

“BEMMFISH”

Developing bioeconomic models for fisheries management in the Mediterranean

In the Mediterranean, fish stocks - with the exception of large pelagic fish - are not routinely assessed or monitored. However, for some stocks, assessment data do exist and these data show that many important target species are overexploited or not exploited efficiently from the economic point of view. Additionally, given the importance of artisanal fleets in the Mediterranean and their technical interaction with other - especially trawl - fleets, potential conflicts of interest can arise that may aggravate the conservation state of stocks.

Due to these technical interactions, but also the multi-species nature of the fisheries' catches – which tend to be highly diverse - and the dispersion of landing sites, single species approaches and output measures, such as current TAC and quota management systems, are often inappropriate for Mediterranean fisheries. The only exceptions are the highly migratory species.

By developing bioeconomic models and software packages for the simulation and testing of various management strategies in Mediterranean and Mediterranean-type fisheries, the **BEMMFISH** project tried to address these questions. The project integrated fisheries economists, fisheries biologists and computer scientists. In addition, specialists in different fields of applied mathematics were brought together so as to enable the exploration of new mathematical approaches, and their application to the modelling of Mediterranean fisheries.

In a first phase of the project, the various system requirements were defined as follows:

- The tool should be sufficiently general and flexible to accommodate easily the realities of most Mediterranean fisheries, and include multiple species and their interactions, multiple

fleets and gear types, and all fisheries management tools currently used by Mediterranean fisheries managers.

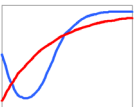
- It should produce a wide range of fisheries performance measures.
- The system should be dynamic, i.e. capable of simulating the fisheries over a long period of time.
- It should be stochastic to incorporate uncertainty in data and models.
- It should be able to run on the Windows platform.

Two main **bio-economic models** were developed. Such models are the result of two interacting sub-models:

- a **biological (or stock) sub-model**, including the dynamics of the resource and their interaction with human activity in the form of fishing mortality; and
- an **economic sub-model** (including fleet, market and fishermen) accounting for the dynamics of fleets and markets, and the rules of the fishermen's behaviour.

The first bio-economic model was based on an age-structured biological model and a micro-scale economic model (disaggregated at the vessel level) for fisheries where biological assessment and small-scale

BEMMFISH BIO-ECONOMIC
MODELLING OF
MEDITERRANEAN
FISHERIES



Project acronym:

BEMMFISH

Full title of Project:

Bio-economic modelling of Mediterranean fisheries

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Q5RS-CT-2001-01533

Web-site:

<http://www.mefisto.info>

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“BEMMFISH HAS CONTRIBUTED BOTH IN PRACTICAL AND THEORETICAL WAYS TO THE UNDERSTANDING OF THE FUNCTIONING OF MEDITERRANEAN FISHERIES AND THEIR MANAGEMENT”

economic data existed. This model has resulted in the package **MEFISTO (Mediterranean Fisheries Simulation TOol)**.

The MEFISTO package allows for testing the effect on the fisheries system of nine types of management actions, based on technical or economic measures: i) change in fuel price, ii) introducing subsidies, iii) change in dismissal price, iv) change in daily fishing time, v) change in annual fishing time, vi) withdrawal of vessels, vii) species imports, viii) sudden change in market price, and ix) changing the selectivity pattern.

The second bio-economic model was based on a global (or surplus) production model and a macro-scale economic model, with the economic module running at the scale of fleet. This **IBEM/MOSES (Italian Bio-Economic Model based on Models for Optimal Sustainable Effort in the Seas)** model is an optimization program that uses data series of catches and effort for a matrix of species and fleets. Given the economic data obtained by sampling the fleets, the optimization routines allow to compute the required biological parameters and optimal distribution of effort for each fleet segment (optimal fishing effort in the sense of producing the maximum economic rent in terms of value added and constraint to the long-term sustainability of the fish stocks).



A SMALL SCALE FISHING VESSEL IN THE MEDITERRANEAN. SOURCE: FRANCESC MAYNOU, CSIC (SPAIN).

BEMMFISH has contributed both in practical and theoretical ways to the understanding of the functioning of Mediterranean fisheries and their management, thus to the strengthening of the CFP's scientific basis applied to the Mediterranean. It has provided a fully documented, easy-to-use set of software packages for distribution among fisheries policy makers and managers, fisheries scientists, the industry and administrators of Mediterranean fisheries at all levels: EU, FAO, national and local administrations.

