- Institutional data (e.g. fisheries administration; monitoring, control and surveillance capacity) (Dr Somying Piumsombun)

Thursday, 1 June

9.00 Design of bio-economic models for the demersal fisheries of the Gulf of Thailand

- A Gordon-Schaefer composite global model
- BEAM 5 model

10.45 Design of bio-economic models for the demersal fisheries of the Gulf of Thailand (continuing)

- ECOPATH-based multi-species model

13.30 Break-up into data preparation working groups

- Working Group A – preparation of biological and economic input data for Gordon-Schaefer global composite model
- Working Group B - preparation of biological and economic input data for BEAM 5
- Working Group C - preparation of biological and economic input data for ECOPATH

Friday, 2 June

9.00 Working groups (continuing)

13.30 Plenary presentation by data preparation working groups on their findings

16.00 Modelling working groups

- Gordon-Schaefer – modelling group
- BEAM 5 - modelling group
- ECOPATH modelling group

Saturday, 3 June (half day)

Modelling working groups (continuing)

Sunday, 4 June (free)

Monday, 5 June

Modelling working groups (continuing)

Tuesday, 6 June

9.00	Modelling working groups (continuing)
13.00	Plenary presentation by modelling working groups on their findings and discussion
16.00	Modelling working groups (continuing)

Wednesday, 7 June

9.00	Preparation of draft report of modelling results

Thursday, 8 June

9.00	Preparation of draft report of modelling results (continuing)
13.00	Plenary discussion of draft report. Preparation of draft report of modelling results.
16.00	Amendment of draft report

APPENDIX E

AGENDA POLICY DIALOGUE MEETING

Management of the Demersal Fisheries in the Gulf of Thailand

9 June 2000[12]

9.00	Opening (Dr Oopatham Pawaputanon, Deputy Director General, DOF)
	Chairman Dr Anant Saraya
9.15	Salient findings of the bio-economic analysis of the demersal fisheries in the Gulf of Thailand (Dr Somying Piumsombun, Mr Pongpat Boonchuwong, and Ms Atchara Vibhasiri)
10.30	The management issues of the demersal fisheries in the Gulf of Thailand (Mr Somsak Chullasorn)
11.30	Fishermen's point of view on marine fisheries management issues (Mr Kumpol Shotepunyo, Executive Committee, Thai Fishermen's Association)
	Chairman Mr Somsak Chullasorn
13.30	Policy options for the management of the demersal fisheries of the Gulf of Thailand (Dr Veravat Hongskul)
16.00	Closure (Mr Somsak Chullasorn)

[12] The Meeting was conducted in Thai

APPENDIX F

ABBREVIATED DESCRIPTION OF BEAM 5

by
Per Sparre
and
Rolf Willmann

INTRODUCTION

BEAM 5 stands for “Bio-Economic Analytical Model No. 5. It is a multi-species, multi-fleet dynamic software implementation of a bio-economic stochastic simulation model, the fifth in a series of bio-economic models produced by FAO aiming at assisting fisheries researchers and managers to generate improved advice for fisheries management and policy-making (Cochet & Gilly, 1990; Coppola, Garcia & Willmann, 1992; Sparre & Willmann, 1993).

Apart from being implemented in Visual Basic with an EXCEL user interface, the key new features of BEAM 5 as compared to BEAM 4 are as follows:

- Non-equilibrium dynamic biological model;
- Optional stock-recruitment relationship;
- Optional stochastic variability of selected biological parameters;
- Dynamic economic model based on the concepts applied in project analysis;
- Inclusion of fisheries management costs and analysis of the impact of fisheries management and fiscal measures on government budget;
- Optional modelling of a buy-back or decommissioning scheme with compensation payments for boat-owners and fishing crew;
- Optional behavioural rules of fishing firms governing fishing effort and investment;
- Optional flexibility of ex-vessel prices in response to changes in fish supply (i.e. landings).

