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## Meeting report

# New directions in management strategy evaluation through cross-fertilization between fisheries science and terrestrial conservation

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**On 1 and 2 June 2010, an international meeting was held at the University of Paris Sud XI, France, organized within the framework of the EU FP7 consortium project HUNT, to bring together fisheries and conservation scientists to discuss a unified framework for the future of management strategies for harvested species.**

**Keywords:** bushmeat; partridge; brown bear; uncertainty; operating model

## 1. INTRODUCTION

Management strategy evaluation (MSE) is a simulation approach, developed by fisheries scientists for testing the effectiveness of proposed management plans and their robustness in meeting objectives under a wide range of uncertainties. This meeting was a first step towards implementing this approach in a terrestrial conservation context. Natural resource management encompasses the conservation of harvested resources, the welfare of their users and the requirements of managers. It is becoming increasingly important in this context to integrate biological research with insights from other fields (particularly socio-economic), as well as to understand and explicitly incorporate the uncertainties that affect decision-making.

The meeting brought together fisheries scientists, empirical ecologists, modellers and economists, to discuss the potential of the MSE approach for terrestrial conservation and to consider the insights that both

conservation and fisheries management could gain from applying the approach in this new context. We first discussed the existing framework for evaluating management strategies as established in fisheries. We then considered how to extend the approach to conservation science through three topical and contrasting case studies; partridge (*Alectoris rufa*) hunting in Spain, brown bear (*Ursos arctos*) hunting in Croatia and Slovenia, and bushmeat hunting in the Serengeti. The workshop finished by identifying future research directions for both fisheries and conservation.

## 2. MANAGEMENT STRATEGY EVALUATION IN FISHERIES SCIENCE

Traditional management of harvested populations is based on an assessment of how the resource population would respond to a particular future extraction rate. However, basing management strategies on best estimates of resource dynamics does not necessarily lead to ecological and economic sustainability. Knowledge is always imperfect and future projections can contain a high level of uncertainty. Thus, there may still be a significant probability of population collapse when using 'best guess' models. To understand how a management strategy is likely to perform in the face of a range of uncertainties, its performance must be evaluated through simulation. The framework for this MSE process was developed by the scientific committee of the International Whaling Commission in the 1980s, but is seeing increasingly widespread application, forming the basis for fisheries management in South Africa and Australia [1].

MSE makes use of an operating model (OM), representing the 'true' resource dynamics and parametrized using knowledge of the biology of the population being harvested. Simulated data are 'collected' in an observation model and used to determine a harvest control rule (HCR) that specifies the level and type of extraction. This extraction is then applied through an implementation model, under which the OM is projected forward to the next time step (figure 1). This simulation loop is repeated, potentially over many years, allowing the user to evaluate the HCR against the management objectives, which may include stability of the yield, profitability and the probability that the stock will stay above a threshold size. Uncertainty is explicitly accounted for in several steps of the process, including parameter and structural uncertainty in the OM, observation and implementation uncertainty. This means that the eventual management procedure (MP) that is chosen by decision makers based on the results of an MSE is more likely to be robust and consistent with the precautionary principle [2].

Since alternative hypotheses of underlying resource dynamics often exist and a range of management strategies need to be evaluated, sets of OMs and HCRs have been used to evaluate which management strategies consistently perform best, relative to suites of objectives [3]. It is necessary that these objectives and the performance metrics to evaluate them are clear before beginning the MSE process, and so MSE has also been seen as a way of heightening stakeholder involvement in management, because stakeholders (e.g. resource users) can be involved both in the development of objectives and metrics

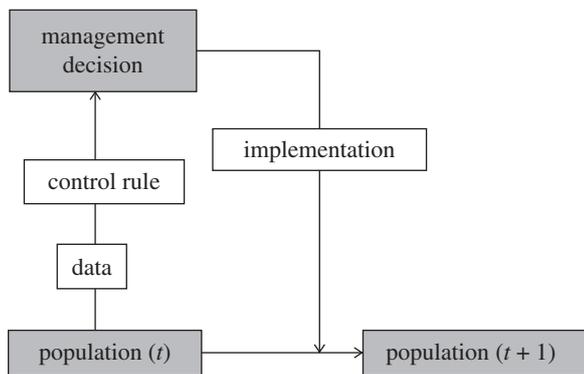


Figure 1. Conceptual diagram of the MSE process. The operating model (OM) describes the population dynamics taking the population from time  $t$  to time  $t + 1$ . The observation model describes the collection of data, which are used to determine the harvest control rule. This leads to a management decision, and then a further model describes the implementation of the rule, which affects the population dynamics through the OM.

and in the decision about which MP to adopt in the light of the results of the MSE.

### 3. CASE STUDIES

We evaluated the potential for the application of MSE, as used in marine systems, to three contrasting terrestrial case studies. In each case, we identified the key management problem, the structure of the system, the major uncertainties, the potential for integration of different disciplines and the form of the MSE that would be required to evaluate the performance of MPs in the light of these factors.