The software produced allows managers to assess the biological and economic consequences of Mediterranean fisheries applying different policy tools; **it should thus serve particularly as a tool to guide the evaluation of alternative management strategies for Mediterranean fisheries.**

“COMMIT”

A framework for evaluating management strategies in fisheries

Fishery management is largely based on annual fish stock assessments. Owing to the uncertainty inherent in annual estimates of the stock size, fish quotas set on such a basis will be variable. This makes planning for the future difficult. A multi-annual strategy is needed and, to be effective, this requires the commitment of managers and compliance of stakeholders with the agreed strategy. Multi-annual assessments that incorporate biological and socio-economic considerations will help improve the decision-making process for medium- to long-term planning and will provide a better basis for fishers to plan their activities.



The EU-funded FP6-project **COMMIT** aimed to **provide the scientific basis for the long-term sustainable planning of fishery management, while identifying any short-term biological and socio-economic consequences**. A main objective of COMMIT was to develop a comprehensive testing system or **Management Strategy Evaluation (MSE)** framework that would allow the development of multi-annual management plans in support of the Common Fisheries Policy by the International Council for the Exploration of the Sea (ICES) and the Scientific, Technical and Economic Committee for Fisheries (STECF).

Such an MSE approach allows the testing of stock assessment models and management strategies and often reveals surprising limitations of longstanding fisheries advice. Under the MSE approach the objective is no longer to come up with “the answer”, i.e. one strategy giving the best assessment – as was done in traditional fisheries advice – but to evaluate the consequences of a strategy to alternative assumptions about stock dynamics, i.e. its robustness. This allows alternative strategies to be proposed and evaluated for a range of management objectives of relevance to stakeholders and trade-offs between them. Designing such a comprehensive testing system and developing all

the required standards for it could not, however, be done by one person or institute alone. It had to be a collective effort that spanned organisations and disciplines before it would be recognised as adequate. COMMIT thus developed a **generic open source framework for MSE** by playing a major role in the development of the **FLR framework** in collaboration with a variety of EU projects. FLR, Fisheries Library in R, is a development effort to build a framework for the evaluation of fisheries management strategies designed to facilitate collaboration within and across (biological ecological, statistical, mathematical, economic, and social) disciplines; and to ensure that new modelling methods and software are more easily validated and evaluated, as well as becoming widely available once developed.

COMMIT combined real data with the FLR simulation framework to simulate scenarios for testing management strategies using the following case studies:

1. North Sea Flatfish

This case study developed a model describing the dynamics of North Sea plaice and sole stocks. The model allowed the evaluation of several proposals for management strategies from both the EU and the North Sea Regional Advisory Council (RAC). An important aspect of this work

Project acronym:

COMMIT

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Creation of multi-annual management plans for commitment.

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Web-site:

<http://www.cefas.co.uk/science/commit.htm>

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“THE WORK OF COMMIT AND THE DEVELOPMENT OF THE FLR FRAMEWORK HAVE BEEN A MAJOR STEP FORWARD IN DEVELOPING A SHARED LANGUAGE FOR SCIENTISTS THAT CAN MAKE A SIGNIFICANT CONTRIBUTION TO CLARIFYING COMMUNICATIONS ACROSS THE SCIENCE BOUNDARY WITH AND AMONG STAKEHOLDERS “

was to ensure the robustness of the management plans with respect to uncertainty about the discarding behaviour of major fishing fleets in response to management. The work of COMMIT indicated that strong fishing effort reductions would improve the sustainability of the two flatfish species, while the current TAC system with quotas for the individual species is less effective because of discarding of over quota catches.

2. Northern Hake

In this case study, the robustness of management decisions for Northern Hake was evaluated for different management plans including the economic performance of the fleets and their response to different economical scenarios. This allowed taking a closer look at potential cost savings and the economic impacts of different management options. The results of this work were used by the STECF to evaluate long-term harvest plans for Northern Hake (June 2007).

3. Baltic salmon

The Baltic salmon case study applied an explicit way of modelling implementation uncertainty and commitment to alternative management approaches. This was based on a three-step procedure: first and expert interview was conducted to understand the mechanisms, then a mail questionnaire was sent around to a large number of stakeholders and finally a new interview of key persons was

conducted, based on previous results. Bayesian models were applied allowing for the incorporation of this expert knowledge. This way, the likely future response of the stakeholder groups was estimated also for those management actions that have never been applied and cannot be studied by usual empirical methods.

