SIXTH FRAMEWORK PROGRAMME

PRIORITY [POLICIES 1-3]

[Policy orientated research (SSP)]

Contract No. 022589

PRONE: Precautionary risk methodology in fisheries

D4.4 Final report:
Publishable final activity report

Period covered: 1st Jan 2006 to 28th Feb 2009 Date prepared: 18th March 2009

Start date of project: 1st Jan 2006 Duration: 3 years

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Revision [*Final*]

Preface

The Final Publishable Report only contains (as specified by the EU Commission) a summary description of the full project and is only meant to briefly describe in non-technical language the: objectives, methods, results and achievements of the project in terms of impacts on the relevant sectors and research community. Therefore all the technical aspects have been excluded, and the full description of each case study, including data, models, numerical analyses have not been presented. This information is available for public use elsewhere after permission from the EU Commission and is presented in the final activity reports and/or the peer reviewed papers as outputs of this project (see Dissemination).

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1 Project execution

1.1 Executive summary

PRONE project has made a major contribution to the development of risk methodology for fisheries management. The methods will provide improved quantitative and qualitative information on the biological, social and economic consequences of current and alternative actions. These new tools are available to fisheries managers and they help to better manage the various risks inherent in EU fisheries.

The main objective of the project was to investigate the ways how risk analysis theory, as currently developed and applied in a variety of fields, can be adapted to European fisheries, embracing the full process from stock assessment, projection and advice, via management decisions, to the practical implementation of the management measures, including control. This also included improved communication of such information to stakeholders and fisheries managers.

The components incorporated include risk identification and probabilistic evaluations of the potential consequences of alternative management actions (risk assessment), the formulation of a variety of tools to manage the risks (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 (risk communication).

Four contrasting case studies were used to collect information from stakeholders on their risk perceptions (risk mapping). These included four contrasting cases: Greece (no TAC), North Sea (TAC), Faroes (ITE) and Iceland (ITQ). This selection of countries and management systems allowed the evaluation of how different risk perceptions and trust on fisheries advice are, depending on the management system and culture.

PRONE project also improved the ways how international agreements should deal with risk management.

Especially now, when the Ecosystem Approach to Fisheries Management (EAFM) is to be implemented in fisheries, the risk modelling experiences from other environmental fields are valuable. There seems to be a longer history in applying models to the stakeholder communication, and these experiences should be utilized in fisheries. For example the implementation of EU Marine strategy and Water Framework Directive ask for methods applicable to stakeholder communication, and fisheries could be linked to these activities.

The current biological reference points are estimated by the stock specific, relatively noisy spawning stock – recruitment estimates. The main aim of the F_{lim} and B_{lim} is to be estimates showing the level of exploitation, where it is very likely that a recruit to the stock can reproduce another recruit. It is obvious, and can be seen from the results of the D13, that hierarchical models (where estimates from several stocks are used at the same time when estimating parameters) will provide more accurate S/R parameter estimates by less stock specific information. Therefore, hierarchical models should be applied to provide reference points which are based on more extensive information than just one single set of S/R estimates. This methodology is especially important when assessing stocks for which data sets are not covering long time periods.

PRONE project applied value-of-information analysis to the S/R problem. This methodology would decrease uncertainties in a cost effective way compared to e.g. more extensive data sets. Methodology could be applied to the planning of data collection programs and research topics This would provide a logical tool for EU Commission to negotiate with member countries about different ways to collect data.

PRONE project also analysed the international fisheries agreements by applying game theory. When a shared resource is harvested, policies and tools helping countries to collaborate via international agreements should be sought for and developed. The argument is that all fishing countries will be better off by cooperating, i.e. by complying with an agreement, than by non-cooperating. Harvest control rules can be used as such a tool, provided that HCR is bioeconomically rational. Reference points such as spawning stock biomass and fishing mortality rate ceiling are commonly applied in the context of precautionary approach. These references can also be used as strategic bioeconomic reference points which optimize a harvest control rule. Applying precautionary approach by the grand coalition through a harvest control rule can add net present value of the fishery compared to the case without the HCR. However, the coalition structure and fishing costs have a strong impact on the optimal fishing strategies of the countries. An optimal HCR has potential of stabilizing multilateral fishing agreements if fishing costs are, on the relative scale applied in the case study, high.

As a risk management option, PRONE project tested the possibility to use insurance system in fisheries. It is potentially a promising tool for the management of large scale fisheries. It seems obvious, that the current self insurance system of the fishermen is to fish more, if uncertainties are raised up concerning the future development of the stocks. In this sense, stock assessment results predicting very pessimistic development for a stock may even accelerate the negative development of the stock by increasing uncertainty among stakeholders.

If successfully implemented, the PRONE project recommendations will improve the economic profitability of European fisheries.

1.2 Objectives

The general overall aims of the project are discussed below.

The general objective has been to investigate how risk analysis theories 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. The project aimed to take advantage of developments in a variety of fields and test their applicability to fisheries management, ensuring high quality scientific methodology and to improve the understandability of the methods. Four case studies are used to illustrate and test the methodology.

Risks were analyzed both 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).

The objectives of the project were as follows:

1. Review the current state of the art of fisheries science and management framework (assessment, management and communication) in Europe, identify weaknesses within the current fisheries science and management and identify potentially useful risk analysis approaches being used in other fields of applied sciences.
2. Identify the knowledge requirements for fisheries management systems and link these to their ability to achieve management objectives by management tools.
3. Identify the necessary controllable elements in different management systems and their ability to manipulate the system to achieve management objectives.
4. Develop risk assessment and management tools to develop, implement and run appropriate risk management systems in fisheries
5. Evaluate the understandability and interest to use risk related information in alternative management systems of case studies (no TAC, TAC, ITQ, ITE), depending also on the cultural backgrounds of actors.

The scientific approach reviewed the methodology and the theoretical underpinning of the four case studies including biological, sociological and economic elements. In the second part of the study, theoretical findings were 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.

The project analyzed the uncertainty methodology currently used by ICES and compared this to a fully integrated analysis of uncertainty for selected case studies. An additional case study in ecosystem health – human health risk analysis (Baltic herring – dioxin case) provided methods to control consumer behaviour in cases where fish consumption may include health risks.

One of the main strategic aims of this project was to speed up the flow of methodological tools from other fields of theoretical and applied sciences.

1.3 Contractors

There were 7 partners (Table 1) in the project and one subcontractor (Faroes). All partners stayed in the project to the end.

Participant list

List of Participants

Participant Role*	Participant no.	Participant name	Participant short name	Country	Date enter project	Date exit project
CO	1	University of Helsinki	UHel	Finland	Month 1	Month 36
CR	2	Centre for Environment Fisheries & Aquaculture Science	CEFAS	UK	Month 1	Month 36
CR	3	Imperial College of Science, Technology and Medicine	IC	UK	Month 1	Month 36
CR	4	Centre for the Economics and Management of Aquatic Resources	CEMARE	UK	Month 1	Month 36
CR	5	Hellenic Centre for Marine Research	HCMR	Greece	Month 13	Month 36
CR	6	Faculty of Natural Resource Science, University of Akureyri, Iceland	UNAK	Iceland	Month 13	Month 36
CR	7	Instituto Tecnológico Pesquero y Alimentario (Fundación AZTI)	AZTI	Spain	Month 1	Month 36

*CO = Coordinator

CR = Contractor

Project was coordinated by Professor Sakari Kuikka, University of Helsinki (Project partner 1, UHel). Contact details of the coordinator:

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1.4 Project website

Project website is at http://www.prone-fish.eu/. It includes all project deliverables, all presentations and all meeting minutes. However, as many of the deliverables will be submitted to journals, which do not allow results to be published elsewhere, all web pages have not been opened to public.

The same web pages will be further updated to serve as fisheries risk methodology homepages, updated by the University of Helsinki.

1.5 Work performed and end results

The project aimed at developing and applying state-of-the-art methodological tools for fisheries management science. These tools include:

1. State-of-the-art use of probabilistic Bayesian stock assessment tools to some of the most important fish stocks
2. Development of risk management control tools to plan multi-disciplinary fisheries management
3. Use of game theory tools to analyze implementation of management (catch and effort controls) on international level.
4. Development of more informative stock-recruitment models for some European stocks (mainly North Sea stocks).
5. Development of human health risk methodology in fisheries context.
6. Development of risk classification methods as part of the Final report, supporting more clear responsibilities of actors.

The detailed success of the project can be seen in original deliverables. In the following, only a short description of the **Methods and approaches** and **Achievements in contrast to state of the art and conclusions** are given. One paper of the following deliverables has been published, one accepted and 4 submitted. Deliverables D1 – D6 are of such nature, that they can not be reported in the format as the rest.

In the following, the references and the tables and figures referred to can be found from original deliverables. The aim of this text is to give an overall view of project outcomes.

D7 Review of risk assessment methodology (CEFAS)

Methods and approaches

The reviews were carried out for different disciplines (Utility Theory, Decision Analysis, Juridical Argumentation, Environmental Risk Analysis and Human Health Risk Modeling).

The review of each discipline covers the following issues:

Aims*:* the most important aims of the methodology

Major field of applications so far (mention a key article/book and a list of applications) (how appropriate or applicable are they in current systems, what would have to change, what short comings of the current system would they rectify)

Intellectual Underpinning

Costs: likely level of applications costs of implementation,

Benefits*:* Chance to replace existing methods, etc.

Shortcomings: Why not applicable to fisheries

Information Requirements: requirements: input data, other required knowledge (causal assumptions, etc.)

Relevance*:* for Fisheries Evaluation of applicability to various fisheries tasks (ability to help achieve management and societal objectives)

Potential for Sustainability*:* Likely interest to use in fisheries and potential suitability for adoption in various European fisheries. How well does the methodology fit to the interests of actors in fisheries (managers, scientists, fishermen, industry, other interest groups

Achievements in contrast to state of the art and conclusions

Risk assessment is defined as the probabilistic evaluations of the potential consequences of alternative management actions. The review of risk assessment methodology covers Utility Theory, Decision Analysis, Juridical Argumentation, Environmental Risk Analysis and Human Health Risk Modeling.

Utility Theory has been developed mainly within the field of economics and is used to infer the utility function (i.e. preferences) of individuals and has applications in Bayesian decision models, where the function(s) to be minimised or maximised represent elements of interest to one or all actor groups. A comparison of the impact of these utility functions by a decision model enables the analysis of sensitivity of risk management on the alternative objectives. Juridical Argumentation is relevant for the precautionary approach, i.e. the burden of proof in alternative management systems and the juridical argumentation needed for risk management in alternative user rights systems. Environmental Risk Analysis includes several types of risk methodology, and some of these may be very relevant when considering the environmental impacts of fisheries. The main difference with terrestrial risk analysis is the higher measurement uncertainty of aquatic environment. Finally Human Health Risk Modeling is also covered in relation to the herring case study where dioxin in the Baltic is of concern.

The report includes conclusions on applicability to fisheries.

D8 Review of risk management methodology (IC)

Methods and approaches

This review aims to define and briefly summarize the methods and practices of risk management in fisheries worldwide. Examples of fisheries risk management methods from several countries inside and outside of Europe are surveyed. In particular, the multi-tier fisheries risk management framework in Australia is outlined and discussed as an example of best practice currently implemented. Finally, recommendations are made that could contribute to the risk management strategy in fisheries in the EU.

Achievements in contrast to state of the art and conclusions

Most of the countries surveyed, in particular Australia and New Zealand, like the EU, are at various stages of developing *new* risk management strategies in fisheries. Although, fisheries have been managed in various ways for centuries, modern concern for environment and social justice, the accelerating pace of technological innovation, globalization, population growth, economic growth, as well as the changes occurring in the ecosystem and climate, all necessitate new and more robust approaches to managing fishing activities.

Below is a short summary of elements that could be considered in the process of developing a European risk management policy:

- Market signals: currently the prices of fish don't reflect the precariousness of the fish stocks, nor do the prices reflect the damage to ecosystems, or the risk of such damage.