These new features allow the use of BEAM 5 in the analysis of the bio-economic and socio-economic effects of the transition process from a poorly managed fishery with excessive fleet sizes, depleted stocks and low or negative returns on investment to a well managed fishery, where stocks are recovering and fleet sizes and fishing effort are being adjusted to desirable levels.

The adjustment process would usually entail certain up-front transition costs for a buy-back or decommissioning scheme of redundant fishing vessels and compensation for displaced crewmembers. Such transition costs would often have to be financed by government whether or not they are subsequently recovered from the fishery participants through taxes, fishing licensing fees or other levies.[13] Investments may also be needed to upgrade the fisheries management capacity at various levels: for improved research; monitoring, control and surveillance; and educational and organisational activities in the promotion of effective co-management arrangements between government and fishing communities and fishing industry.

BEAM 5 uses the net present value (NPV), i.e. the sum of the discounted future stream of net benefits (i.e. benefits minus costs) to evaluate the desirability of alternative adjustment paths and management and fiscal measures. A discount rate (or factor) is applied to the benefits and costs that arise in the future to account for the fact that a Dollar earned (or spent) today is worth more than a Dollar earned (or spent) in a future year. In the evaluation, a distinction is made between the financial performance of the fishing firms and the performance of the fishery from a point of view of the economy as a whole.

The financial analysis estimates how well the fishing industry will be doing over a series of future years. It is based on estimates of the likely revenues and costs of the fishing firms. The economic analysis, on the other hand, includes certain costs that are usually not paid for by the fishing firms and are thus excluded from their financial calculus. These include fisheries management costs such as research, administration and surveillance and enforcement.[14] Another important difference is that the economic analysis uses shadow prices of inputs whenever there is a discrepancy between the prices paid by fishing firms or the government and the economy wide opportunity costs of such inputs. Furthermore, pure transfer payments from one 'pocket', i.e. the fishing industry, into another 'pocket', i.e. the government treasury, such as taxes and subsidies, are excluded from the economic analysis.

BEAM 5 also allows analysing the impact of the adjustment or transition process on the government budget. The fishing industry contributes to the government budget through the payment of taxes (e.g. on fuel), duties (e.g. on imported equipment) and fishing licence fees. On the other hand, government incurs various expenditures in support of the fishing industry including fisheries management costs, subsidies and eventual payments under a buy-back programme for vessel decommissioning and compensation of displaced crew.

BEAM assumes a one-to-one functional relationship between Effort and fishing mortality, which in its simplest form reads: "Fishing Mortality = Q * Effort", where Q is the catchability coefficient. This is one of the essential links between the biological production function (based on the traditional Thompson and Bell prediction model) and the economic model. In the latter, changes in effort result in changes in operating costs. Where changes in fishing effort cannot be accommodated within a certain fishing capacity limit (expressed as the product of the maximum number of effort units per vessel multiplied by the number of vessels), the number of fishing vessels will change and with it fixed harvesting cost. Two other links between the biological and economic model are also indirectly related to effort. Firstly, fish handling costs increase or decrease with the amount of fish landings. Secondly, where prices are responsive to supply, these will increase or decrease with the amount of landings.

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13 There is a strong argument in favour of recuperating from fishery participants transition costs such as vessel decommissioning payments in order to avoid the principal threat of such buy-back programmes, namely that the compensatory funds received by vessel owners are used to re-invest into new and more powerful vessels or to modernize existing vessels (Holland, D., E. Gudmundsson and J. Gates. 1999)

14 It can be argued that where industry benefits from fisheries management, management costs should be recovered from fishery participants (Arnason, R., R. Hannesson and W.E. Schrank. 2000).

