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Ecotourism and fishing in a common ground of two interacting species

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ABSTRACT

This paper investigates some economic consequences of implementing ecotourism which is inhabited by two interacting stocks: a stock of prey (fish) and a stock of predator (marine mammals, e.g., whale, seals, shark, etc.). The prey species is targeted for commercial fishing while the predator species is not subject to fishing but is a potential basis to implement the eco-tourism. We specifically address two key issues. First, we examine the consequences of entrance fee on the total benefit (fishing + eco-tourism) depending on the sensitivity of the number of tourists to the predator abundance level. It is found that total benefit always increases with entrance fee until the entrance fee reaches its optimal value. Second, we examine the effects on interacting species from attempts to reach MSY in prey species. It is found that total benefit always higher than the benefit coming from fishing only even if the fishing is done at MSY level.

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1. Introduction

For decades management and sustainable use of natural resources have been the key challenges for development agencies and concerned stakeholders alike. The question arises how can we effectively manage as to these resources to prevent a catastrophic bust to our global economy? All humanly used resources are embedded in complex, socio-ecological systems and in spite of having some effective management tools including taxation, license fees, lease of property rights, seasonal harvesting, etc., we need to consider alternative management approaches or options to stem the damage. One important option may be marine mammal watching based tourism development which has become a significant source of income in some areas. One example could be the whale-watching based tourism development worldwide after the commercial whaling moratorium in 1986 (Kuo et al., 2012).

Continuous declines of exploited natural resources and biodiversity loss, need us to think about the non-consumptive values of nature associated with tourism (Davies, 1990). This type of nature based tourism known as eco-tourism, is one of the popular and fastest growing tourism industry in the worldwide. One of the leading contemporary arguments for shark conservation is that sharks can be worth more alive for tourism than dead in a fish market. Gallagher and Hammerschlag (2011), mention that shark diving operations can generate significant revenues, benefiting local communities as well as national economics. Recently, Gallagher et al. (2015) present a review on biological effects, conservational potential and research priorities of shark diving tourism. Boncoeur et al. (2002) investigates some economics consequences of creating a marine reserve on both fishing and ecotourism. Their simulation work on a prey–predator system suggests that the stock of predators may be economically valued by means of ecotourism and the implementation of the reserve generates additional income through this channel. Whale watching based ecotourism is one of the fasted growing sectors of the international ecotourism market and it has become the most economically viable and sustainable use of cetaceans (Parsons and Rawles, 2003). Due to growing demand for whale meat and oil, the global whale population declined dramatically and primarily, for this reason, the IWC moratorium on commercial whaling was enacted. A larger whale population in the oceans will increase the satisfaction of whale watchers, and thereby attract greater whale-watching tourism. Commercial whaling may reduce whales for whale watching, and decreasing the attraction of whale-watching tourism. Kuo et al. (2012) examines some potential impacts of whaling on the global whale-watching tourism. Recently, Kar and Ghosh (2013) presents sustainability and economic consequences of creating marine protected areas in multispecies multiactivity context. They mention that tourism and recreation could contribute significantly to the society.

In spite of significant economic benefit, ecotourism may have some negative impacts on the population in the destination places.

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These ecotourism tours are generally conducted by boat, air or from land both in formal and informal way. Bejder et al. (2006) and Lusseau et al. (2006) indicated that repeated exposure of individuals to boat-based whale watching led to long term impacts on population living in restricted areas. Gallagher et al. (2015) mention that majority of shark diving operations offered food rewards to lure sharks in close proximity to tourists. Such practices have generated public and scientific concern as it may have potential negative consequences for shark health as well as for human society. These types of undesirable negative side effects have led to the growing concern for the conservation of natural resources and socio-ecological sustainability of society (Butler and Boyd, 2000; Richard and Hall, 2000).

Most of the worldwide assessed fished stocks are overexploited, and so not optimally exploited. Species mortality due to exploitation has also a strong impacts in marine ecosystem. The growth of human population and improvement technology has led to unsustainable harvesting of many resources. To reach the goal of sustainable harvesting, a balance is needed between over and under exploitation of ecosystems. So, biologists have proposed a concept called maximum sustainable yield (MSY), which can be defined as the maximum catch from a fish stock overtime on a sustainable way without deteriorating the productivity of the fish stock (prey) (Ghosh and Kar, 2014; Paul et al., 2015). Walters et al. (2005) show that the wide spread application of MSY policy in single species model would in general cause severe deterioration in ecosystem structure, in particular the loss of top predator species. Recently, Legovic et al. (2010) established that harvesting the prey species at MSY level cause the extinction of the predator species in a traditional prey–predator system. Kar and Ghosh (2013) showed that predator species may or may not go to extinction in the case of prey harvesting at MSY level if predator possesses strong intraspecific competition. Researchers or managers often recommend the establishment of marine protected areas (MPAs), however, scientific evidence of the effects of marine reserves is still not sufficient (Roberts et al., 2005). Takashina et al. (2012) shows that the establishment of the MPA can enhance a reduction in prey abundance, and even extinction of prey species in a prey–predator system. Krishna et al. (1998) considered tax as a control instrument to prevent the extinction of predator species in a prey–predator fishery with prey harvesting as well as to maintain the monitory social benefit. Chakraborty et al. (2011) also considered the regulation of a prey–predator fishery incorporating prey refuge by taxation.