- Overcapacity: Overcapacity in the European fishing fleet is a major obstacle towards implementing a risk averse management system, because it can result in many losers when changes are introduced.
- Incentive-based management: explore ways to create incentives for fishers to avoid overexploitation, for example by issuing long-term property rights which are either individually, group or geographically based
- Expand marine protected areas to cover all ecosystem types in the European waters, as well as parts of the areas that are keys to the functioning of ecosystems such as spawning grounds, wetlands, coral reefs, etc.
- Reduce disturbance such as pollution, toxic or nutrient rich run offs and restore environments, such as spawning and rearing habitats in rivers for anadromous species.
- Organization of scientific advice: with respect to risk analysis, research activities need to be better coordinated and focused on risks.
- Stakeholder participation: there is a need to develop new institutional settings to enable more constructive engagement with the industry and other interested parties.
- Economic and sociological factors: currently economic and social factors are considered at stages separate from the scientific analysis. This situation can lead to scientific advice being diluted and contested after it is given.
- Ecosystem based management: risk in fisheries management needs to be dealt with in the ecosystem context.
- Consensus over risks: managers need to clarify and make explicit management objectives and try to foster and express consensus over risk attitudes.
- Precautionary approach: if there are insufficient data or resources for thorough quantitative analysis in a given fishery, a qualitatively based risk management approach should be considered since models for such approaches appear to have been implemented successfully elsewhere, and particularly in Australia.
- Minimum information: determine a minimum level of information about risks for the various different types of fisheries in European waters. If uncertainty is too high, restrict fishing until more information becomes available.
- Data collection and industry: create incentives for the industry to collaborate financially and practically with data collection and analysis.
- Improve scientific methodology with respect to the considerations of uncertainties.
- Stock assessments: require all stock assessments to quantify and explicitly document the forms and degree of uncertainty associated with the predictions and reference points that result from uncertainty in model parameters and uncertainty over the forms of dynamics accounted for in the models.

- Standardization of risk reporting: standardize the reporting of risks, uncertainties with regard to predictions and reference points (e.g., follow up on the concept of a risk register).
- Management strategy evaluations: use MSE methodology to evaluate alternative management options.
- Market based mechanisms for implementing restrictions: explore the applicability of fishing fees, the ITQ and ITE systems, in addition to quotas.
- Emergency measures: expand the mandate of managers to impose emergency measures based on decision rules associated with stock assessment outputs.
- Enforcement: invest in greater enforcement of fisheries management rules and regulations.
- Climate Change: Initiate further research to identify risk management approaches that are found via simulation evaluations to be robust to the potential impacts of short-term and long-term climate change on marine ecosystems.
- Insurance schemes: identify insurable risks and consider implementing a insurance scheme (Ludwig 2002).

D9 Review of economic risk analysis and multi-species economics (Uhel/econ)

Methods and approaches

Awareness of limitations in the current fisheries policy-making models calls for the exploration of methods applied in several other domains to decrease economic risks in fisheries. These methods include portfolio analysis, mean-variance analysis and more advanced methods from financial and insurance economics.

Achievements in contrast to state of the art and conclusions

The environment can be treated as a productive asset and to adapt four principles from financial decision making: 1) protect your capital, 2) hedge your investments, 3) do not risk more than you can afford to lose, and 4) buy insurance. By modifying and interpreting the original principles, the first rule of asset management is to protect the stock of assets and live off the dividends or the interest. In the context of fishery management, fish stock biomass must be maintained at such a high level that it is capable of producing sustained yield. Hedging is a common sense concept of "not putting all of your eggs in one basket" which is more formally implemented by the portfolio approach. That is, diversifying limits risks caused by the possibility that investment on one fishery sector would not yield the expected outcome. The third principle orders to assess and communicate what is at stake and to make decisions at all levels of institutions keeping the stakes in mind. Lessons from history indicate that several regional civilizations collapsed because they risked more than they could afford to lose. Insurance should be acquired to protect oneself against the above mentioned cases.

The principles above are obvious and comply with common sense but nonetheless are not commonly implemented. The problem is that the scale of management problem surpasses the scale of current institutions and, importantly the lack of ownership of living marine resources. Scientific certainty and consensus in itself will not prevent overexploitation and destruction of resources unless human motivation and responses are integrated as part of the management system. As problems are economic, social, political, and to a smaller extent ecological, the pursued solutions must consider these dimensions in a multi-disciplinary framework

D10 Review of psychological, sociological and cultural risk theories and assessment methodologies (CEMARE, HCMR, UNAK))

Methods and approaches

The aim of the review is to improve the assessment, management and communication of risk and to provide an integrated approach including biological, economic and social objectives.

This report seeks to address the following two questions:

"What does research currently tell us about Psychological, Social and Cultural issues with respect to the fisheries system in general in a range of countries?" And;

"What Psychological, Social and Cultural risk theory concepts from the non-fisheries specific literature can be most usefully applied to the fisheries system?"

Achievements in contrast to state of the art and conclusions

Given the complex challenge of fisheries management and the many factors that influence people's decision making – it is not possible to identify one model to encompass all aspects of psychological, cultural and sociological risk theory considerations into fisheries risk management. However aspects from many may be taken and combined into a relevant framework for risk management in fisheries. These may differ from country to country because of differing psychological, sociological and cultural characteristics.

Assessments of risk, whether they are based upon individual attitudes, the wider beliefs within a culture, or on the models of mathematical risk assessment, necessarily depend upon human judgement. In this respect it can be argued that assessments of risk involve a degree of subjectivity, to a greater or lesser extent.

This review identified a number of suitable tools which will be employed within the 2007 case studies.

D11 A report on the interview results (CEMARE, HCMR, UNAK, AZTI)

Methods and approaches

The interview process was designed around the presentation of a succession of ‘mental models’ to interviewees. Mental Modelling is a qualitative analysis technique used by social scientists, cognitive psychologists and decision-making theorists.

Mental modelling has been used to elicit risk perceptions in relation to a wide variety of issues.

In the context of this research project, mental modelling was used to capture the thought process behind an individual’s perception of the key risk events or hazards within the fisheries system. It was also used to capture explanatory information in relation to perceived linkages between risk factors, e.g. ranking, weighting and the direction of these linkages.

A semi-structured face-to-face format was chosen for the interviews and the following mental models (MM) were presented in turn at the appropriate stage:

- MM1: Blank model
- MM2: Comprehensive model
- MM3: Revised model

Achievements in contrast to state of the art and conclusions

The results of each case study are given in 4 different reports. The summary of the results is given in joined deliverable D17_D18.

D12 Journal MS/report: Probabilistic Evaluation of ICES uncertainty methodology and comparison to Bayesian stock assessment (UHel/biol)

Methods and approaches

The purpose of this paper is to evaluate the methods most commonly used in the ICES stock assessment working groups in the light of their approach to quantifying uncertainty. Those methods are then compared to the Bayesian approach to stock assessment.

In order to identify proper criteria for the evaluation and comparison, it is first necessary to define what the uncertain quantities are for which the uncertainty should be measured. Another important issue is to dig deeper into philosophical meaning of uncertainty in order to decide what type of measure of uncertainty would be desirable and also to find out whether it is of any relevance to discuss about whose uncertainty is going to be measured.

In order to put the discussion in a concrete context, the assessment of the North Sea herring is used as an example, because the assessment is considered to represent very well the mainstream of the methods used by ICES stock assessment working groups. The report of the Herring Assessment Working Group (HAWG) for the Area South of 62° N (ICES 2006) is used here as the source of information about the North Sea herring assessment.

Achievements in contrast to state of the art and conclusions

According to our evaluation, the most commonly used stock assessment methods in ICES working groups do not directly quantify the uncertainty about quantities that are of interest to fisheries management. For example, HAWG reports point estimates and associated variances or confidence intervals of key quantities such as SSB and F. These measures do not quantify uncertainty about the quantities themselves, but give an indication about potential variability of point estimates calculated from hypothetically repeatedly collected data sets. This clearly is irrelevant for management, because only one data set has actually been collected, and uncertainty about the stock status should be quantified based on the observed data set and other relevant knowledge.

This type of conceptual error is not in any way specific to HAWG, or limited to ICES stock assessment working groups. Instead, the error is widely spread through most of the fields applying some sort of statistical inference. There are at least five misinterpretations that are common:

1. 95% confidence interval as an interval in which the true value lies with probability 0.95
2. p-value as the probability that the null-hypothesis is true
3. Maximum Likelihood Estimate as the value that is most probable given the data

4. Standard error of a point estimate as the standard deviation of a probability distribution of the quantity of interest given the observed data
5. Sampling distribution or a histogram of bootstrap samples as a probability distribution of the quantity of interest given the observed data

From these, the last one (5) is most pronounced in ICES stock assessment. Sampling distribution or a bootstrap sample of a point estimate is used in place of the probability distribution of the current stock status when forward projections under alternative management options are made. This implies that the future stock status projected with a population dynamics model is not conditioned on the uncertainty about the current stock status but on sampling properties of a point estimator, which implies that the probability statements about the future stock size are not defined in a conceptually consistent way: two different interpretations of probability are mixed and variables are not exactly those that are of interest.

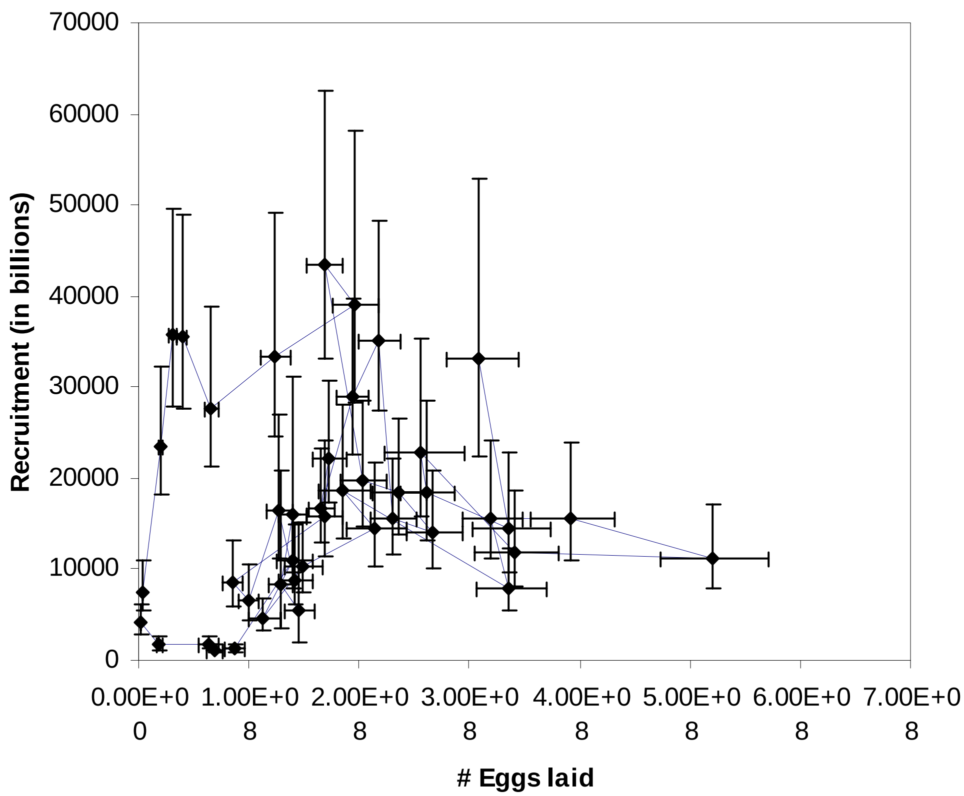

Figure. Example figure from D12. Posterior distributions of the size of the spawning stock plotted against the corresponding posterior distributions of recruitment. The bars represent 95% probability intervals and the dots represent medians. The line connects the medians in chronological order.

D13 Journal MS/report: Improvement of S/R information by hierarchical models (IC)

Methods and approaches

In this paper issues of combining information from several stocks within a hierarchical Bayesian meta-analysis of stock recruit relationships are explored with an example of several principal ICES herring stocks. The emphasis is on including more of the existing information by formulating this knowledge as priors within the analysis. Information from surveys on weight at age, maturation rates and adult natural mortality is used in a theoretical model to describe uncertainty in spawner biomass per recruit. The objective of this paper is to quantify the uncertainty in resilience across herring populations to recruitment overfishing as characterized by the steepness parameter – the proportion of virgin recruitment that can be produced when the spawning biomass is reduced to a fifth of the size of the unfished stock biomass. This paper also addresses the gaps in previous similar studies by including the uncertainty in spawner biomass per recruit, arising from observed changes in the vital rates of herring stocks. Furthermore, we use a retrospective analysis of the stock recruit data to show how the hierarchical model aids in the distribution of information across the stocks and significantly helps to decrease the uncertainty in the key stock-recruit parameters, and by association key management reference points, over time.