THE BIOLOGICAL FRAME OF BEAM 5

The biological model behind BEAM 5 is the traditional model by Thompson and Bell (1934), which has been discussed in many textbooks on dynamics of fish stocks (e.g. Ricker, 1975, Beverton & Holt, 1957 and with emphasis on tropical fisheries Sparre & Venema, 1998). The major part of the biological model behind BEAM 5 is the traditional model, or generalizations of the traditional model. BEAM 5 extends the traditional models with a spatial model, among opthers accounting for migration, using the approach of Quinn *et al.* (1990). All these models originally were thought of as "fish stock assessment models", where parameters were estimated by methods like Virtual Population Analysis (VPA) or Cohort Analysis (Derzhavin, 1922; Fry, 1949). Lassen and Medley (2001) give a summary of contemporary practical applications of VPA.

In its present form BEAM 5 focuses on the fisheries component of the exploited marine ecosystem. It is, however, imagined that BEAM 5 will be added to some general ecosystem model, such as the ECOPATH suite of models (Christensen *et al.*, 2000; Pauly *et al.*, 2000) and multi-species VPA (Sparre, 1991). BEAM 5, has certain areas which overlap with that type of ecosystem models and therefore merging should be possible. Application of fish stock assessment in tropical waters, however, is problematic (Mahon, 1997). The so-called "tuning of model" in BEAM 5 can replace the traditional fish stock assessment to some extent.

The concept of "stock" is rather complicated and there is no consensus among scientists on how to define it. A full discussion of the stock concept in the context of fisheries management is given in Begg *et al*. (1999). The separation of species into stocks is often very problematic. Even for stocks in non-tropical waters with relatively few species, stock separation is often difficult. Tropical stocks may in theory be separated by the same methods as used in cold waters, such as comparison of meristic characters (for example, size and position of fins and other body parts), number of vertebrae, blood type, parasites, etc. However, these kinds of data collection may well exceed the capacity of the resources of a developing tropical country. The collection of data on maturity, spawning grounds and migration routes often may be within reach of a modest research budget, but usually not for all species of commercial interest.

In a tropical country, more than 500 species of fish, cephalopods and shrimps may be included in the list of species of commercial interest that ought to be sampled, in addition each of the species could consist of a number of "stocks". Thus in practice, a sampling programme is often not able to apply the stock concept rigorously. Therefore, a more operational concept is required. For management of fisheries the concept of "management unit" is more useful. A management unit is a fisheries resource for which it is possible to make predictions, or, in other words, something for which we can give answers to "What-if questions".

Due to limited personnel and funds, it is usually not possible to collect data for fish stock assessment from all species (stocks) of commercial interest in the waters of a tropical country, therefore a limited number of species has to be selected as "representatives" for the entire living resources. The selection of representative species must account for both their ecological and economic importance, that is, large stock size (potential yield) and high price per kg should be the main criteria to implement biological sampling.

According to the agreed international standards (FAO, 1995,1996,1997,1999, ICES, 1998, UN 1995), “reference points” are an important concept in implementing a precautionary approach to fishing. Reference points are closely related to the stock concept (Caddy & Mahon, 1995, Gislason, 1999). Therefore, fishing mortality rates, biomass, or other measures should be regarded as indicators of the status of the stock in relation to predefined reference limits, that should be avoided, or targets, that should be aimed at, in order to achieve the management objective.

The identification of reference points requires a time series of scientific data, often over many years. A key concept in some reference points is the Spawning Stock Biomass (SSB), which is defined as the number of individuals multiplied by the fraction of mature individuals for each age group, summed over all age groups. Another important concept is the “recruit”, which is a juvenile fish entering the exploited part of the stock.

With a few rare examples, the identification of the relationship between parent stock (SSB, spawning stock biomass) and subsequent recruitment (R) has remained elusive for marine fishes (Gilbert, 1977, Hilborn, 1997, Myers, 1997). The precautionary approach dictates that unless it is scientifically demonstrated that there is no relationship between the parent stock and subsequent recruitment, such a relationship should be assumed to exist, even if the data are ambiguous. Observations of stock and recruitment show large variation around any SSB/R curve, so scientists are not in a position to predict future recruitment with any accuracy. They are only able to tell the probability distribution of the future recruitment and only in cases where a long time series of SSB/R observations is available.