#### (a) *Red-legged partridges in Spain*

The red-legged partridge is a socioeconomically and ecologically important game species widely distributed in farmland habitats in Spain, which has substantially declined in the past 40 years, mainly owing to agricultural changes and hunting pressure. The number of hunters doubled from the 1960s to the 1990s, and the philosophy underpinning hunting changed from recreation to a highly profitable business [4]. Releases of farm-reared partridges to maintain or increase partridge availability for hunting have steadily increased since the mid-1990s, and currently more than four million partridges are estimated to be released annually in Spain [5]. Wild-stocked estates are perceived as struggling to remain profitable, and there is considerable uncertainty in population estimates as well as in understanding the relationship between the number of released and wild birds, and hunting off-takes and profitability.

We believe that an MSE approach could contribute to improved management, by explicitly demonstrating the contribution that reducing uncertainty in the system could make to robustness and profitability of management. An MSE approach could also illuminate the sustainability and profitability of estates using different combinations of wild and farm-reared stock, hunted at different intensities. Interesting parallels

exist between the questions we identified in this system and the management of wild and released salmon stocks, which has been subject to considerable modelling and management effort (e.g. [6]).

#### (b) *Brown bears in the northern Dinaric mountains*

The Dinaric brown bear population is one of the last large natural populations of this species in Europe. It ranges from the Alps in the north to the Rodopi Mountains in the south, and is estimated at 2800 individuals in several subpopulations [7]. The northern part of the population is shared between Slovenia and Croatia.

Although both countries manage and harvest the same population, there is virtually no common vision or cooperation, and considerable differences in management goals; while bears are trophy-hunted for profit in Croatia, they are a protected species but culled to control population size in Slovenia. Conflicts with humans are a major concern in Slovenia but almost non-existent in Croatia. Major issues include the long-term effect of the current management on the shared bear population, and promoting cooperation between the two countries to better address their social, economic and ecological management aims for the population. As these questions concern the relationship between different elements of the harvesting system, they are ideally suited to investigation using MSE.

One of the most interesting questions that we identified was the potential for developing a genetically based MSE. The demography of the population is highly skewed by selective hunting, and as in any small population it is not the census population size, but the effective population size ( $N_e$ ) that is the key concern for long-term viability [8]. However, human-wildlife conflict and hunting quotas are driven by actual population size. Hence managers must both limit population size and ensure that hunting does not skew the age-sex ratio to the extent that the  $N_e$  becomes dangerously low. An MSE that incorporates observations of  $N_e$  with management based upon both  $N_e$  and actual population size, incorporating different social aims (profitability and acceptable levels of conflict) would be a novel approach with wide applicability.

#### (c) *Bushmeat in the Serengeti*

With abundant herbivore and carnivore populations, the Serengeti is an iconic ecosystem. Bushmeat is widely consumed and hunting is conducted both for food and cash. The seasonally available migratory ungulates represent the bulk of harvested wildlife but hunting occurs all year round, affecting a wide range of species. Some resident populations appear to have been severely reduced by hunting, while migratory species appear relatively stable [9].

Bushmeat is, in theory, a state-controlled natural resource in Tanzania. Hunters must obtain a hunting licence and quotas are set annually. However, there is a high rate of non-compliance, potentially owing to legal complexity and high fees, as well as lack of benefit

distribution, poor governance and control, such that bushmeat is being used by the local communities as a de facto open access natural resource [10]. Because of the illegal and sensitive nature of hunting, there is enormous uncertainty surrounding hunting rates and catch composition.

This is a very different system from those usually considered for MSEs, although it is typical of many conservation problems. We considered how the MSE approach could be adapted to a system in which management of hunting levels is not the main issue, instead it is the implementation of conservation policies directly or indirectly to affect hunter decisions. The main requirement for an MSE approach to be appropriate is that there is feedback between observations of the resource stocks and management action to control harvest. We felt that the underlying philosophy and modelling framework were indeed transferable, with the HCR in this case being investment decisions in law enforcement when compared with more indirect interventions such as livelihood enhancements. The use of MSE in this system would be a major development, and one with great potential.

#### 4. FUTURE DIRECTIONS

Fisheries research and management has been gradually evolving to broaden its focus from management of single target species towards a more holistic view of fisheries impacts on ecosystems and the socioeconomic issues of user reliance on fishing. The MSE framework is increasingly being used in this wider context to address trade-offs that are necessary when whole ecosystems and multiple stakeholders are considered [11,12]. Recent MSE applications include the use of OMIs that account for plausible climatic drivers, species interactions and behaviour of fishers and fleets [13,14]. However, most research efforts for MSEs are still focused on the OM, rather than on the other side of the equation—management decision-making, user behaviour and implementation of the HCR.

The MSE approach has the potential for use in linked socio-ecological systems far beyond the realm of fisheries. Novel applications in terrestrial systems are at the frontier of this research. In this meeting, we considered how to move this research agenda forward. Our discussions highlighted the current weakness of implementation models in fisheries, and the explicit need to incorporate the behaviour of users, rather than just assuming that HCRs are implemented with error. This was particularly obvious in the bushmeat case study. We also saw the potential for advances in biological research, for example through the development of a genetically based MSE for brown bears, as well as for the use of MSE approaches to highlight the effects of uncertainties and evaluate alternate options in harvesting systems reliant on supplementation of wild stocks.

This meeting generated a great deal of excitement about the potential of cross-fertilization between fisheries science and terrestrial conservation, and between natural and social scientists. Advances can

be made in these disciplines through meetings such as this, which both contribute to an emerging research field within fisheries science, demonstrate how the technique can be translated for application in a terrestrial conservation context, and show how synergies between researchers and disciplines lead to novel insights and approaches.

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