The aim of this paper is to improve the understanding of resilience to recruitment overfishing of principal ICES herring stocks based on a hierarchical Bayesian meta-analysis of stock recruit data. The recruitment dynamics of herring are thought to be strongly related to environmental conditions, so much so that the stationarity assumptions underpinning most conventional stock recruit analyses are questioned: evidence for regime-type changes in productivity in response to environmental drivers have been postulated in a number of articles (Brunel and Boucher 2007; Olsen and Melle 2007; Simmonds 2007). Winter and Wheeler (1987) point to salinity and temperature to be important factors affecting recruitment success. They also conclude that the evidence from observed collapses and recoveries of Atlantic herring stocks indicate that steepness of stock-recruitment relationships must be high in general, and higher for more northern stocks (Winters and Wheeler 1987). It is believed that salinity and temperature affect the availability of food (plankton) for hatching herring larvae, thus influencing the size and growth of a recruitment cohort (Schweigert and Haegele 1985).

In this paper we present an analysis that improves on the theoretical framework presented by Dorn (2002) and Michielsens (2004) by addressing the issues that arise with the inclusion of uncertainty in spawner biomass per recruit. This type of analysis is not capable of explicitly addressing time-dependent changes – stock recruitment analysis assumes stationarity, or observation error. This kind of stock recruit analysis assumes that the independent variable, i.e. SSB, is known without error, but it can feed into the state space methodology that is capable of dealing with those issues by formulating existing knowledge in the form of priors (Peterman 2004). The observed variability in the vital rates of different herring stocks, such as weight at age, natural mortality and maturity at age is taken into account by quantifying the uncertainty in spawner biomass per recruit and including this information into the analysis. In previous published studies that used spawner biomass per recruit (SBPR)/steepness parameterisation, either no uncertainty in spawner biomass per recruit was considered (Dorn 2002) or SBPR was estimated simultaneously with the steepness parameter; however, in the latter approach the estimates of steepness and SBPR are inevitably highly confounded (Michielsens and McAllister 2004).

Achievements in contrast to state of the art and conclusions

When using the steepness characterisation of the stock-recruitment relationship we developed a clear and rigorous way to define the hyperprior for the steepness parameter, using a modified beta distribution. Previous approaches (Dorn, 2002) used a logit-type formulation while in Michielsens and McAllister (2004) the mean and variance of a beta-type prior for steepness was employed, but required additional constraint information to guarantee the steepness to be constrained sensibly. By using directly the parameters of a modified beta-type steepness prior we were able retain the flexibility of this distribution (in terms of accurately expressing skew in the distribution which is more difficult in the logit-approach) but avoid the need for constraining the mean and variance, but do show how the mean and variance of the prior steepness are uniquely expressible in terms of the steepness hyperparameters. When using the steepness-virgin biomass parameterisation the spawning potential per recruit is required, itself a combination of several vital key rates (maturity, natural mortality, weight and growth). Previous work has either assumed this input parameter as fixed and known without error or has been estimated along with the rest of the stock-recruit parameters and assigned an informative prior distribution. The spawning potential per recruit is clearly confounded with the steepness/slope-at-the-origin parameter making estimation a potentially risky approach – even with informative priors. In this paper we demonstrated a clear framework for the inclusion of uncertainty in this key input parameter and, given derived Monte Carlo samples of the SSB-per-recruit for the herring stocks in question, also demonstrated the potential effect of not considering uncertainty in this input variable in terms of the resultant estimates and precision of our stock-recruit parameters. Finally, most analyses of this kind have tended to concentrate on the steepness as the key parameter likely to be shared across stocks (given its non-dimensionality) but we also demonstrated how the (normalised) gradient of the stock-recruit curve at the origin is just as suitable for consideration as the hierarchical parameter: it is both non-dimensional and is directly related to the steepness in the Beverton-Holt/Ricker models. Furthermore, the steepness lacks a suitable parameterisation for other stock recruit models such as the Shepherd (Shepherd and Cushing, 1980) and hockey-stick (Barrowman and Myers, 2000) stock-recruitment models but this normalised gradient at the origin is common to all four of these the most commonly used stock-recruitment relationships thus allowing for a potentially wider field of models to be used in future such analyses.

This paper will be submitted in April 2009.

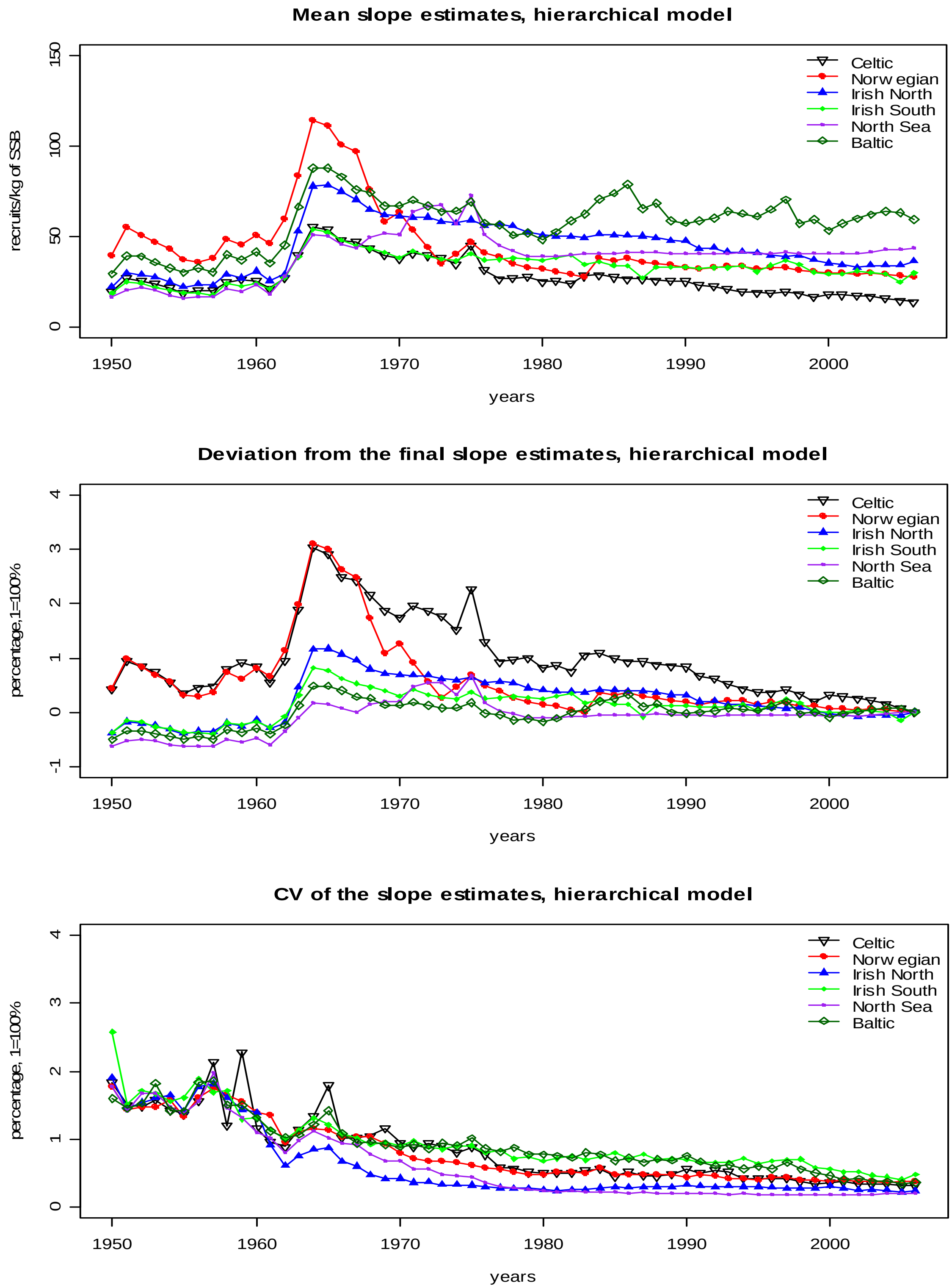

Figure. Example figure from D13. Hierarchical estimates of slopes from 1950s to 2006.

D14 Journal MS/report: Risk classification results (CEFAS, IC and Uhel/biol)

Methods and approaches

Data on life history characteristics (from Gislason et al., 2008) were used to construct generic fish populations based upon the life history traits of demersal fish species. The populations were characterised by their size and stock recruitment relationship.

Reference points such as F_{MSY} and F_{Crash}, which are used as proxies for the level of exploitation that would provide the maximum sustainable yield or drive the stock to extinction respectively, are dependent upon the characteristics of the fishery, as not all ages are equally vulnerable to a fishery. Therefore the impact of different types of fisheries were evaluated by assuming selection patterns where L_{50} were either i) to the left, ii) equal to or iii) to the right of the L_{MAT} with either a flat topped or domed selection pattern.

Plotting the expected yield against biomass gives the surplus production (see figure 3), i.e. for any level of biomass the production in a year is indicated by the equilibrium line. In the absence of fishing there are two stable equilibriums, biomass = K or 0. K is the carrying capacity above which, due to density dependence, the stock will decline. At the origin the intrinsic rate of increase of the stock is a maximum, due to the lack of density dependent effects. The two lines represent replacement lines equivalent to a given exploitation rate (yield/biomass), maximum productivity is found at the curve maximum, and the replacement line passing through this point corresponds to an exploitation rate of F_{MSY}. The line to the left of this curve has a slope equal to the slope at the origin (i.e. r). An exceeding exploitation rate is unsustainable and so provides an upper limit on exploitation.

Achievements in contrast to state of the art and conclusions

This analysis illustrates how even for data poor stocks both limit and target reference points can be derived at least to allow comparison between stocks and fisheries. This could be used as a first screening to provide a simple and transparent way to classify stocks and their limits to exploitation. In this way it should be possible to improve our management by providing a general risk identification protocol of use for bodies like STECF and ICES. The framework providing a screening process to identify stocks and fisheries at risk for which effort should be directed. In particular its use to develop management reference points, based upon the biological dynamics and fisheries. In addition linking utilisation to data quality linkage may lead to an interest to improve data quality by industry. An important aspect in this regard is identification of the relative value of information relative to control. The framework can also be extended to bycatch and non-target species for which currently assessments aren't provided.

The next step will be to work out how to provide management advice using such an approach and to develop tools that will allow priority stocks e.g. those most at risk in tier 4 to be moved up a tier.

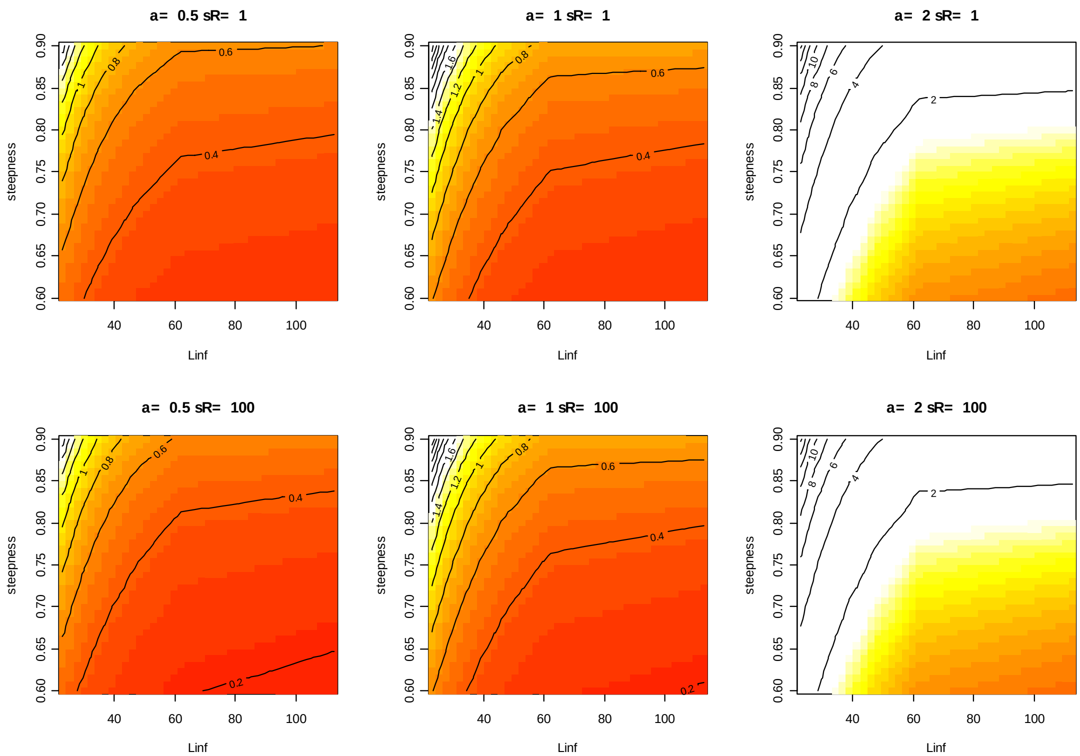

Figure. Example figure from D14. Beverton and Holt stock recruitment relationship; contours of F_{Crash} for different values of L_{∞} and steepness. Rows correspond to i) flat topped and ii) domed selection patterns and columns for selection patterns whose L50s were i) to the left, ii) equal to or iii) to the right of the Mat50 of the maturity ogive.