The work of COMMIT and the development of the FLR framework have been a major step forward in developing a shared language that can be used amongst scientists and then can make a significant contribution to clarifying communications across the science boundary with and among stakeholders. There is a clear demand from stakeholders to be more involved in the decision-making process including a demand for increased transparency and understanding, both of the knowledge base of advice and of the criteria entering the management decision process. Therefore, the scientific framework developed during COMMIT will be applied in the FP7-funded JAKFISH project that will work together with stakeholders so as to allow for management plans to be developed in collaboration with stakeholders.

“EFIMAS”

Managing fisheries in a virtual environment in order to provide more reliable scientific advice to stakeholders

European fisheries are under pressure at the moment. Not only are many commercially important fish stocks declining, so are the number of fishing boats and people employed within the fishing industry. At the same time, the management and regulation of the fisheries becomes more complicated every year. Stakeholder confidence in existing assessment and management models has been shaken, since these models currently only consider the effects of fishing on single fish stocks and the ecosystem, and do not take into account the social and economic impacts of fisheries management decisions as well as mixed fisheries and long term management strategy evaluation.



To facilitate the development of better fisheries management regimes, a European research project, **EFIMAS**, was launched to develop and integrate a set of new tools into a robust framework within which to **simulate and evaluate the biological, social and economical consequences of a range of fishery management options and objectives within different management regimes.**

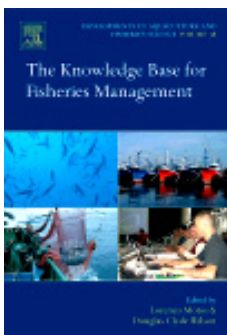
The project involves cooperation between 30 research institutions from all over Europe covering the disciplines of fisheries biology, economy and sociology, and is coordinated by the Technical University of Denmark, National Institute for Aquatic Resources.

One of the major challenges is to ensure that the best possible knowledge is synthesised and made available to decision-makers. To this extent, some of the project participants have reviewed the state-of-the-art knowledge base for fisheries systems and consequently published this in a book, **“The Knowledge Base for Fisheries Management”**, which is available from Elsevier. Such information provides the background to draw conclusions of what is needed to improve fisheries management.

The tools that are being developed take account of the dynamics in the fisheries systems (including fleet and mixed fisheries interactions and fisheries behaviour) as well as effects of using e.g. alternative stock and fishery assessment models, economic based fishery models, and also considers uncertainties in the dynamics and in the data collection, assessment, modelling, advisory and management processes.

The framework and simulation models are tested in selected case studies covering different types of EU fisheries in different areas: North Sea mixed roundfish and flatfish fisheries, North East Atlantic mixed Nephrops and mixed Northern hake fisheries, Mediterranean Swordfish and mixed hake fisheries, and Baltic Sea Salmon and cod fisheries.

An overview of the simulation module of EFIMAS is given in the conceptual box flow diagrams on the back. The input data to module are generated by a descriptive model (operating model), which is assumed to represent the “true/real” system. The input data are then processed by a traditional or an alternative fish stock or fisheries assessment model (knowledge production model), which is used



“THE STATE-OF-THE-ART KNOWLEDGE BASE FOR FISHERIES SYSTEMS HAS BEEN REVIEWED AND CONSEQUENTLY PUBLISHED IN A BOOK”

Project acronym:

EFIMAS

Full title of Project:

Operational evaluation tools for fisheries management options

EU contract number:

502516

Web-site:

www.efimas.org

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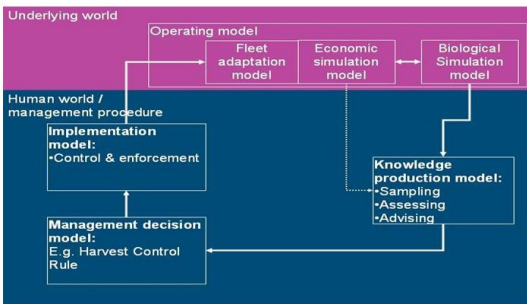
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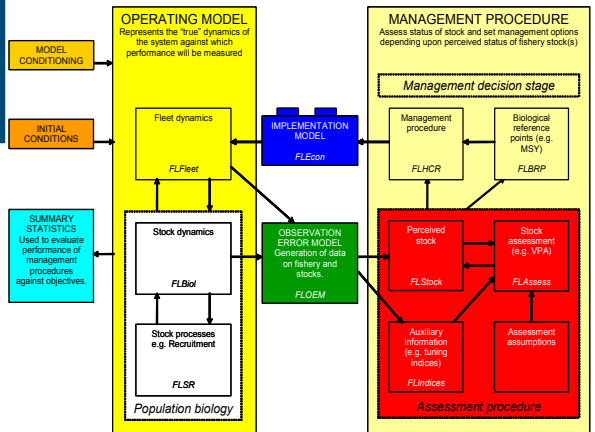
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to generate management advice. By simulating the effect that the resulting management actions would have on the “true/real” system it is possible to generate a range of performance measures, covering the resource as well as the fishery (such as minimum mesh size, minimum landing size, closed areas, closed seasons and effort regulations). These performance measures will then enable the comparison of a range of management options under alternative management systems and objectives. In the same way that a pilot might fly in a simulator before flying for real, the simulation tool evaluates the robustness of alternative management strategies and options to give more holistic management advice before implementation.

