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New directions in Management Strategy Evaluation through cross-fertilisation between fisheries science and terrestrial conservation

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On 1st and 2nd June 2010, an international meeting was held at the University of Paris Sud XI, France, organised 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.

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. The meeting was a first step towards implementing this approach in a terrestrial conservation context, encompassing the conservation of harvested resources, the welfare of their users and the requirements of managers. It is becoming increasingly important in the management of natural resources to integrate biological research with insights from other fields (particularly socio-economic), as well as to understand and explicitly incorporate the uncertainties which 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; bush meat hunting in the Serengeti, brown bear hunting in Croatia and Slovenia and partridge hunting in Spain. The workshop finished by identifying future research directions for both fisheries and conservation.

2. MSE 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. Fisheries are subject to periodic reviews, during which an extraction rate and other management controls are chosen, based upon their likelihood of meeting management objectives. However, it is not clear that this strategy necessarily leads to the ecological and economic sustainability of the system. 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 in these types of assessment. To understand how a management strategy is likely to perform in the face of a range of uncertainties, its performance must be tested through simulation. This process is known as management strategy evaluation (MSE) - a framework developed by the scientific committee of the International Whaling Commission in the 1980s, but which is seeing increasingly widespread application in fisheries management (Punt & Donovan 2007).

MSE makes use of an operating model (OM), representing the 'true' resource dynamics and parameterised based upon 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) which 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, 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) which is chosen by decision-makers based on the results of an MSE is more likely to be robust and consistent with the precautionary principle (Butterworth 2007).

Since alternative hypotheses of underlying resource dynamics often exist and a range of management strategies need to be evaluated, sets of operating models and HCRs have been used to evaluate which management strategies consistently perform best relative to suites of objectives (Rademeyer et al. 2007). 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 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 MSE approach to be of use in driving management decision-making in three contrasting case studies. In each case we identified the key management problem, the structure of the system, the major uncertainties, and the form of the MSE that would be required to evaluate the performance of management procedures in the light of these factors.

a) Red-legged partridges in Spain

The red-legged partridge, *Alectoris rufa*, is a socioeconomically and ecologically important game species widely distributed in farmland habitats in Spain, which has strongly declined in the past 40 years, mainly due to agricultural changes and hunting pressure. The number of hunters doubled from the 1960s to the 1990s, and the philosophy underpinning hunting activities changed from family entertainment to a highly profitable business, increasingly based on released farm-reared animals (Blanco-Aguiar et al. 2008). Releases of farm-reared partridges to maintain or increase partridge availability for hunting have steadily increased since the mid 1990s, and currently more than 4 million partridges are estimated to be released annually in Spain (Arroyo & Beja 2002). 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 released birds, wild stocks and hunting offtakes.

We felt that an MSE approach could in the first instance contribute to the sustainability of management of this system by explicitly demonstrating the contribution that reducing uncertainty in population estimates could make to robustness and profitability of management. In the future, the issue of the impact of releases on the ecosystem and on wild populations, and the sustainability of estates mixing wild and farm-reared stock, could also be tackled. 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 (eg. Michielsens et al. 2006).

b) Brown bears in the Northern Dinaric mountains

The Dinaric brown bear (*Ursus arctos*) population is one of the last large natural populations of this species in Europe. It ranges from the Alps in the north to Rodopi Mountains in the south, and is estimated at 2800 individuals in several subpopulations (Zedrosser et al. 2001). 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. This leads to vast differences in structure and size of the bear harvest, as well as in the impacts and importance of this harvest for local communities.

Major questions that need addressing include the long-term effect of the current management on the shared bear population and ways in which the two countries could cooperate to better address their social, economic and ecological management aims for the population.

One of the most interesting questions that we identified for this case study in the meeting was the potential for developing a genetically-based MSE. In this small population, with demography highly skewed by selective hunting, the effective population size (N_e) is a key concern for long term viability (Taberlet & Bouvet 1994). It is also a metric for which non-invasive genetic data are being collected. However, human-wildlife conflict and hunting quotas are driven by actual population size. An MSE that linked observations of N_e and an N_e-based OM with management based upon actual population size would be a novel approach with wide applicability.

c) Bushmeat in the Serengeti

Encompassing some of the most abundant herbivore and carnivore populations in the world, the Serengeti ecosystem is one of the most emblematic coupled human-natural systems. 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, whilst migratory species appear relatively stable (Sinclair et al. 2008).

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 due to legal complexity and high fees, as well as lack of benefit distribution and poor governance, such that bushmeat is being used by the local communities as a de facto open access natural resource (Loibooki et al. 2002). Due to the illegal and sensitive nature of hunting, there is enormous uncertainty surrounding hunting rates and catch composition.

This is a very different system to those usually considered for MSEs, although it is typical of many conservation problems. At the meeting we considered how an MSE approach could be adapted to a system in which management of hunting levels was 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 in these situations is that there should be 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 as compared to more indirect interventions such as livelihood enhancements. The use of MSE in this system would be a major development, but one with great potential.

4. FUTURE DIRECTIONS

Alongside adopting a precautionary approach to uncertainty, fisheries research and management has been gradually evolving to supplement its focus on 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 now increasingly being used in this wider context to address trade-offs that need to be made when whole ecosystems and multiple stakeholders are considered (Levin et al. 2008; Smith et al. 2007). Recent MSE applications include the use of OMs that account for plausible climatic drivers, species interactions and behaviour of fishers and fleets (Kell et al. 2005, Fulton et al. 2008). However, most of the research effort for MSEs is still focused on the OM, rather than on the other side of the equation - management decision-making 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 frontiers 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 need explicitly to incorporate the behaviour of users, rather than just

Comentario [MSOFFICE1]: not sure "in" is the best preposition, but in my (admittedly ignorant) view, "for use for ... systems" sounds odd. Of maybe “the potential for being used for”??

assuming 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-fertilisation between fisheries science and terrestrial conservation in the area of MSE. Advances can be made in both 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 the two fields lead to novel insights and approaches.

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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.