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Environmental cost-effectiveness analysis in intertemporal natural resource policy: Evaluation of selective fishing gear☆

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ABSTRACT

In most decision-making involving natural resources, the achievements of a given policy (e.g., improved ecosystem or biodiversity) are rather difficult to measure in monetary units. To address this problem, the current paper develops an environmental cost-effectiveness analysis (ECEA) to include intangible benefits in intertemporal natural resource problems. This approach can assist managers in prioritizing management actions as least cost solutions to achieve quantitative policy targets. The ECEA framework is applied to a selective gear policy case in Danish mixed trawl fisheries in Kattegat and Skagerrak. The empirical analysis demonstrates how a policy with large negative net benefits might be justified if the intangible benefits are included.

1. Introduction

Recent years have seen increased interest in endangered marine species.[1] Nearly 1900 species are listed under the Endangered Species Act of 1973 (ESA),[2] and several important fish stocks are being overfished and are below long-term sustainable levels (Commission of the European Communities, 2009). For many of these species, active recovery plans typically determined by non-economic expert opinions, such as those of the ICES,[3] are implemented with the aim of rebuilding depleted stocks. Several recovery plans exist within the European Union for different endangered fish species, including sole in the Bay of Biscay, Southern hake and Norway lobster stocks in the Cantabrian Sea and Western Iberian Peninsula, and cod stocks in Kattegat and the North Sea (Council Regulations (EC) 2166/2005, 388/2006, 1342/2008). While many of the recovery and conservation plans[4] are aimed at a single endangered species, they often have broader ecosystem consequences. If recovery plan regulations are interpreted as an increased political willingness to pay for conserving species, economic consequences for the fisheries of other species must also be taken into account. Otherwise, the total costs and benefits of the regulation are unknown, and the regulations are set by fumbling in the dark.

Cost-Benefit Analysis (CBA) is, in principle, an appropriate approach for evaluating changes in fishery policies to achieve a

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[1] E.g., mammals, turtles, fish, invertebrates and plants.

[2] http://www.nmfs.noaa.gov/pr/pdfs/laws/esa.pdf (last accessed March 2013).

[3] International Council for the Exploitation of the Sea, www.ices.dk (last accessed March 2013).

[4] The simple scientific justification for drafting recovery plans is that by limiting the fishery in the short-run, the stock biomass will grow over time and will provide the basis for a better fishery in the long-run. This classical bio-economics reasoning was formulated 40–50 years ago (see Clark, 1976) and has been promoted regularly since then (see Grafton et al., 2007 for a recent example).

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first-best solution.[5] In most cases, this approach involves a dynamic bio-economic model, including the interaction between the ecosystem and the fishery. In reality, such model exercises are not performed, most likely because doing so is too complex and time-consuming. Furthermore, the targets for the fishery policy may be predetermined and even non-monetary, such as changes in stock biomass. However, a recent trend in the literature applies bio-economic modeling approaches in simulation exercises, where management strategies are evaluated in terms of biological, economic and management criteria (Kraak et al., 2008; Hoff and Frost, 2008). Several of these criteria are important. Because no systematic statement of benefits and costs is made, it is difficult to evaluate whether the management strategies are improving the economic welfare. Furthermore, concepts such as biodiversity and protection of habitat are often used to justify policies and are implicitly added to the benefit side without quantification (Armstrong, 2007). These benefits, called intangible benefits, are part of the total economic value and are important to include, but difficult to assess.

Thus, if there is no good measure of all the benefits, it is impossible to make an efficient policy choice. In some cases, however, measures of the intangible benefits are not needed. Such is the case where the tangible net benefits (NB) are positive and intangible net benefits are expected to be positive. For example, it has been argued by Grafton et al. (2007) that reducing the fishery effort in a single species fishery below the Maximum Sustainable Yield level will pay off. In some cases with positive tangible net benefits, one could imagine that the intangible cost increases and that the assessment of these costs will be necessary. However, our focus is on cases where the net benefits of the tangible benefits and costs are negative. If, for instance, the reduction of effort is made in a mixed fishery,[6] it might result in a reduction in catches of several economically important species for which the future tangible benefits are lower than the tangible costs due to a reduction in catches. In these cases, assessment of the intangible benefits and costs becomes important.[7]