The evaluation framework established through EFIMAS and its sister projects is an open source simulation tools and is made available from www.efimas.org and <http://flr-project.org/>. The evaluation framework has been used in ICES (www.ices.dk) stock assessment and mixed fisheries working groups, in EU STECF (<http://europa.eu/scadplus/leg/en/cha/c11127.htm>) working groups and EU RACs (Regional Advisory Councils), NAFO (www.nafo.int) and IWC (www.iwcoffice.org), and presented through a long row of scientific papers, conferences, courses and workshops. By incorporating a wider range of variables and their uncertainty to illuminate the decision process and allowing for stakeholder feedback in the evaluation process, fisheries management will be made more accessible to all kinds of stakeholders.



SIMULATION MODULE OF THE EFIMAS PROJECT.
 SOURCE: J.R. NIELSEN.



“FEMS”

A framework for evaluating management strategies in fisheries

The management of fisheries increasingly embodies multiple and conflicting biological, ecological, economic and social objectives. However, despite constant efforts to regulate fisheries by regional management bodies and national governments, fishing capacity often remains above that necessary to ensure the sustainable exploitation of marine resources, especially in developed countries. This failure has been analysed in depth during the past decade by the scientific community, which has repeatedly recommended substantial changes in incentives and governance, as well as adjustments in the way that fisheries research and monitoring are conducted and expertise is deployed.

The FEMS project proposed to **develop a computer-based simulation framework that allows evaluating the performance of management strategies that are consistent with the precautionary approach whilst maintaining the viability of the fishing industry.** A simulation framework was chosen since it is difficult or undesirable to compare alternative strategies by conducting experiments on real fisheries.

Initially simulation models (referred to as base cases) were developed for the study of stocks (demersal and large pelagics) consistent with current dynamics assumptions and management procedures as used by the International Council for the Exploration of the Sea (ICES) and the International Commission for the Conservation of Atlantic Tuna (ICCAT). The following base cases were selected:

- North Sea Demersal (ICES):
 - ◊ Cod
 - ◊ Plaice
 - ◊ Flatfish (plaice and sole)
- North Atlantic & Mediterranean Tuna (ICCAT)
 - ◊ Albacore
 - ◊ Bluefin
 - ◊ Tropical (bigeye, skipjack and yellowfin)

These cases were chosen because of their importance but also to help develop a general framework that could cope with a variety of biological, sampling, fleet and assessment types.

Evaluation was performed by comparing the trade-offs between management objectives, e.g. sustainability of the stock, level of yield(s) and variability in yield. This permitted the performance of data collection schemes, assessment methods and management regulations (e.g. harvest control rules and/or recovery plans) to be evaluated against plausible hypotheses about fishery dynamics.

A major failing of conventional management advice has been that it does not explicitly incorporate important sources of uncertainty. For example, it is generally assumed that (i) input data are appropriate and not biased, (ii) stock assessment models accurately reflect both population and fisheries dynamics, and (iii) management measures are perfectly implemented.

The FEMS framework, however, has explicitly taken into account uncertainty, which makes it possible to evaluate the relative importance of the various

Project acronym:

FEMS

Full title of Project:

Framework for the Evaluation of Management Strategies.

EU contract number:

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Web-site:

<http://www.flr-project.org>

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elements of the scientific advisory system, such as

- Data quality
- Assessment methods
- Understanding of the biology
- Response of the fishers to regulations
- Interactions between these (e.g. discarding)

The FEMS framework has now become known as the FLR initiative (www.flr-project.org). From a general perspective, FLR aims to provide a solid basis for the development and evaluation of methods in fisheries science. It allows operating models to be developed, conditioned on a variety of data and hypotheses, and alternative stock assessment and management procedures to be implemented in software.