D15 Journal MS/report: The use of value-of-information and value-of-control in the planning of risk management (UHel/biol and CEFAS)

Methods and approaches

We take a decision theoretical approach to fisheries management, using a Bayesian approach to integrate the uncertainty about stock dynamics and current stock status. We express management objectives in the form of a utility function. The value of new information, possibly resulting in new control measures, is high if the information is expected to help in differentiating between the expected consequences of alternative management actions. Conversely, the value of new information is low if there is already great certainty about the state and dynamics of the stock, and/or if there is only a small difference between the utility attached to different potential outcomes of the alternative management action. The approach can therefore help when deciding on the allocation of resources between obtaining new information and improving management actions. In our example we evaluate the value of obtaining perfect knowledge on the type of stock–recruitment function of the North Sea herring (Clupea harengus) population.

Achievements in contrast to state of the art and conclusions

We have demonstrated here that a VoI analysis can be performed in a fisheries decision-making context when using a complex population model including structural uncertainty. The VoI analysis can be performed on any uncertain quantity that is included explicitly in a probability model that describes the current knowledge of the current state and dynamics of a fishery system. Therefore, the concept should be useful in decision-making at all levels, from an individual fisher to international communities who make decisions and plan and fund research activities. The VoI analysis provides a clear comparison between the consequences of management actions and decisions to obtain more information, because the VoI is expressed on the same scale as the objectives that the manager is trying to achieve. Systematic analysis of VoI would then provide a way of finding the most critical uncertainties from a decision-making perspective. As we demonstrated here, the steps needed to obtain the VoI also produce results that can be used to calculate the price of overconfidence, the expected loss of ignoring the uncertainty that is admitted to exist. Such an approach might be helpful when trying to simplify a complex model structure so that it can be used in practice. As intentional simplification of a model for a system known to be more complex typically leads to overconfidence about the state of the system and model parameters, the process of simplification could potentially be guided by the goal of trying to minimize the price of overconfidence. Then the simplified model with artificial certainty would still work similarly to the more realistic model. Similar procedure has been suggested also by Morgan and Henrion (1990), who calculated the expected value of ignoring uncertainty.

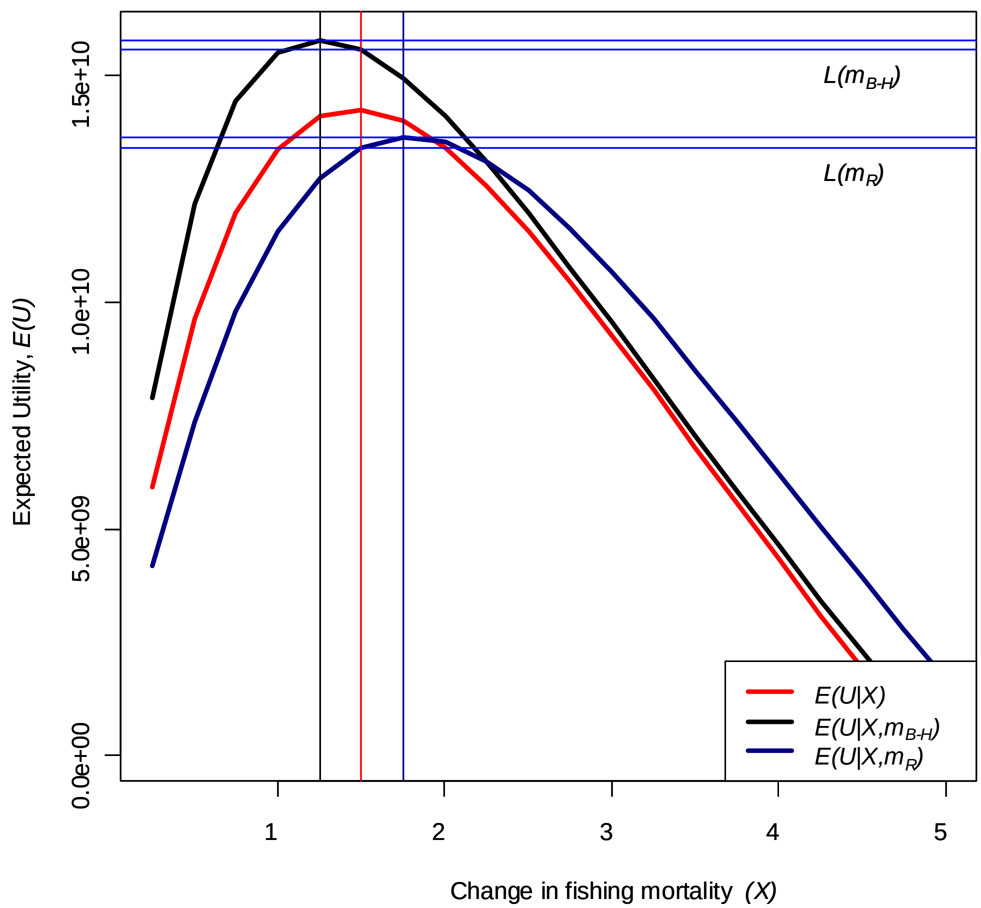

Figure. Example figure from D15.

The concept of VoI is potentially most useful when analysed jointly with the Value of Control (VoC). Analogous to VoI, VoC is the increase in expected utility that would result from obtaining control on a variable that is currently uncontrollable. Comparison of VoI and VoC can then be used to distribute limited resources between management actions and gathering of new information. These concepts were utilized, e.g., by Varis et al. (1990), who demonstrated in a water quality decision analysis, that the most risk adverse strategy in that case was to invest mainly on management actions instead of monitoring, since only management actions improved the state of the system. Similar type of analysis has been done in fisheries science as well, but without explicit consideration of VoI and VoC (e.g. Hansen and Jones 2008a, Hansen and Jones 2008b).

This deliverable paper has been submitted to ICES Journal of Marine Science.

D16 Journal MS/report: Strategic risk management: Stability of international fisheries agreements and ecological harvesting strategies (UHel/econ)

Methods and approaches

Open access drives fisheries to inefficient harvest rates and ultimately to stock collapses. International agreements are often necessary for exclusion of open access because many fish resources are spread across national boundaries and international waters. In fisheries economics, game theory is a common tool for analysing the strategic interactions of different countries. The main point is that all countries should be better off by cooperating, i.e. by complying with the agreement, than non-cooperating. We parameterized an age-structured bioeconomic model for the North Sea herring fishery to analyse the economic impact of harvest control rule (HCR) on this fishery.

Achievements in contrast to state of the art and conclusions

The trigger points of the current HCR are developed from spawning stock biomass and fishing mortality rate ceiling. They can be regarded as strategic bioeconomic reference points which operationalize the precautionary approach. Applying precautionary approach by the grand coalition through current harvest control rule adds net present value of the fishery compared to the case without the HCR. However, it does not pay off for a partial coalition to apply harvest control rule if the outside player does not comply with it and harvests using an optimal fixed fishing mortality rate. The coalition structure and the fishing costs have a strong impact on the optimal fishing strategies of the countries. The grand coalition is stable only when low fishing costs are low for two of the countries. If fishing costs are identical among countries, there will be incentive for free riding and multinational fishing agreement is never stable. However, HCR has potential of stabilizing multilateral fishing agreements if fishing costs are, on the applied relative scale, high.

We analysed what are the international consequences of harvest control rules where the trigger points can be regarded as strategic bioeconomic reference points. Non-cooperative equilibria (Nash) were compared to the partial (subcoalition) and full cooperative (grand coalition) outcomes. The shares that each country will receive were determined by cooperative solution concepts (Shapley value). We solved reaction functions for the countries in a case study to find the optimal fishing mortality rate of a country as a function of fishing mortality rate of other countries harvesting the same fish stock. The results of our study will help to understand the dynamics of international fisheries negotiations. Indicating the key obstacles to stable international arrangements is a key issue in international risk management. In some cases risks may increase cooperation and in some cases decrease it.

The simulations for the North Sea herring stock indicate that using precautionary bioeconomic harvesting strategies may increase stability of international fishery agreements. Stability of agreements depends crucially on costs of harvesting. The grand coalition is always stable only when low fishing costs for two of the players are assumed. In this case, it would be beneficial for all countries to cooperate in the grand coalition. If fishing costs are identical among countries, there will be incentive for free riding and multinational fishing agreement is never stable so that at least one of the countries will have incentives not to sign in the agreement or to sign out from the grand coalition. However, HCR has potential of stabilizing multilateral fishing agreements if fishing costs for two of the players are high. In this case, acceptance of the precautionary approach as the baseline of management will induce stability of the grand coalition.

This deliverable has been submitted to Marine Resource Economic.

D17 Report on results of work in each Case Study country under WP4.3 (CEMARE, , HCMR, UNAK, AZTI, CLRD)

This deliverable is a joined one with D18, put in three parts (a, b and c). The most important findings are collected to a journal paper.

D18 Journal MS/report: Comparative review of risk perception and identification in Case Study Countries 4.3 (CEMARE, , HCMR, UNAK, AZTI, CLRD)

Methods and approaches

A Mental Modelling interview process was constructed to elicit interviewee perceptions of risk, and the strength of these perceptions, in relation to the fisheries sector. A series of semi-structured face-to-face interviews were carried out in 2007 in each Case Study Country with a variety of fisheries sector stakeholder groups. Mental Modelling is a qualitative analysis technique used by social scientists, cognitive psychologists and decision-making theorists which does not impose a pre-structured set of 'expert' beliefs on the interviewee. It is used to explain an individual's thought process in relation to how something works in the real world (Johnson-Laird, 2004) and has been used to elicit risk perceptions in relation to a wide variety of issues, for example, the UK fishing industry's views on the potential socio-economic impacts of offshore wind energy (Mackinson, Curtis, Brown, McTaggart, Naylor, Neville & Rogers, 2006), health risks from heavy metals exposure (Vasquez, Regens & Gunter, 2006) and expert perceptions for managing climate change (Lowe & Lorenzoni, 2007). The technique is also often used as a starting point in the construction of a program of risk communication (Morgan, Fischhoff, Bostrom & Atman, 2002).

Interviewees were initially asked to identify as many separate risk issues that they felt were of relevance to the fisheries sector (Blank Model: MM1). The interviewer did not influence the interviewee or make any suggestion as to what people may perceive as a risk in the fisheries sector. Interviewees were asked to rank their risks numerically (e.g. from 1 to n depending on number of risks identified) and to assign each risk with a weight using the scale 0.1 to 1.0, with 1.0 being the highest possible weight representing the most serious risk. Explanatory information was also captured in relation to perceived linkages between risk factors, e.g. ranking, weighting and direction of linkages. At the next stage (Comprehensive Model: MM2) interviewees were shown a 'Comprehensive model' which was specially constructed for each group of stakeholders and used consistently across all Case Study Countries. These Comprehensive models were comprised of a collection (and description) of possible risks relevant to this stakeholder group and were based on the results of pilot surveys undertaken Case Study Countries in 2006. These risks were not linked or ranked. Interviewees were asked if they wished to revise their MM1s to form MM3 (Final Model: MM3) and asked why they chose to add (or to omit) risks that had been included in the Comprehensive model.

