行政院國家科學委員會補助專題研究計畫成果報告

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計畫主持人：張文俊
共同主持人：

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執行單位：淡江大學 經濟系

中　華　民　國 89 **年** 09 **月** 20 **日**

行政院國家科學委員會專題研究計畫成果報告
具有存在價值的多物種資源之生物經濟分析
A Bioeconomic Analysis of Multispecies Resources with Existence Values

計畫編號：NSC 89-2415-H-032-013
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一、中文摘要

多物種再生性資源的研究通常忽略了物種存在價值的重要性。而在探討物種間的生態互動上，僅有捕獲的經濟利益是被考慮的。這項研究是探討物種的存在價值在多物種的經濟分析架構下的重要性。令人意外的是，本研究的結果發現，物種較高的存在價值，並不一定意謂著會有較高的最適數量。相對的，何種的物種間的生態互動關係具有重要的決定性。因為生態上的互動關係可能會對獵捕者的行為和物種的最適數量產生正向或負向的影響。

關鍵詞：存在價值 絕種 多物種 再生性資源

Abstract

Studies on the management of renewable resources in a multi-species framework usually neglect the importance of species' existence values, while only harvesting benefits are considered explicitly in examining the impacts of biological interaction on the optimal populations and the inefficiency caused by free access. This paper provides some economic insights into the concerns of species' existence values in multi-species setting. Surprisingly, it is found that species' higher existence values do not necessarily lead to higher optimal populations. Instead, the type of biological interaction may play a significant role in determining the effects of existence values on exploiters' behaviors, because the biological interaction can have positive or negative impacts on agents' harvesting as well as species' populations

Keywords: existence value, extinction, multi-species, renewable resource

二、緣由與目的

Studies on renewable resources, especially fisheries, have been focused on the problem of over-exploitation caused by free access resulting from the lack of well-defined property rights to the resources. As it is known, inefficiency occurs when property rights are not well defined and the resources are freely depleted to a level under social optimum because individual exploiters do not take into account the effect of his harvesting on others. To eliminate the inefficiency, the externalities ignored by individual exploiters must be internalized. Nevertheless, most previous studies aim at the externalities from harvesting activities that deplete the resource stocks to a non-optimal level; on the other hand, the externalities caused by the biological interaction between different species have not been emphasized until recent years. When the biological interaction is considered in decision-making, behaviors of individual exploiters will be substantially affected by the interplay of the forces from both the harvesting and the

biological externalities. Thus, the degree of over-exploitation could be largely different from what we have recognized from previous studies.

The first economic analysis dealing with the issue of biological interaction appears to be done by Anderson (1975) in studying the optimal harvesting under a framework of biologically interdependent fisheries. Among following researches, May et al. (1979) offer the guidance to the problems in managing multispecies resources, while Neher (1974) and Getz (1979) shows that, for maximizing harvesting profits, it is possible to optimally deplete one of the interdependent populations to extinction. However, most of these studies have focused the problem on the case of predator-prey interaction until Falk (1988) and Flaaten (1991) turn their attentions to the case of competing species. Recently, Fischer and Mirman (1992) examine the effects of biological externalities on harvesting in a model of two interdependent species in which a log-linear growth function is adopted when each agent is allowed to catch one of the two species. It is found that different types of biological interactions could lead to different levels of inefficiency away from the optimal harvesting. For example, the biological interaction of symbiotic relationship leads to a higher level of harvesting because the positive effects each species has on each other are neglected, while the predator-prey relationship lead to a lower stock of prey and a higher stock of predator compared to the optimal cooperation outcome. Fischer and Mirman (1996) later incorporate both the harvesting externalities and biological externalities into the bioeconomic model, allowing each agent to catch both species, to analyze the behaviors of harvesting agents under different types of biological interactions. More recently, Datta and Mirman (1999) extend the analysis to the effect of strategic market manipulation on the common property resources in the presence of harvesting and biological externalities. Again, different types of biological relationship results in different levels of over-exploitation since the biological interactions can display positive or negative effects on the species' populations. In contrast, unlike the log-linear growth function used by Fischer and Mirman, Chiarella et al. (1984) construct a general model of fishery and analyze four sets of conditions for satisfying a socially optimal outcome. Without an explicit form of growth function, only a general conclusion is provided by Chiarella et al, but the corresponding harvesting or population level can not be known.

Despite many significant conclusions have been drawn, none of these multi-species studies have precisely incorporated species' existence values, which are the benefits received by individuals and/or the society from the species' existence even there is no direct use of the resources involved, into analysis.

The purpose of this paper is to further discuss the issue on over-exploitation resulting from both harvesting and biological externalities in the presence of existence value (non-use value). By incorporating the existence value into a bioeconomic model, the effects of non-harvesting benefits on species optimal populations can be known under different types of biological interactions. It is found that higher existence values do not necessarily lead to higher optimal populations because the biological interaction can have positive or negative impacts on agents' harvesting as well as species' populations.

In addition, the optimal conditions for depleting the species to extinction will be derived in terms of economic and biological parameters used in the model. This study also shows that the species' existence value can be significant for determining whether depleting the species to extinction is optimal for the resource exploiters. Under different types of biological interaction, the existence value may have substantially different effects on sustaining the species' populations from extinction.

三、結果與討論

We have discussed the importance of species' existence values for determining the optimal populations in the cases of different biological interactions with the setting of simple and logistic growth functions. This study offers numerous economic insights into this concern that has not been emphasized previously. Surprisingly, it is found that the species' higher existence values do not necessarily lead to higher optimal populations. In contrast, the effects of existence values on optimal populations are sensitive to the type of biological interaction as well as the functional forms of species' growth. In particular, when the biological interaction is a predator-prey interaction, the species' existence values will have ambiguous cross effects on the optimal populations. Besides, agents' non-cooperative harvesting will not always lead to lower species' populations compared to the case of cooperation under different types of biological interactions, and consequently, non-cooperative harvesting could lead to under-exploitation or over-exploitation.

四、計畫成果自評

As the issue on preserving endangered species and environmental biodiversity has drawn enormous attention in recent years, it seems interesting to incorporate species' existence values into the economic analysis of resource management. Apparently, this study attempts to consider the role of species' existence values for resource exploiters in their determination of harvesting behaviors by allowing the presence of both the harvesting and the biological externalities. As many studies on multi-species resource have suffered, the result from this study does not lead to a general conclusion but only the economic insights based on special assumptions and an explicit model setting. However, this study should still embody considerable policy implications. For example, in recent years, the dispute over whaling in the Antarctic and some coastal areas has raised enormous concerns on the protection of marine species. Studies have show that the ecosystem in the Antarctic contains a compound biological relationship among different whales and other marine species. While different countries place different existence values on these marine species as well as intend to harvest some of the species, it would be valuable to recognize the interplay of the existence values and the species' biological interactions. To derive the optimal harvesting and conservation policies for different countries and/or the whole global community, the considerations of this study should not be ignored.

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