FLR can also be used to perform exploratory data analysis and provide estimates of population parameters based upon a range of data and assumptions in order to create and run simulation operating models. It can also perform stock assessments (incorporating existing methods written in Fortran and C/C++ and any new methods that are developed) and test harvest control rules for stock assessment working groups. All of this can be done in either a frequentist or Bayesian framework. In addition FLR is currently being extended to incorporate mixed fisheries, multispecies and ecosystem and

economic models. Routine for automatic differentiation are also being included to help increase the running speed.

FLR is constantly being further developed and is supported by various projects including the EU-funded projects COMMIT (FF-ALL-ADVICE-04), EFIMAS (FF-ALL-ADVICE-01), FISBOAT (FF-ALL-STOCK-01) and UNCOVER (FF-ALL-RECOV-01).

“FEMS PROPOSED AND INITIALLY DEVELOPED A GENERIC FRAMEWORK THAT HAS NOW BECOME KNOWN AS THE CORE OF THE FLR (FISHERIES LIBRARY IN R) INITIATIVE”

“POORFISH”

Improving the scientific advice relating to data-poor fisheries

In fisheries management, the reliability of scientific advice is highly dependent on the quantity and quality of data that are available for stock assessment. In many areas these data are of poor quality and managers may only have indications about the status of the stocks to base their decisions on. Poor data could also mean that the options for practical management are restricted. Nevertheless, management must be operational in order to secure sustainable fisheries. To improve the quality of scientific advice relating to data-poor fisheries, further research is thus required.

There are basically at least three types of data poor situations:

- artisanal/local fisheries with usually several target species of otherwise mixed fisheries, where data collection is sparse (many coastal fisheries in Mediterranean and northern Baltic areas);
- industrial, but recently developed fisheries, where insufficient time series of information is available to develop reasonable assessments (many deep sea fisheries belong to this group); and
- industrial, well developed fisheries, where the quality of data is getting worse, due to e.g. misreporting and discarding.

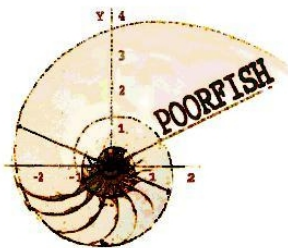
The **POORFISH** project is focusing on each of these types and is undertaking a variety of case studies exemplifying data-poor fisheries around Europe, plus two off the coast of West Africa. For each of these cases, POORFISH is reviewing the assessment and management approaches applied, and obtaining expert opinions from actors within the case study fisheries, identifying key problems and issues.

This way, POORFISH is gathering information for utilisation within a **probabilistic assessment**,

management and advice model (PAMAM). The strength of such a PAMAM is that it allows probabilistic advice, and thus enables the evaluation of management and assessment uncertainties. It also allows additional information to be incorporated, as fisheries develop and become less data poor.

POORFISH aims to improve the structure and reliability of this PAMAM model. It is continuing the work carried out within the EU-funded projects EFIMAS (FF-ALL-ADVICE-01) and COMMIT (FF-ALL-ADVICE-04), which have developed and used a simulation framework (FLR) to evaluate candidate management strategies before implementation. As a part of this, it will add mechanisms that will enable the framework to collect information from alternative scientific sources (meta-analysis) and stakeholders (e.g. fishers, assessment scientists and managers). This way, POORFISH will focus on those management measures that are likely to be effective given the practices and understanding of the stakeholders.

The PAMAM model will make it possible to examine the performance of alternative assessment and management approaches, compared to the current approach used. As the



Project acronym:

POORFISH

Full title of Project:

Probabilistic assessment, management and advice model for fishery management in the case of poor data availability.

EU contract number:

022745

Web-site:

www.poorfish.eu

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model outcomes are information dependent, i.e. dependent on the expert knowledge and published information available in addition to existing data sets, it should be noted that the information available is likely to define the assessment approach undertaken. But the quality of the data will also define the accuracy and precision of assessment outputs, which will have a knock-on effect to management, as it will define the level of precaution required.