For the tropical fish stocks it is often not possible to apply the methodology of reference points, for the simple reason that information on stock and recruitment, as well as fishing mortalities and other population parameters are not available. The typical information needed for the calculation of reference points is a long time series of recruitment estimates. This type of data is usually only available for stocks in temperate waters.

If a data collection programme is to implement international standards for responsible fishing, it has to choose reference points that can be calculated by means of the data currently available. The basic data collected is first of all catch rates or CPUE (Catch Per Unit of Effort), usually expressed in kg per day by fleet, season, fishing grounds and species group. Thus, possible candidates for reference points could be derived from catch rates. BEAM 5 is designed as a tool to be used in cases where long time series of data are not available and where the definition of stocks is problematic or even impossible.

THE TECHNICAL FRAME OF BEAM 5

The technical units of BEAM 5 are the “fleets”. The definition of fleet is also problematic (Sparre, 2000). A formal definition is: A “fleet” is a group of uniform vessels, which have approximately the same size and the same construction. The vessels should use the same type of gear and fishing techniques and most often, they share fishing grounds.

The definition is problematic, because, the operations of a vessel may change during the year. A vessel may, for example, do pair trawling for fish during one season and do single trawling for shrimp during another season. Some vessels use a combination of gears during a fishing trip, which may complicate the allocation of vessel to fleets.

Fleets may be defined by a combination of gear, engine horsepower (size of vessel), type of construction and fishing grounds. Horsepower, tonnage and length of vessel are usually correlated within a group of vessels of the same basic construction type. One practical problem is that BEAM 5 must adequately cover every major fleet. An example of pragmatic fleet definitions is given in Holland & Sutinen, 1999.

When the fleets have been defined, we assume (as an approximation to reality) that all vessels in a fleet are exactly equal and behave in exactly the same way. All members of a fleet are assumed to have the same "fishing power". Two fishing vessels are said to have the same "fishing power" if they can catch the same amounts and types of fish under similar conditions. One may simplify the concepts of fishing power by making it species-specific. In practice, this ideal definition can rarely be shown to hold. Instead, if two trawlers catch the same amount of "demersal fish" during a fishing operation on average, they have the same fishing power, and if one vessel catches X % more on average than the other vessel it has X % more fishing power.

A concept closely linked to fishing power is that of a "standard vessel". It is often desirable to express the fishing power relative to some selected vessel type. Usually the most common vessel type is selected as "standard vessel" (e.g. bottom trawlers of 15 m length with an engine of 60 HP and perhaps some other more specific characteristics). Other types of vessels are then expressed in units of standard vessels. If a vessel has 80% of the fishing power of a standard vessel, it counts as a "0.8" standard vessel.

THE SPATIAL FRAME OF BEAM 5

BEAM 5 offers the opportunity to account for spatial aspects, in the sense that fish and fleets can be allocated to a number of areas in a given time period. BEAM 5 uses a simple "box-model" to handle spatial aspects. However, the inclusion of spatial aspects is optional and the user may choose to consider the sea one homogenous area. If several areas are considered, this will require a number of additional input parameter, for example, "migration coefficients", the concept of which will be explained below.

The selection of areas or "fishing grounds" is most often constrained by the data. If logbooks are not maintained, precise information on where catches were taken is often absent. Often the practical circumstances dictates that only few areas are considered, sometimes all fishing areas have to be merged into one single area. A first natural division of the fishing area would be to use depths for the definition of areas. That may lead to areas like "in-shore", (say from 0-20 m depth) and "off-shore" (say, >20 m depth). Such a division will match both the distributions of vessels (mainly small vessels in the in-shore area, and large vessels in the off-shore area) as well as the distribution of stocks and size groups within a stock. Some areas may also be defined as "nursery areas", that is, areas where juvenile fish are known to be abundant. Such areas may be closed for fishing to protect the juvenile fish and to avoid discarding (see example in Pastoors *et al.*, 2000). Other criteria may be used, which depends on the size and nature of the marine area under study. For example, it will be natural to separate coral reefs from other areas. Bottom type (sandy, muddy, rocky) combined with depth may also form the basis for area definition. In large areas, currents and temperature gradients may give natural definitions of areas. Examples of pragmatic fleet and area definitions are given by Holland & Sutinen (1999).