The objective of recovery plans is to increase the stock biomass with a given rate (Council Regulation (EC) 1342/2008). The framework suggested in this paper is rooted in the cost-effectiveness analysis (CEA) tradition, in which the best action among alternatives that achieves the objective with the least cost is identified. CEA is appropriate as a criterion for assessing management actions in at least two cases. In the first case, actions are determined primarily for conservation reasons (e.g., fishery managers want the fish stock to increase by a certain percentage rather than choosing the stock level that maximizes economic rents). In the second case, already-determined management actions have a highly uncertain or non-monetary benefit. Fishery conservation policies fall within both categories because they are often based on opinions with no economic expertise, and the benefits are often non-monetary. The framework studied here attempts to answer questions such as the following: Which policy should be implemented if we want to have, for example, a stock biomass that is 20% higher than the current one 10 years from now? What are the costs per unit of the stock biomass?

The outcome of applying CEA to conservation fishery policies is a cost-effectiveness ratio, which consists of a measure in monetary terms of costs per physical (non-monetary) unit change in the relevant fish stock (called effects). Thus, CEA has the advantage of measuring the effects of a policy alternative in quantitative, non-monetary units and relating these effects to the costs of the policy. CEA has been applied in several different areas of environmental management, for example, in water quality (Hajkowicz et al., 2008), waste management (Van Beukering et al., 2009), nitrogen emission (Schou et al., 2000) and the mitigation of climate changes (Berndes and Hansson, 2007). Goulder et al. (1999) find the cost-effectiveness ratio of different environmental instruments in a second-best setting. To the knowledge of the authors, CEA has not yet been applied to the evaluation of fishery regulations. Such application would be an appropriate way to assess different management instruments under fishery conservation policy, where the objective of the policy is predefined and the objective of the evaluation is to find the least cost option.

In summary, the aim of the paper is to formalize a framework for the economic evaluation of management actions in dynamic conservation policies where the objective of the policy has been identified. The approach is developed for cases where tangible net benefits from the policy are negative but with some intangible benefits from the policy that have to be allowed for. A second aim is to open a discussion about the measurement of effects in fisheries after implementing resource-saving technologies and then to relate these effects to the costs in a cost-effectiveness framework. The evaluation approach and the effects measured are empirically applied to the Kattegat and Skagerrak mixed trawl fishery, where analysis of the bio-economic consequences of the implementation of selective gear show negative tangible net benefits (Kronbak et al., 2009).

The paper continues as follows. Section 2 introduces the methodology. Section 3 frames the methodology in an economic fishery context, including definitions of effect measures and decision rules. Section 4 introduces an example in which the framework developed in Sections 2 and 3 is applied. Section 5 presents the discussion, and Section 6 concludes the paper offers suggestions for further research.

2. Methodology

A comprehensive economic evaluation analysis includes every change in costs and benefits of a policy implementation. A cost-benefit analysis is an example of such an evaluation. By comparing the costs and benefits based on the net present value criteria, it is possible to give recommendations about the changes in the economic welfare of the policy. Formally, the net benefits are represented by:

$$\Delta \text{NB} = \sum_{t=0}^{T} \frac{\Delta B_t - \Delta C_t}{(1+r)^t} \tag{1}$$

where ΔB_t measures the changes in benefits compared with the baseline scenario at time t, ΔC_t measures the changes in costs compared with the scenario baseline at time t, r is the discount rate and T is the last period included in the evaluation, or the project's lifetime.

In the area of natural and environmental resources, however, some of the environmental effects or impacts are difficult to

[5] For a comprehensive discussion of CBA's role in the evaluation of natural resource policy, see Van Kooten and Bulte (2000).

[6] It is well known that in a multispecies fishery, optimal equilibrium stock may be below the single species MSY stock level, and economically optimal management involves a trade-off in exploitation of different species.

[7] These intangible benefits could be included in a CBA by using the non-market valuation. The aim of the proposed methodology is to provide recommendations on policy alternatives where non-monetary targets for the fishery policy may be predetermined. The overall societal value is not in the core but is instead the ranking of different alternatives. Furthermore, non-market valuation is not straightforward because the information to describe the change in the marine ecosystem in terms of services people care about is often unavailable. According to Innes and Pascoe (2010), the same is true for other non-market benefits such as reductions in the level of habitat change or the mortality of bottom fauna due to gear passage across the seabed.