In the last phase of the project, the cross-case study findings will be synthesized, operational management tools identified, the mutual dependencies of management and success will be evaluated and the benefits and failings of the approach within the case studies will be identified. As a result, **guidelines for assessment and management in data-poor fisheries will be developed.**

POORFISH will address issues relating to the problems in the International Council for the Exploration of the Sea (ICES) and the Scientific, Technical and Economic Committee for Fisheries (STECF) to give advice on poorly known fish stocks. More broadly, the project should contribute to the improvement of fisheries management all over the world. The tools and methodologies that are being developed will allow

management strategies to be formulated that ensure the sustainability of marine ecosystems at the highest level and provide greater security to fishers and fishing companies, enabling them to make the most appropriate investment or disinvestment decision. This, in turn, will allow greater stability in communities dependent upon fisheries and contribute to reducing their vulnerability.

**“THE TOOLS AND
METHODOLOGIES THAT ARE
BEING DEVELOPED IN
POORFISH WILL ALLOW
MANAGEMENT STRATEGIES
TO BE FORMULATED FOR
DATA-POOR FISHERIES“**

“PRONE”

Introducing risk analysis theory in fisheries management

Fishery management is beset with uncertainty, the causes of which occur from the point of capture through to consumer demand and market fluctuations. Hitherto, there has been little opportunity to allow for uncertainty, yet the likelihood of any given management action having a positive outcome is affected by these uncertainties. Although some sort of risk assessment may be available for the biological impact on fish stocks resulting from management decisions, a systematic approach including also economic and social risks is missing in European fisheries management. Thus, there is no mechanism for dealing with the uncertainty in fish stock assessment and the risk which management decisions based on this represents in social and economic terms.



Improved quantitative and qualitative information on the biological, social and economic consequences of current and alternative actions and tools available to fisheries managers are required to better manage the risks inherent in EU fisheries.

The main objective of the **PRONE** project is therefore to **investigate how risk analysis theory can be adapted to European fisheries management, embracing the full process from stock assessment, projection and advice, via management decisions, to the practical implementation of the management measures, including control.**

This will also include **improved communication of information to stakeholders and fisheries managers** making it easier to achieve the long term goals of fisheries management.

Risk analysis is a formalized approach increasingly used in various types of management, e.g. environment, natural resources, and food safety. As it is comprised of risk assessment, risk management and risk communication, the **components to be incorporated in the PRONE project** include:

- risk identification and probabilistic evaluation of the potential consequences of

alternative management actions, i.e. risk assessment; the formulation of a variety of tools to manage the risks, i.e. risk management; and the development of mechanisms to ensure that the outputs of risk assessment and the risk management options available are adequately understood by stakeholders, i.e. risk communication.

Risk will be analysed from the point of view of management (the possibility to implement the knowledge) and from the point of view of advice (the possibility to understand the given scientific advice).

Four contrasting case studies will be used to illustrate and test the methodology:

- Greece: no Total Allowable Catches (TAC)
- The North Sea: TAC
- Faroe Islands: Individual Transferable Effort (ITE)
- Iceland: Individual Transferable Quota (ITQ)

The scientific approach will review the methodology and the theoretical underpinning of the four case studies including biological, sociological and economic elements. In the second

Project acronym:

PRONE

Full title of Project:

Precautionary risk methodology in fisheries.

EU contract number:

022589

Web-site:

www.prone-fish.eu

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“THE PRONE PROJECT WILL HELP VALIDATE MANAGEMENT DECISIONS BY IDENTIFYING THE RISKS ASSOCIATED WITH EACH OPTION CONSIDERED. BY IDENTIFYING SUCH RISKS, THE MANAGEMENT WILL BECOME MORE TRANSPARENT, TO THE BENEFIT OF ALL STAKEHOLDERS”

part of the study, theoretical findings will be used to construct interviews where the aim is to contrast the theoretical basis with empirical data in order to find practical risk management systems for European fisheries.

This will allow current methodologies, such as the uncertainty methodology currently used by ICES, to be analysed and compared to a fully integrated analysis of uncertainty for the selected case studies. An **additional case study in ecosystem health – human health risk analysis (the Baltic herring dioxin case)** will provide methods to control consumer behaviour in cases where fish consumption may include health risks.

The PRONE project will help improve “risk assessment, risk management and risk communication” within European fisheries. This way, it will help validate management decisions by identifying the risks associated with each option considered, i.e. with different fishery types, management regimes, data collection programs and scientific advisory frameworks. By identifying such risks, the management will become more transparent, to the benefit of all stakeholders.

In addition, the identification and evaluation of economic risk will enable fishery managers, the EU and member states to include the socio-economic aspects in fisheries management. If

successfully implemented, the project recommendations will improve the economic profitability of European fisheries. This is of great importance in ensuring the sustainability of the fisheries since failures in management have been linked to an inability to understand the inherent uncertainty of fisheries systems.