Interviews in each country were targeted at fisheries sector stakeholders with a direct or partial interest in a particular type of fishery: North Sea cod fishery in the UK, cod fishery in Iceland and the Faroes and the hake and karamote prawn fisheries in Greece. These target fisheries provide a form of comparability between Case Study Countries in the sense that they are prominent in terms of their economic and political profiles, comparable in terms of fishing gears and being targeted by both inshore and offshore fleets and are the focus of contrasting management measures. However, the interviewee selection process did not obtain interviews from a statistically meaningful representative sample of stakeholders – particularly for fishermen and consumers - therefore the robustness and comparability of results should be treated with caution.

Achievements in contrast to state of the art and conclusions

The experiences from the interview process highlight the subjective nature of eliciting risk perceptions and the dynamic and fluid way in which people adapt their thoughts even within the interviews themselves. For example, scientists and government officials tended to have a clear pre-defined idea of their risk perceptions whilst the interview process for others was more fluid: ideas (and risk rankings) were re-evaluated as the interview progressed. This was partly to be expected given the type of structured, analytical and ordered work those in the former group undertake as part of their normal duties. With the exception of consumers, the majority of respondents identified most risks at the MM1 stage. When shown MM2, many had either already identified the risks or felt that 'new' risks were already encompassed within those they had identified at the MM1 stage. This highlights the rich nature of the interview data and interwoven and linked thought processes of interviewees. However, responses from consumer groups were more varied between countries: UK consumers – particularly the fishing 'unaware' identified relatively few risks compared to those in the other countries. This may have been influenced in part by the interview settings, but probably also reflects the fact that fishing and consumption of fish products is relatively less important to the UK public than is the case in Greece, Faroes and Iceland.

The results clearly show both differences and similarities in the preferred ranking of types of risks perceived by different stakeholder groups within each country. For example, the clustering and proximity analysis identified a strong similarity in the type of risks identified by scientists and inshore fishermen in the Faroes, with the focus being upon perceived risks from poor fisheries management, stock reduction, overfishing and excess fishing effort. However, risks identified by government interviewees tended to be more widespread but with a strong focus upon the potential environmental legislation and other pressures (e.g. demands to introduce ‘eco-labelling’) from the environmental lobby. In Greece, scientists tended to be concerned with stock depletion due to overfishing, discards, bycatch and gear-related ecosystem impacts where as offshore fishermen were focused upon ‘economic’ risks such as labour supply and the rising cost of fishing. Differences between perceptions at the national level were also apparent. Icelandic and UK interviewees were nearly twice as likely to assign maximum scalar values to risks. The Faroese were less likely to record maximum values, but more likely to assign lower scalar values to risk issues. Greek responses tended to fall within these extremes. Given that the interview method was designed to allow for a degree of comparability in results between countries, this result may indicate the importance of cultural, societal and ethnic factors and norms which influence the strength which with people proffer opinions.

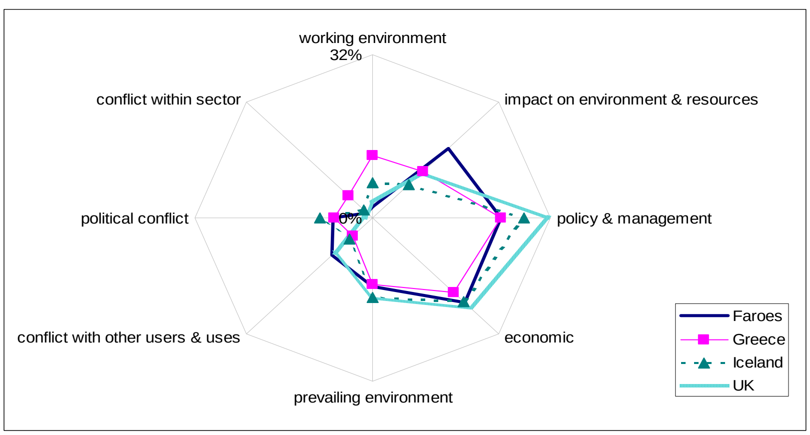

Figure. Example figure from D17-S18. Proportion of total risks cited, by major grouping and country (% of total).

The perceived risk in relation to a fisheries management or policy issue was the most important risk generic to all countries in terms of ranking. Fishing organisations ranked some aspect of fisheries management or policy first in all countries and all other stakeholder groups (except consumers in Greece and the UK who did not mention this risk at all) ranked some aspect of this risk between first and sixth. This risk was ranked highest, on average, across these stakeholder groups in the UK (average ranking of 1.7), followed by Faroese, Greece and lowest in Iceland (3.3). In the UK the perceived risk related to a lack of quota under the FQA system, compatibility problems in respect of the 'days at sea' system and ineffective policies and a rigid management system mostly imposed by the EU. Risks in the Faroese related to concerns about political mismanagement as excessive fishing effort was not curbed in spite of scientific recommendations that effort on cod stocks should be reduced and to illegal fishing, particularly in the blue-whiting fishery. Greek risks related to an outdated legislative framework with high levels of management bureaucracy and inadequate enforcement. Finally, Icelandic risks related to concerns about political interference with TAC setting, the recent 30% reduction in cod TAC and quota allocation and community-related issues. The average ranking amongst stakeholders at the country level suggests that the UK sector perceived the combined FQA and 'days at sea' management system imposed in part by the EU to be more risky than the Icelandic sector perceives its ITQ and related-management system to be. The Faroes transferable effort-based system and related political interference, and outdated and ineffective Greek management system appear to lie within this continuum. However, compared to other key risks identified in each country (e.g. overfishing, climate change, fisheries science and environmental organisations and their potential legislation) fisheries management or policy issues were most important across stakeholder groups and countries.

This deliverable has been submitted to Marine Policy.

D19 Document on evaluations of the behaviour and performance of alternative risk management methods (IC).

Methods and approaches

A stochastic population dynamics model of a herring-like stock was developed to illustrate how the economic stability of a fishery can be affected by an insurance regime. This model allows us to explore, quantitatively, the links between risks introduced through either environmental, or knowledge related, uncertainties versus risk introduced through implementation of fisheries management, and the scale of insurance premium required to mediate the risk.

The insurance policies modeled here are based on systems employed in agricultural risk management, such as the RMA of USDA. Harvest shortfalls are covered at selected price levels. Indemnity payments are triggered when the harvest falls below the covered proportion of an historical average harvest (for example, the previous ten years). The size of an insurance payment depends on an agreed price coverage level, modeled as a proportion of the preceding average price.

We calculate the size of a premium needed to guarantee that the insurance fund is sufficient to cover losses after the first 10 years of operations in 75% of the simulations. The most extreme 25% of the simulations are assumed to be covered by reinsurance; a premium charged for re-insurance is calculated separately. During the first 10 years of operation the fund is allowed to borrow money at 8% interest. Insurance funds can earn 5% annual interest when not used to make payments. The introduction of reinsurance to the model deviates from the Salmon insurance example and simulates the Potatopol use of reinsurance to limit fund exposure to high cost/low probability events.

The model is stochastic and the variability of its predictions can be controlled by changing the standard deviation of the parameters representing biological or fishermen's behaviour-related uncertainty. The model is designed to explore ideas related to insurance, building on the theoretical framework suggested by Ludwig [7]. We use an age-structured model, with a stochastic stock-recruitment Beverton and Holt type relationship. Prices are considered elastic with respect to the supply of fish [10]. The parameters of the stock-recruitment relationship are based on Bayesian hierarchical meta-analysis of the herring stocks [11]. Other parameter values, such as maturity, mortality and weights at age are based on ICES stock assessments.

Achievements in contrast to state of the art and conclusions

The size of the payouts and therefore the premiums is influenced by all the factors that contribute to the variability in predictions. We can use the model to explore how changing the assumptions regarding the variability of model parameters could affect insurance. This is useful because certain sources of uncertainty are indeed controllable: knowledge can be improved, reducing uncertainty in the estimates of model parameters; fishing can be controlled so as to reduce both the level of exploitation and the variability of harvest rates. We can use the model to investigate the benefits of reducing the controllable sources of uncertainty measured by the lowered cost of insurance.

The focus of an insurance tool varies between fishing industry and fisheries regulators. For industry the focus is on revenue (a product of catch and price) set against individual or fleet average records and effort employed. A variety of fund creation and management options are available including: fixed premium, variable fund; variable premium, fixed fund; invest or return surplus in fund, at various intervals; frequency of premium or fund review; capped or uncapped liabilities; reinsure upper tail of liability, or leave unmet, etc. Our example model has been developed for a fixed on/off premium variable fund with capped liabilities (enabled by the use of reinsurance) but any system could be simulated and their impacts evaluated. The model demonstrates how insurance payouts can provide a "soft landing" when there are short, sharp declines in harvest (such as in Fig 3b, years 7-9), giving a few years for longer term adjustment. Where there is a long term decline in harvest insurance is not likely to be able to help (Fig 4). The level of insurance is important in determining the effect on subscribers; in Fig 3a a 60% harvest threshold does not trigger payouts, an 80% threshold holds net revenue level for a few years as harvests fall (Fig 3b), while a 100% harvest threshold (Fig 3c) results in "over-compensation" for several years, which may send the wrong signal to fishermen. Lower thresholds than those in Fig 4 do not trigger insurance payouts in steadily declining harvests, as the average reference base falls at a continuous rate. In these conditions progressively smaller catches coupled with continued premium payments feeding a growing fund would make an insurance scheme highly unpopular. This suggests that other forms of fund creation and management should be evaluated in future models, such as a continuously variable annual premium reassessed each year, or a constant, fixed premium.

Insurance has three values:

- Reduces intrinsic unmanageable variance, which is worth a premium to subscribers (such as in hail insurance)
- Reduces risk behaviour by subscribers, so can alter outcome variance or mean or both (contract compliance like crop hygiene, or good agricultural practice)
- Increases enforcement or control by regulators (either as a direct party to insurance as an underwriter, like RMA; or indirectly, like political pressure on flood control authorities from subscribers facing high insurance costs)

Fishing is well suited to insurance, since it has fairly high intrinsic variance in outcomes, a propensity to risk inducing behaviour by fishermen, and a history of ineffective regulation.

<u>This deliverable has been accepted for publication in ICES Journal of Marine Science:</u>

Mumford, J. D., Leach, A.W., Levontin, P., and Kell, L.T. 200x. Insurance mechanisms to mediate economic risks in marine fisheries. – ICES Journal of Marine Science, XX: 000–000.

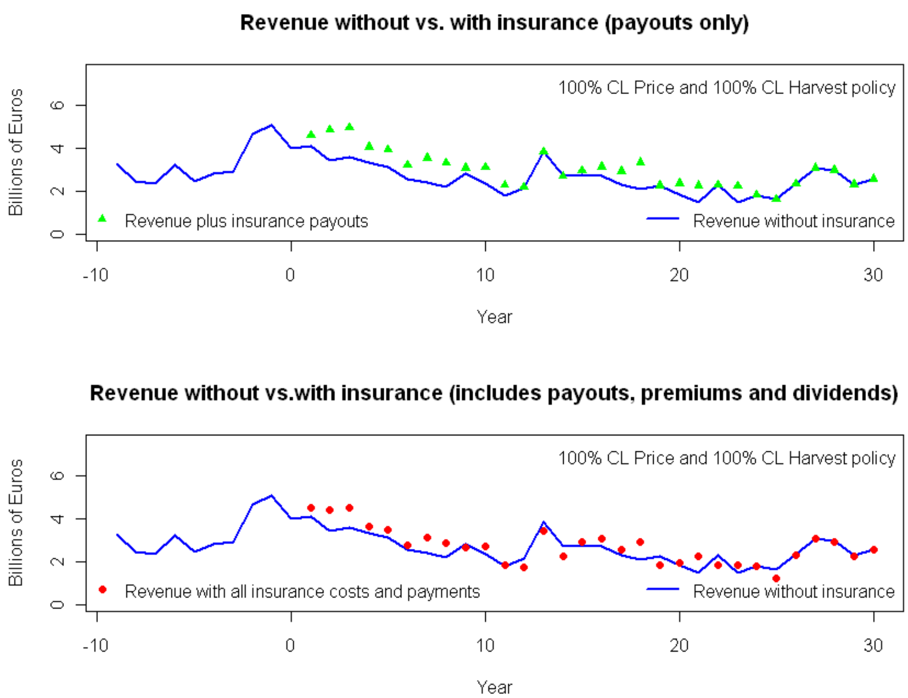

Figure 4. Example figure from D19. Revenue with and without insurance policy (100% price and 100% harvest coverage levels)

D20 A Journal MS/report:: Management of dioxin – Baltic herring problem: biological or human risks? (Uhel/biol)

The original aim of D 20 is dealt with in two separate deliverables (D20 A and D 20 B).