BEAM 5 however, is not suited for the handling of a large number of areas. It is not anticipated that BEAM 5 applications will use more than, say, 20 divisions of the total area. BEAM 5 also is not constructed to deal with a division of the areas into small squares (say, 30 by 30 nm, or smaller).

For a theoretical discussion of migration in connection with age-based fish stock assessment the reader is referred to Quinn II *et al.* (1990). These authors also discuss the estimation of migration parameters. In principle their model is the approach planned for BEAM 5. Chapter 11 in Sparre & Venema, 1998 discusses the assessment of migratory stocks at a somewhat lower mathematical level, and it does not deal with the estimation of migration parameters.

THE ECONOMIC FRAME OF BEAM 5

The economic part of BEAM 5 uses the concepts developed for project analysis to evaluate the financial and economic performance of the fishery during the project horizon (i.e. simulation life span) given different fisheries management measures, government financial transfers and assumptions about the investment and operational behaviour of fishing firms. The financial performance is assessed from the point of view of both the fishing firms and the government treasury[1].

The project horizon is defined as the time span from the initial base year, until the 'end' of the project. The user of BEAM 5 determines the number of project years. In the choice of project years, the user would be guided by various factors and assumptions including the time when management measures are taken and the number of years they take to produce the expected biological and economic results, the chosen value of the discount rate, the lifetime of fishing vessels and other factors as appropriate. A short project horizon of say 5 years may fail to reveal the full benefits of taking management measures such as a reduction of fishing capacity and effort because the population dynamics of the fish stocks have not yet yielded their full recovery to the desirable level. A long project horizon of say 20 years would show very little discernible difference in results to a project horizon of 15 years whenever the discount rate is 15% or higher.

The evaluation of the financial performance is undertaken from the point of view of both the fishing firms and the government, while the economic performance is assessed from the standpoint of the economy as a whole. The principal differences between the two financial analyses and the economic analysis are as follows:

1) The economic analysis includes certain costs that are usually not paid for by the fishing firms and are thus excluded from their financial calculations. These include fisheries management costs such as research, administration and surveillance and enforcement. These costs lead to a cash outflow from the government budget or treasury. This cash outflow, however, might not be equal to their true costs to society to be accounted for in the economic analysis as is further explained below.

[1] The user of BEAM 5 is directed to the specialised literature for detailed explanations of the terms and concepts applied in project analysis. A well-written and quite accessible text, even for non-economists is provided by Gittinger (1984). Other standard literature includes Little & Mirrlees (1974), Squire & Tak (1975) and Dasgupta *et al.* (1972).

2) The economic analysis uses shadow prices as inputs whenever there is a discrepancy between the prices paid by fishing firms or the government and the economy-wide opportunity costs of such inputs. For example, where fuel prices are subsidised, thus lowering fuel expenditures incurred by fishing firms, the economic analysis will be based on fuel prices net of such subsidies.

3) The financial performance of fishing firms will be affected by the way investments into fishing craft and gear were financed (i.e. own savings or loans) and by the capital servicing terms of any loans taken in the past or in future years.

4) The financial performance of the government treasury depends on the cash inflows from the fishery through taxes, licensing fees, fines etc. and cash outflows for fisheries management expenditures, subsidies, etc. during the project horizon.

5) The economic analysis applies opportunity costs of capital to reflect the real social cost of using capital in fisheries rather than elsewhere in the economy. The opportunity cost concept is only applied to new investments. Past investments are sunk costs to the extent that they have no alternative economic use outside of fisheries.