This paper presents a simple bioeconomic model describing some consequences of implementing ecotourism in part of an area which inhabited by two interacting stocks: a stock of prey (fish) and a stock of predators (marine mammals, e.g., whale, seals, shark, etc.). The prey species is targeted for commercial fishing while the predator species is not subject to fishing but is a potential basis to implement the eco-tourism. In Section 2, the structure of the model is described and in subsequent sections qualitative studies are described under different circumstances. Finally, the results are used to discuss the direct and indirect impacts on ecotourism and fishing.

2. Model description with eco-tourism

The model described here combines two separate topics which are usually treated separately, namely fishing and ecotourism. Topics are studied in a simplified modelling approach. Model is of prey–predator type with fishing on prey (fish) species and ecotourism is based on predator species (e.g., whale, seal, dolphin, etc.). Here fish are targeted both by predators and fishers, and predators are not harvested but have some economic value as a resource for a non-extractive recreative use.

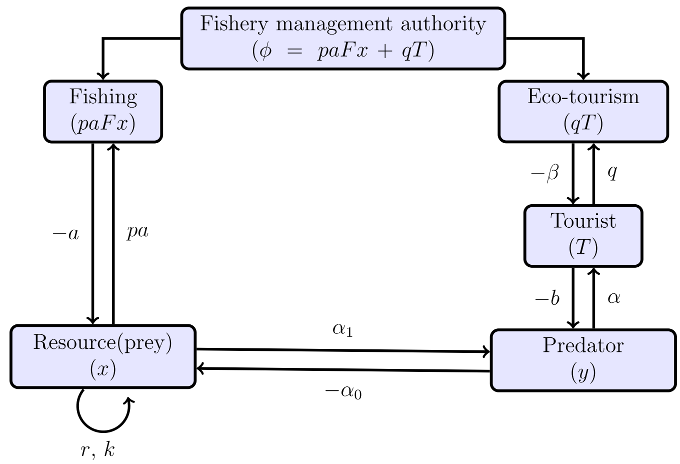

Fig. 1. Schematic representation of the prey–predator model (1) and total rent function ϕ. Here traditional divers exploit the fish (prey species) only and tourists come to watch the predator species and create some losses due to their activities. The benefit to the fishery management authority is the sum of the collected entrance fee coming from tourists and income coming from the fishing.

The change in the prey population level x depends on the growth rate of the prey and the loss of the prey population due to fishing and predation. Similarly, the predator population level y depends on its growth rate and the loss due to activities of the tourists (e.g., the threat posed by boat strike or by the bows of larger ships) (see Gallagher et al., 2015; Norman, 1999) and can be described as follows:

$$\begin{aligned} \frac{dx}{dt} &= rx\left(1-\frac{x}{k}\right) - \alpha_0 xy - aFx, \\ \frac{dy}{dt} &= \alpha_1 xy - m_1 y - bTy. \end{aligned} \tag{1}$$

The prey population is logistically related to the carrying capacity k and intrinsic growth rate r. The prey is decreased by predation rate α_0 and the fishing activities as indicated by the third term aFx, where a is the catchability coefficient and F is the fishing effort. It is based on the catch-per-unit effort hypothesis given by Clark (1990). The number of tourists T is assumed to depend on the predator level y and the entrance fee q and takes the form (Lee and Iwasa, 2011) (Fig. 1).

We consider

$$T = T_0 y^{\alpha} e^{-\beta q}, \tag{2}$$

where T_0 is the number of tourists if the predator level is one and there is no entrance fee ($q = 0$). A high value of T_0 represents more tourists, which reflects people's interest in tourism activities. Tourist increase is proportional to predator size relating with the power α (see Boncoeur et al., 2002). If α is very low and close to 0, the number of tourists is almost independent of the predator level. If α is 1, the number of tourists grows in proportion to the predator abundance. If α is greater than 1, then the number of tourists increases with y at the rate faster than proportionality. This might be the case if tourists are attracted only to the site with the largest predator level (Table 1).

Following Lee and Iwasa (2011), here we consider the number of tourists T to be a negative exponential function of the entrance fee q, so that tourists decreases as q increases. β is a constant indicating the sensitivity of tourists to the entrance fee. The proportionality coefficient T_0 in T depends on the number of tourists who are potentially interested in visiting the local marine environment. T_0 is expected to increase when more people become interested in

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