Methods and approaches

Population and bioenergetics models are used to evaluate the effect of fisheries on organochlorine concentrations in the herring catch through density dependent growth and herring physiology. The data are further used for probabilistic estimation of human organochlorine intake.

Achievements in contrast to state of the art and conclusions

Our results clearly demonstrate that in the risk management of organochlorines, regulating fishing (in this case increasing fishing pressure) is a far less effective way to decrease the risk than regulating the consumption of herring (Table 1). If fishing was used as a management tool, the managers would need to compare the risk of overfishing the herring stock to the health risks, which is a very difficult trade-off. There is effectively no manager for such an issue because fisheries authorities are different from food safety and health authorities. However, an individual fish consumer could easily decrease this risk by consuming other fish instead of herring. Our results also demonstrate that the randomness arising from the big differences in toxin concentrations among herring individuals is an underestimated issue. It is likely that the randomness in other sources of uncertainty of organochlorines may also be high, and therefore all these uncertainties should be taken into account when considering risk management in future.

This deliverable has been published in Ambio:

Kiljunen, M., Vanhatalo, M., Mäntyniemi, S., Peltonen, H., Kuikka, S., Kiviranta, H., Parmanne, R., Tuomisto, J.T., Vuorinen, P.J., Hallikainen, A., Verta, M., Pönni, J., Jones, R.I. & Karjalainen, J. 2007. Human Dietary Intake of Organochlorines from Baltic Herring: Implications of Individual Fish Variability and Fisheries Management. Ambio 36(2–3): 257–264.

D20 B Journal MS/report: Uncertainty in decision analysis: A case study of dioxins and Baltic herring (Uhel/biol)

Methods and approaches

Bayesian networks (BNs, also known as belief networks or probabilistic causal networks, Charniak 1991) are graphical models describing probabilistic relationships between a set of variables. Formally they are directed acyclic graphs (DAGs), whose nodes represent discretized (random) variables that have certain states and arcs probabilistic dependencies between the variables.

The model represents the complex management problem related to the elevated concentrations of dioxins in Baltic herring populations, and consists of 17 variables: 3 decision variables, 12 random variables, and 4 utility variables (Fig. 2 in MS). The model was constructed with Hugin Educational 6.8 software (Madsen et al. 2005). Posterior distributions for the variables ***Concentration_herring***, ***Limit_exceed_individual*** and ***Limit_exceed_population*** were calculated using a Markov chain Monte Carlo (MCMC) simulation algorithm (Gilks et al. 1995). Simulation was implemented using the OpenBUGS 2.2.0 software package, which is an open-source continuation of the well-known WinBUGS software (Spiegelhalter et al. 2003).

Achievements in contrast to state of the art and conclusions

The decision options included in the model have substantial effects on the losses related to human health in Finland.

Intensifying the fishing mortality F decreases the concentrations of dioxins in herring and thus the probability of an individual to exceed the limit set by the EU as well (Fig. 3). This reverberates also to population level and finally to the losses related to cancers resulting from dioxins in Baltic herring. The probability for fewer cancer deaths increases when F is increased demonstrating thus the effect of management (Fig. 4 in MS). This can be quantified also in monetary terms: e.g. by increasing the fishing mortality by 50 % from the present, the losses resulting from cancer deaths can be decreased by € 710 000 per year, from € 5 360 000 to € 4 650 000 (Table 1).

The closure of commercial does not seem to be a plausible management option for the dioxin problem. Although the losses related to dioxins can be eliminated this way, the probability for deaths and thus losses related to CHDs increase substantially. For instance, with present F the expected loss will be € 484 000 000 (Table 1). Hence, the losses will be approximately 100-fold compared to the situation, where the commercial fisheries are kept open. It is also important to notice that the losses resulting from keeping the Baltic herring fisheries open can also be seen as benefits that are attained, if the dioxin concentrations in herring can be reduced to the minimum.

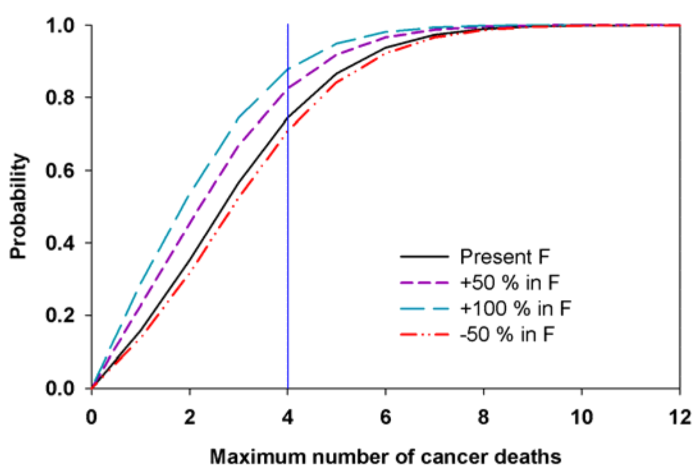

Figure. Example figure from D20b. The probability of the maximum number of cancer deaths caused by dioxins present in Baltic herring per year. E.g. the probability that present F results in 4 cancer deaths at the maximum is 0.74. If F is increased by 100 %, the probability will be 0.8, i.e. the probability to have fewer cancer deaths is higher with more intense fishing. The difference demonstrates the effect of different management decisions.

The model enables the assessment of the impacts of different management options related to toxicants present in the Baltic Sea on human health in monetary terms. In addition to this, it highlights some aspects that need to be taken into account when planning and carrying out further studies. The results emphasize the importance of the inclusion of uncertainty, especially in issues where the potential losses may be high. In addition, it is essential to recognize that the spatial scale of the study is highly relevant when considering e.g. the cost-effectiveness of different mitigation measures, as the ability of a single country to affect e.g. emissions resulting to pollution may be highly limited.

D21 Journal MS/report: Exploiting information - exploiting fisheries: Management, asymmetric information and risk communication (Uhel/econ)

Methods and approaches

Two model components were used: one for the biology and one for the economics.

Population dynamics of herring are simulated using an age-structured model describing recruitment, mortality, and life history attributes in discrete time. The mature component of the stock first spawns and produces new recruits in the youngest age class. Spawning stock biomass is adjusted to beginning of September when spawning mostly takes place. Beverton and Holt stock-recruitment function is fitted in maximum likelihood using stock and recruitment estimates by ICES (2006b).

The model is a duopoly 10 year period normal form game solved by backwards induction. Information asymmetry is considered as particular parameter sets in a 11 deterministic empirical setting as described in the previous section. The total profits and profits of both countries are calculated using noncooperative Nash equilibrium. In the game theory setting assuming perfect information each player can calculate the outcome of the game independently. In the noncooperative setting, the countries are assumed to act independently. In our setting, the information is imperfect, and the decisions made are based on the beliefs, rather than perfect information on the opponent's economic parameters. As the game is played as a oneshot game, no updating of the information is assumed. Thus, our game setting concentrates on the economic consequences of biased information of the opponents' economy.

Achievements in contrast to state of the art and conclusions

Gaps in the knowledge of economic performance of fishing fleets have strategic implications and, therefore, potential information gaps should be screened for. These strategic implications can be positive or negative depending on whether a country possesses or does not posses economic information, and whether information is asymmetric or asymmetric and uncertain.

Asymmetric information creates problems in a non-cooperative fishery because a country can, by giving false information about fishing costs, manipulate the reaction the other country not possessing equivalent information about the costs of its adversary. A medium term value of having cost information can be tens of millions euros in a single fishery.

Another type of a problem develops when a country has biased or uncertain knowledge of own fishing costs. In these situations, management schemes are likely to be suboptimal. Moreover, the probability of excessive fishing pressure is higher of the order of magnitude in the presence of asymmetric and uncertain fishing cost information, compared to case when cost information is asymmetric but not uncertain.

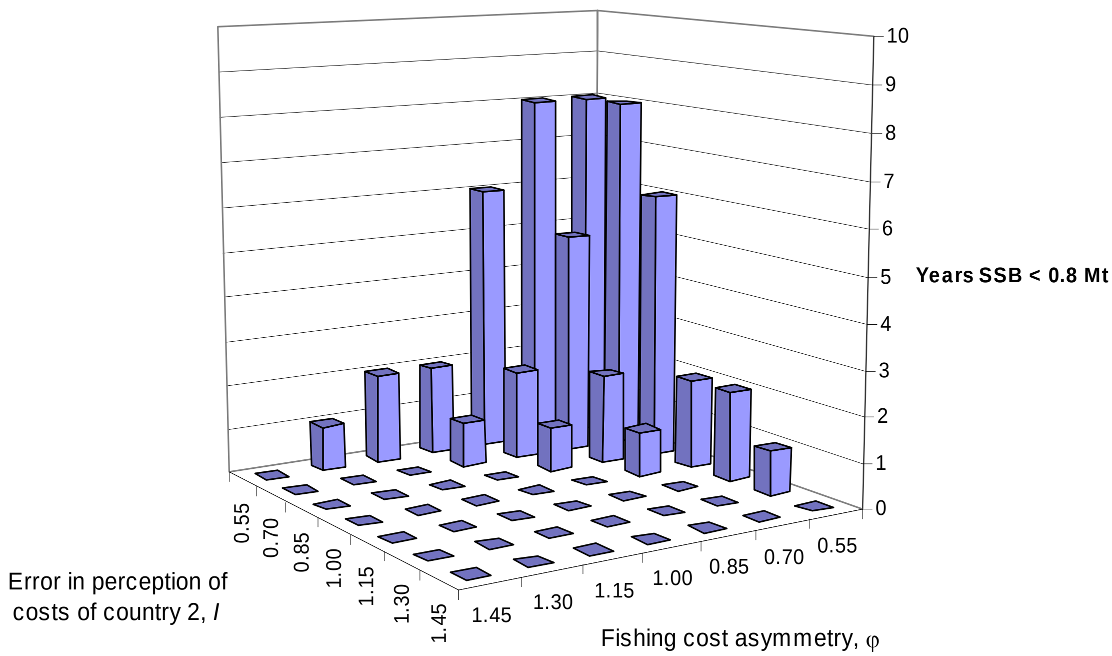

Figure. Example from D21. The number of years when SSB is below B_{lim} during a 10 year simulation period.

This paper will be submitted in near future,

D22 Report of findings of Risk communication work in Case Study countries (CEMARE, HCMR, UNAK, AZTI, CLRD)

Methods and approaches

The contents of this report have addressed the question of risk communication within the fisheries science process, notably that of ICES. It has taken the findings of previous research within the PRONE project and looked to explore two of the principle roles of risk communication: the communication of risk information and the ability of risk communication to "change mental models of risks by correcting errors, shifting emphases, filling in gaps, and providing details to specify vague or general beliefs" (Bostrom 2003 p563). It has done so with reference to five main challenges:

- The validation of the key findings and concepts of the prior mental models from the previous PRONE survey (D11 and D17/18)
- Establishing the extent of common appreciation of the risks within the fisheries science process (between stakeholders within countries and across countries),
- The identification of stakeholder perceptions of current communication strategies within fisheries science and their strengths and weaknesses, and
- The identification of the extent of consensus and diversity over the corollary of risk communication, trust.
- The identification of areas in detail where risk communication could be targeted to readily improve the common appreciation of risks (i.e. where there are major deviations from the generally held opinion) and to build essential trust.

The overall objective of the analysis was ultimately to improve the likelihood of meeting the short and long-term objectives of management.