6) In the financial analyses, labour costs are based on observed payments made to the fishing crew or government employees.

7) In the economic analysis, opportunity cost of labour is applied to reflect the real social cost of employing people in fishing or government rather than elsewhere in the economy.

8) In the financial analysis, payments made to fishing firms to decommission excess fishing capacity increase their net cash flows. Some firms may exit the fishery altogether and may invest decommissioning payments into other economic activities. If so, these firms would not be further considered in the simulation model of the fishery.

9) Decommissioning payments (i.e. compensations to fishing firms and to displaced fishing crews) are considered as transfer payments, i.e. a cash outflow from the government treasury. These payments are not considered a cost in the economic analysis.

No adjustments are made to fish prices observed in the market which are assumed to accurately reflect social values. However, a simple function has been included to model changes in fish prices as a result of changes in fish landings.

The rules (or algorithms) that attempt to model the behaviour of the skippers or owners of the fishing vessels are a crucial component of BEAM 5. As all vessels in a fleet are assumed to be the same (i.e. the fleet is perfectly represented by the average vessel), these rules are fleet and not vessel specific. There is one exception, however, to the extent that the fleet is structured according to the age of the vessels. The age takes importance for some of the rules that deal with vessel decommissioning (buy-back) and with vessel attrition (retirement due to old age, i.e. wear and tear and technological obsolescence).

The rules have been introduced into BEAM 5 for several reasons. First, being a dynamic model, there is a need to allow additions and reductions in the number of vessels over the simulation period arising from investments into new vessels, attrition of old vessels, bankruptcy and vessel decommissioning. Second, to achieve certain realism, there is a need to model the response of skippers and vessel owners to changes in profitability. This is especially important for simulating a vessel buy-back scheme for the following reason: the higher returns that the decommissioning payments, a smaller fleet and a restored stock produce create a powerful incentive for re-investments when no measures are taken to extract the resource rent and/or have in place effectively enforced exclusive use or property rights.

THE APPLICATION OF BEAM 5

In a typical BEAM 5 simulation of a fishery, the team of biologists and economists would first decide jointly on the system dimensions, i.e. the number of fleets, species and areas to model and the simulation horizon. As a general rule one could say that the model dimensions should be kept as simple as possible for generating relevant answers to relevant 'what-if-questions'.

The team would then create the 'base year' that is the set of biological, technical and economic parameters that best represent the current bio-economic condition of the fishery (say some average over recent years). The base year parameters can be assumed to either remain stable over the simulation horizon or change in accordance with reasoned predictions about future developments (e.g. in respect of fish prices, operating and fixed costs, catchability, etc.).

BEAM 5 has been designed in a manner to allow for maximum flexibility as decided by the users and to take advantage of the opportunities offered by the program EXCEL. For most part, BEAM 5 only specifies broad cost categories and leaves it up to the user to decide which specific kinds of costs are subsumed under each of these categories. For this reason, ample space is provided next to the columns of input parameters where the specific cost items can be listed, mathematically manipulated and the result directed into the appropriate input cells.

Once all the parameters have been entered, the team can start to perform some simple deterministic simulations without enabling the behavioural rules. This will allow checking whether the model can re-produce the current fishery situation in the base-year. It can also produce an estimate of the Net Present Value for each fleet and all fleets combined under the assumption that the fishery remains stable over the simulation horizon.

More complex simulations can then be performed (e.g. stochastic simulations; changes in price and cost parameters during the simulation horizon, enabling of the behavioural rules; etc.) and assumptions made about the use of various governmental management measures (e.g. buy-back programme; changes in taxes and licensing fees; closed seasons and areas; fishing capacity and effort limits).[15]

[15] For introduction to fisheries bio-economics the reader is referred to, for example, Anderson, 1977, Clark, 1985, Cunningham, *et al.*, 1985, Gilbert, 1988, Gordon, 1954 and Hanneson, 1988, 1993.

APPENDIX G

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