The survey was undertaken in five case study countries – Iceland, Greece, Spain, the UK and the Faroe Islands – and targeted four groups of stakeholders – fishermen, fishermen's organisations, administrators and policy-makers (grouped under the latter heading) and scientists. While not all groups were fully represented in each case study, the survey successfully produced sufficient data to evaluate (a) the likelihood and impacts of risk during the six stages of the fisheries science process, and (b) attitudes to a series of trust statements grouped in accordance with a 'components of trust' diagram (after Dietz and Den Hartog (2006), Levin et al. (2002) and Usoro et al. (2007)). The data was evaluated using risk registers, descriptive statistics, cluster analysis, Pearson's product moment correlations/ Similarity Matrices and qualitative summaries of the verbal comments. Cluster analysis proved to reveal little and was correspondingly not included in the report. A variety of additional matrix formats were also used to facilitate interpretation. From this analysis a range of risks and trust issues were identified, representing weaknesses within existing risk communication strategies and presenting opportunities for further risk communication.

Achievements in contrast to state of the art and conclusions

The data revealed a common appreciation of risk severity during the fisheries science process between certain stakeholder groups both within countries and between countries, but this was not universal. There were general perceptions of higher risk among fishermen, while scientists perceived the risks to be lower, which would match with initial expectations. The other stakeholder groups, however, varied between the two in their perceptions of risk. The variety of risk perceptions (especially between the scientists and those stakeholders with greater access to the outputs of their research) would suggest that a common appreciation of risk is lacking. However, certain overall patterns were evident.

Among the different stages of the fisheries science process, the risks were generally perceived to be highest for part D (negotiation of management decisions) of the process and slightly less for parts A (science input data and modelling choices) and F (stakeholder involvement in science process). Part B (presentation of science results) of the fisheries science process was seen to attract the lowest risks. In terms of the nature of the risks, part A was notable in demonstrating broad agreement over a relatively large number of risks with the two most widely cited being insufficient, poor quality and unreliable data and insufficient socio-economic data. For part B there was broad concern that overly complicated and scientific language and presentation styles represented a risk. Parts C (creation and review of official advice) and D attracted similar risk comments, with the broadest concern registered for political influence, lobbying and partiality. Poor quality science and biological bias were also noted as risks for these parts of the process, with fisher and stakeholder exclusion ranking second in the risks cited for part D. Part E (practical aspects of science process) attracted less consensus for any of the risks, although there were a number cited. Strongest concern here was that the science lacked the flexibility necessary. The last part of the process, part F, in contrast attracted widespread recognition, noting that the lack of stakeholder involvement was a risk, along with inappropriate stakeholder involvement.

The survey included also the level of agreement and disagreement registered by the respondents for a series of trust statements targeting the ICES scientific community. From this part of the survey there was revealed a notable lack of trust among certain groups of stakeholders, primarily fishermen (particularly those from the UK and Faroe Islands), with whom the scientists have the least contact. In contrast, the scientists recorded the strongest trust, as would be expected, albeit with caveats.

Notable from the results was the lack of consensus on the existence of a common language and vision, and in respect of the second competence trust statement pertaining to whether the ICES scientific community performs its stated role well. To a lesser degree there was also marked disagreement with the benevolence statement addressing whether the ICES scientific community acts in the best interests of all stakeholders. With regard to the latter, multiple respondents noted that ICES needed to be independent and not act in the interests of stakeholders, while fishermen noted their frustration at not seeming to be considered within the science and subsequent decision-making.

In contrast to these statements, there was broad consensus over a number of the other statements with only one or two groups disagreeing with each, notably:

- ICES2 - ‘ICES can be relied upon to produce the scientific information and advice that decision-makers need’ (General)
- ICES10 - ‘The ICES scientific community is interested in the sustainability of the fishery as well as the sustainability of living marine resources and protecting the marine environment’ (Benevolence)
- ICES15 - ‘In general, members of the ICES scientific community would use any information provided to them in confidence sensitively and only in the manner for which it was intended’ (Integrity)
- ICES16 - ‘The ICES scientific community carries out its work in a consistent, reliable and predictable manner’ (Predictability)

A number of other statements also only saw four or five groups disagreeing. In addition to these broad patterns spanning across the case studies and stakeholder categories, it should be noted that there were also particular national patterns evident.

In terms of the issues noted as undermining trust, a wide range was extracted from the comments registered by the respondents for each of the trust statements. However, only one or two received broad agreement from the respondents. The broadly cited issues included:

- Lack of soundness and credibility
- Unresponsive and inflexible
- Flawed data and weak science
- Poor communications
- Political and lobby group interference
- Lack of stakeholder involvement

Many of these issues were cited in response to more than one of the trust statements, reinforcing their significance. In terms of the two trust categories that attracted the broadest disagreement – common language and common vision - there were particular issues raised: divergent understanding, interests and agendas among stakeholders, inappropriately technical presentation styles and stakeholder exclusion. The first of these was noted as a particular challenge in any development of a common language and vision, while the latter in many respects seems to be at odds with the widely cited need for ICES to be independent, unless one uses another term cited – 'impartial'.

D26 Setting up a Management Plan for the Anchovy Fishery in the Bay of Biscay

This is an extra deliverable (not included to Technical Annex, provided by AZTI).

Methods and approaches

The main objective of this paper is to analyze and discuss the process of development of the LTMP for the Bay of Biscay anchovy up to the current stage. First, the Bay of Biscay anchovy fishery and the actual assessment and short term management advice are described. Then, the MSE process conducted by scientists in the STECF meetings is summarized. The main focus is not in the details and results of the simulations, but in the process itself. Specifically the key elements of the management system which were included in the simulations (the biological and fishing process, the economic and the management procedure) to satisfy the international management context adopted by the

EU and the different views and expectations on the LTMP of stakeholders and managers (TAC formulation and dispatching key between countries, degree of detail of the different national seasonal fisheries, economic modeling and inclusion of biological uncertainties among others) are addressed. The performance indicators selected to assess the biological, economical or social risks associated with the different HCRs being tested are also covered, whereas the need to place the discussion about the allowable threshold levels of risks on managers and stakeholders levels is emphasized. Finally, the communication and dynamic interaction established in this process between scientist, stakeholders and managers are discussed, describing the role it has played and the benefits arising from it.

Three harvest control rules have been tested by scientists: (a) exploit a constant proportion above an escapement biomass (b) exploit a constant proportion of biomass and (c) exploit to keep a constant risk of 15% in the short term. Uncertainty to different population dynamic models have been tested and economical indicators have been incorporated into the decision making process. In addition, political considerations such as % quota between countries and between semesters have been implemented to try to incorporate underlying decision factors into the framework. Finally, the participation and communication among different stakeholders in each of the process steps are discussed, with special emphasis to the concept of risk, and the next and challenging future steps are outlined.

Conclusions

- There is no clear road map defined about the process of development of LTMP for Bay of Biscay anchovy. Furthermore, though not finished, the current process has not incorporated up to now planned iterations between the MSE, presentation of results and discussion among the different parties, affecting negatively the transparency and participation of the process.
- More involvement and interaction with managers is desirable. Moreover, interaction between the different parties should be clearly specified in the road map.
- RACs play a relevant role for MSE and feed back for further definition of the LTMP. If attended this should also increase their compliance with subsequent regulations.
- The degree of detail of the MSE should in principle be high to satisfy as much as possible the requirements of managers and stakeholders. For instance, the assessment of economic and social impacts might imply assumptions even at national seasonal fisheries. However, a trade off between the level required and the one that can be provided with warrantees must always be kept for not invalidating the results.
- Short lived pelagic species are invariantly fluctuating depending heavily on environmental conditions. Therefore, the existence of biological risks should be recognised and the acceptable levels agreed as a compromise between biological

and social sustainability. A too precautionary biological approach may confront to the sustainability of the fishery.

- Limitations of the scientific team to duly incorporate natural variability in productivity (regime shifts) or ecosystem context of management, and hence to correctly evaluate risks, should be admitted and communicated to managers and interested parties, so that they can judge about their implication and decide to eventually incorporate them in a future revisions of the LTMP.

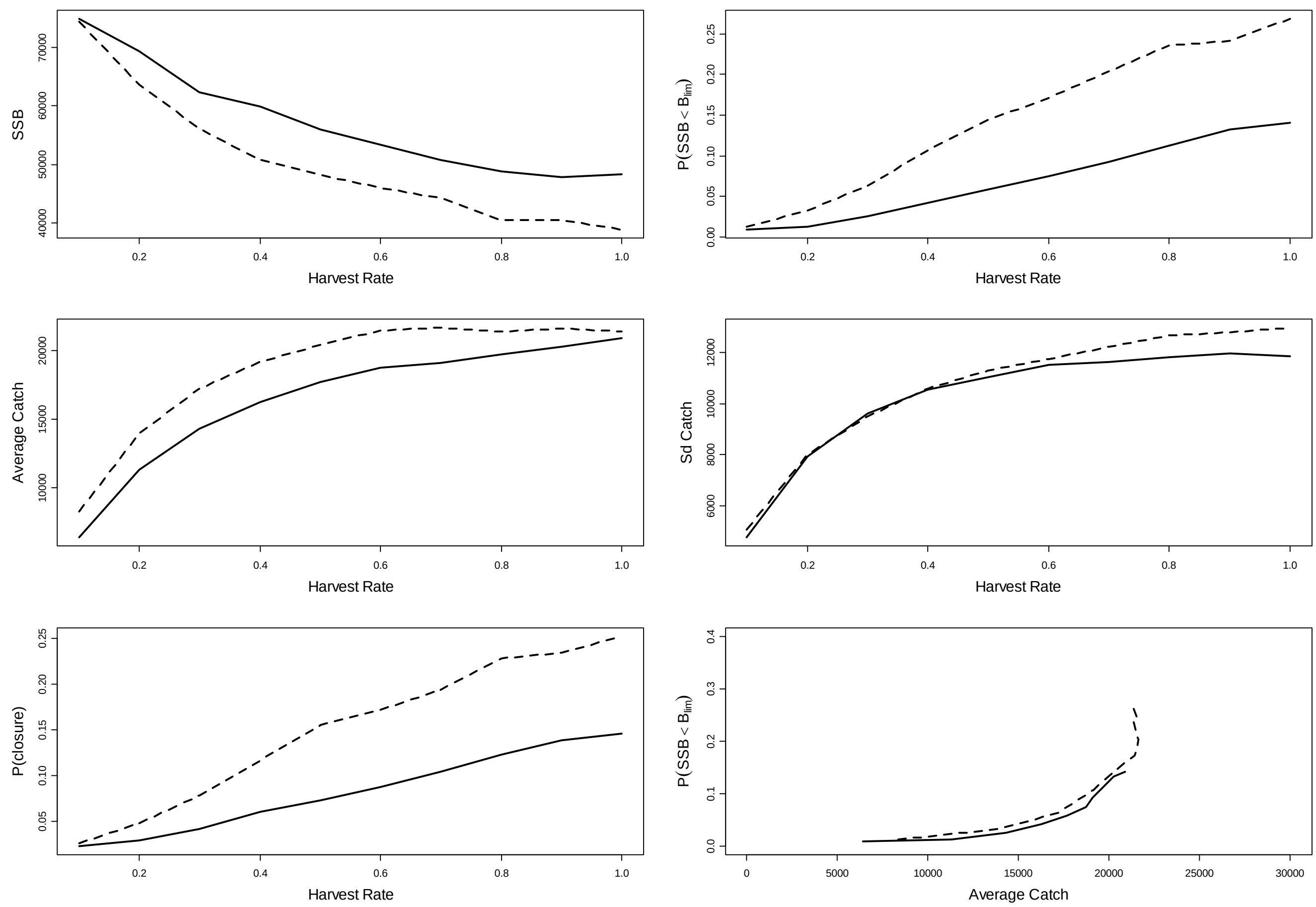

Figure. Example figure from D26. From left to right and from top to bottom; comparison between SSB, probability of SSB being below B_{lim}, average catch, standard deviation of catch and probability of closure according to different harvest rates for HCR A (solid line) and HCR B (dashed line).

1.6 Impact of the project on research sector

Below, the original SSP call objectives are given in italics, and the main outcomes of the project are given, mainly for research sector but somewhat also to industry.

Risk analysis is comprised of risk assessment, risk management and risk communication. It is a formalized approach increasingly used in various types of management, e.g. environment, natural resources, and food safety.

- These elements were modified for fisheries use by PRONE project. The project was successful in providing high quality scientific methodology. Especially, project demonstrated that risks are very specific for different fisheries, asking for specific model structures and estimation procedures. Hierarchical Bayesian models seem to offer very valuable tool especially fro S/R analysis, where uncertainties are high. One of the case studies provided methodology for food safety.

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 economical 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 economical and social terms.

- The project evaluated the current ICES uncertainty methodology, which seems to include some Bayesian type of approaches, even though not correctly applied. Bayesian approach is the most advanced scientific approach to deal with uncertainty and therefore recommended to be adapted widely in European fisheries.
- The project included theoretical and empirical sections on economic and social risks and provided and tested some of the possible tools. Decision analysis (Bayesian influence diagrams) can be used to combine the multidisciplinary information into a management orientated advisory model. In PRONE, decision analysis was applied only to biological parts of the modelling, as planned.

The development and increased use of risk analysis in management offers a new avenue for fisheries management, which would support a move from predictive based systems towards more adaptive management strategies.

- The project developed first steps for an easily applicable risk classification for EC use. The value of information analysis applied in one case study demonstrated how better scientific information can lead to improved catches and thus create an interest to industry to improve information.

The objective is 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.

- The project reviewed the current risk methodology both from a theoretical and a practical point of view. The tested framework helps to find a balanced evaluation of risk management systems (risk identification, risk assessment, risk management and risk communication), including a strong human dimension (related to understandability and to interest to use information) and advise on the elements of international agreements controlling fisheries risks.

1.7 Suggested follow up call text for risk analysis

In the final meeting, PRONE consortium agreed to suggest the following follow up call to future framework research:

Development of an ecosystem based risk framework for results based management in sustainable fisheries

The application of an Ecosystem Approach to Fisheries Management (EAFM) requires new ways to estimate risks for less studied species, and risk assessment methodology to link these estimates to better known stocks and overall fishing activities. At the same time, these more complex risk estimates must be effectively communicated to stakeholder groups having different risk perceptions and potentially conflicting or unrelated objectives. The project should develop risk methodology to classify and demonstrate risks, and to link ecological risks to the interests of various stakeholder groups. It aims to create innovative mechanisms and to create alternative incentives for risk mitigating behavior and improved use of information and management to decrease risks for common interests. The risk framework needs iterative steps to exchange feedback among stakeholders, and the developed methods must systematically support the integration and dynamics of the four steps of a risk framework: risk identification, risk assessment, risk management and risk communication. The classification should also serve the interests of markets to take into account the impacts of fishery products on ecosystems. The methodology must be developed and disseminated to support results based management and the project should analyze the suggested shift to a requirement for shared burden of proof on fisheries activities. The methodology must be applied to several different types of connections between fisheries activities, ecosystem damages and types of management institutions.

Expected impact: The project will link the enhanced risk methodology to ecosystem risks, and develop methods that help stakeholders to understand and further use the relevant risk estimates in the effective and efficient management of more complex real world fisheries systems. More transparent understanding of complex risks will enable greater trust and consistency in risk management and wider satisfaction with management outcomes.

2 Dissemination and use

Final plan for using and disseminating the knowledge

2.1 Exploitable knowledge and its Use

For the PRONE project there are no results that can be defined as exploitable results; that is: *defined as knowledge having a potential for industrial or commercial application in research activities or for developing, creating or marketing a product or process or for creating or providing a service*.

2.2 Dissemination of knowledge

The most important part of dissemination has taken and will further take place through scientific manuscripts (MS) that have been and will be sent to peer reviewed scientific journals. This is especially important in this type of projects, where totally new risk analysis areas are tested and applied to fisheries, as the new risk methodology will fulfil the scientific requirements. During the project, the manuscripts have been used as deliverables and the final activity report summary is based on them.

A theme session on risk methodology in fisheries was organised in ICES ASC 2009, and a similar session was organised in IIFET meeting, August 2008, Vietnam. This opened the multidisciplinary aspects of risk analysis in fisheries.

In addition to these formal dissemination ways during the project, the findings of the project will be actively applied in scientific organizations in future. The coordinator of the project, Professor Sakari Kuikka, is current member of STECF and has in this role good possibility to utilize the results of the project in scientific activities of EU. Many other members are active participants in international organisations and will continue the dissemination process of project outcomes.

A very important aspect is the inclusion of project findings to University teaching, as there are several University partners. The fact that most recent findings can be directly applied to teaching will accelerate the development of sciences compared to the pure publication process in scientific journals.

The involvement of the European Commission in this project has been demonstrated by adding the following sentences to the publications: “This study has been carried out with financial support from the Commission of the European Communities, specific RTD programme “Specific Support to Policies”, SSP-2005- 022589 “Precautionary Risk Methodology in Fisheries”. It does not necessarily reflect its views and in no way anticipates the Commission’s future policy in this area. “

Overview table

Actual Dates	**Type**	**Type of audience**	**Countries addressed**	**Size of audience**	**Partner responsible /involved**
2007	**Paper** published in Ambio: Human dietary intake of organochlorines from Baltic Herring: Implications of individual Fish Variability and Fisheries Management	Scientific	International		**UHel**
5–9 February 2007	**Talk** by Laurence Kell in Study Group on Risk Assessment and Management Advice (SGRAMA), Cape Town, South Africa	Scientific	International		**Cefas**
3rd April, 2007	**University seminar**: Drakeford, B. (presenter) Precautionary risk methodology in fisheries (PRONE) – case study development. University of Portsmouth.	Scientific, Higher education	UK		**CEMARE**
20-24 May 2007	**Presentation** (Speaker: Mari Pylkkö neé Vanhatalo): SETAC Europe 17th Annual Meeting, Porto, Portugal: "Multiple stressors for the environment - present and future challenges and perspectives".	Scientific	International		**UHel**

9-11th July 2007	**Conference presentation**: Drakeford, B. (presenter): Precautionary risk methodology in fisheries (PRONE) – case study development. XVIIIth Annual EAFE Conference, Reykjavik, Iceland.	Scientific	International		**CEMARE**
9-11th July 2007	**Conference presentation**: Drakeford, B. (presenter) Precautionary risk methodology in fisheries (PRONE) – case study development. XVIIIth Annual EAFE Conference, 9-11th July 2007 Reykjavik, Iceland.	Scientific	International		**CEMARE**
June 12th 2008	**Presentation** in the conference Future challenges for the seafood industry, University of Akureyri**:** What do stakeholders in the fishing industry see as the future risk for the industry?	Scientific	International	100	**UNAK**
July 22-25, 2008	**A Special Session** proposed by CEMARE entitled 'Dealing with risk and uncertainty in fisheries' was also accepted, organised and executed at IIFET 08 in which four papers based on PRONE research were presented.	Scientific	International		**CEMARE**
July 22-25, 2008	**Conference presentation**: Tingley, D. (presenter) Risk Identification and Perception in The Fisheries Sector: Comparisons between the Faroes, Greece, Iceland & UK - IIFET 2008 'Achieving a Sustainable Future: Managing Aquaculture, Fishing, Trade and Development ', Nha Trang University (NTU) Nha Trang, Vietnam.	Scientific	International		**CEMARE**, UNAK, HCMR
August 2008	**Book** by Dennis Holm and Borgi Mortensen: "Nøgdir og nýbrot - føroysk fiskivinnumenning í fimmti ár" (English title: "Quantum and innovations - development of Faroese fisheries over the last fifty years") Sprotin, 2008.	Education, public, decision makers, scientific	Faroes, Nordic countries		Center for Local and Regional Development (Faroes, subcontractor to CEMARE)

22-26 September 2008	**Presentation** in ICES 2008 Annual Science Conference in Halifax, NS, Canada. Fisheries management systems and risk perception among fishermen in Greece, Faroes, Iceland and UK.	Scientific	International		**Cefas**, UNAK, HCMR
22-26 September 2008	**Presentation** in ICES 2008 Annual Science Conference in Halifax, NS, Canada. Mika Rahikainen: Stability of international fishery agreements using precautionary bioeconomic harvesting strategies.	Scientific	International		**UHel**
5.-6 November 2008	**Poster** in NJF's 90 Year Jubilee Symposium: Mari Pylkkö: Risk Assessment of Global Agrifood Production Chains, Helsinki, Finland; Uncertainty in decision analysis: A case study of dioxins and Baltic herring	Scientific	Finland, international		**UHel**
December 2008	**Talk** by Laurence Kell in Study Group on Risk Assessment and Management Advice (SGRAMA), Copenhagen, Denmark	Scientific	International		**Cefas**
2009	**Paper** submitted to ICES Journal of Marine Science. Fisheries management systems and risk perception amongst fishermen in Iceland, Faroe Islands, Greece and UK.	Scientific	International		**UNAK,** CEMARE, HCMR
2009	**Paper** (to be submitted). Fishermen's risk perception in four European countries.	Scientific	International		**UNAK,** CEMARE, HCMR
2009	**Presentation** to the EU COST Fish Reproduction in Stock Assessment (FRESH) Working Group	Scientific	EU		**IC**

2009	**Paper** (submitted 2009 to Marine Policy): Diana Tingley, Jóhann Ásmundsson, Edward Borodzicz, Alexis Conides, Ben Drakeford, Ingi Rúnar Eðvarðsson, Dennis Holm, Kostas Kapiris, Bogi Mortensen: Risk Identification and Perception in The Fisheries Sector: Comparisons between the Faroes, Greece, Iceland & UK.	Scientific	International		**CEMARE**, UNAK, HCMR
2009	**Paper:** Mumford, J.D., Leach A. W., Levontin P., Kell L. (2009) Insurance mechanisms to mediate economic risks in marine fisheries. ICES Journal of Marine Science, (in press).	Scientific	International		**IC**, Cefas
2009	**Paper manuscript:** Tingley D., Ásmundsson J., Borodzicz E., Conides A., Drakeford B., Rúnar Eðvarðsson I., Holm D., Kapiris K. and Mortensen, B. 2009 Risk Identification and Perception in The Fisheries Sector: Comparisons between the Faroes, Greece, Iceland & UK. (Submitted to 'Marine Policy')	Scientific	International		**CEMARE**
2009	**Paper manuscript:** Drakeford B. and Borodzicz, E. 2009. Mental Modelling: A methodology to improve understanding and communication about risk in the Marine Environment.	Scientific	International		**CEMARE**
2009	**Chapter in the report** "The economics of the state of the Baltic Sea": ch. 5.2. Uncertainty in decision analysis: A case study of dioxins and Baltic herring.	Decision-makers	Baltic Sea countries		**UHel**

The time and resources used for dissemination are given in the description of WP7 Dissemination.

2.3 Publishable results

Publishable results of PRONE project are and, to a wider extent, will be published in peer-reviewed international scientific journals, conferences and books. The sectors that will be interested in these results include the fishing industry and their representative organisations and the government bodies responsible for fisheries management. As mentioned, these papers have been published in various journals and as such are publicly available. Collaboration is sort with other marine science institutes who have an interest in the methodology and they can access these published results in the journals. The intellectual property rights are published and copyright exist on each article. The contact details of the first author are published in the journal, which is protocol. In addition to published journal papers, all University partners will use the project material in teaching. Material provides a very update view on risk issues in fisheries.

The results that are already published in international journals, reports or books include:

Kiljunen, M., Mari Vanhatalo, Samu Mäntyniemi, Heikki Peltonen, Sakari Kuikka, Hannu Kiviranta, Raimo Parmanne, Jouni T. Tuomisto, Pekka J. Vuorinen, Anja Hallikainen, Matti Verta, Jukka Pönni, Roger I. Jones and Juha Karjalainen 2007. Human Dietary Intake of Organochlorines from Baltic Herring: Implications of Individual Fish Variability and Fisheries Management. Ambio Vol. 36 (2–3): 257-264.

Holm, D. and Mortensen, B: "Nøgdir og nýbrot - føroysk fiskivinnumenning í fimmti ár" (English title: "Quantum and innovations - development of Faroese fisheries over the last fifty years") Sprotin, 2008.

Helle, I. Mari Pylkkö, Samu Mäntyniemi & Sakari Kuikka 2009. Uncertainty in decision analysis: A case study of dioxins and Baltic herring. Chapter 5.2 in: The economics of the state of the Baltic Sea - Pre-study assessing the feasibility of a cost-benefit analysis of protecting the Baltic Sea ecosystem.

Mumford, J.D., Leach A. W., Levontin P., Kell L. (2009) Insurance mechanisms to mediate economic risks in marine fisheries. ICES Journal of Marine Science, 66: xxx-xxx (in press).