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ANALYSIS

The economic costs to fisheries because of marine sand mining in Ongjin Korea: Concepts, methods, and illustrative results[☆]

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ABSTRACT

We illustrate a methodology for estimating the damages to commercial fisheries from entrainment and from temporary loss of seafloor habitat productivity because of marine sand mining. A Beverton–Holt, year-class model is used to estimate illustrative short-term, long-term, and indirect (food web) effects from the inception of mining through the time to recovery of the injured resource stocks. A Base Case analysis evaluates hypothetical mining for a 4 km² mining site with biological recovery of the mined area beginning seven months after mining ceases and the bottom excavation fills in. Sensitivity analyses also are used to illustrate damages for alternative recovery paths and for 20 hypothetical mining sites for one year of mining and for recurring mining for 5 and for 10 years. Important qualifications and directions for further research are outlined.

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1. Introduction

Sand is a critical input for construction in modern industrial nations. Combined with aggregate and cement, the resulting concrete is used for buildings, roads and pipes, among many other uses. Korea depends on concrete perhaps more than any industrialized economy (Cho, 2006, pp. 1–2), and a substantial and increasing amount of its sand comes from marine sources (Table 1).

Marine sand mining in Korea provides significant economic benefits (rents), part of which accrues as revenues to local municipalities, which collect a 30% royalty on the value

of sand extracted. But by nature, mining is an intrusive activity and raises environmental concerns. Marine sand mining using a hydraulic dredging barge could cause heavy mortality to bottom species (e.g. crab, shellfish, and other species), and the concentrated plume from the overflow water slurry can harm exposed fish eggs and larvae. Furthermore, removal of substantial amounts of material from the seafloor disturbs the bottom habitat and causes changes in seabed morphology, which may eventually contribute to shoreline erosion, including loss of beaches, as has occurred at Dukjeok Island near Incheon Harbor (Cho, 2006, pp. 13–15), for example.

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Table 1 – Sand mining in Korea by source including Ongjin District, 1992–2002 (thousands of cubic meters)

Year	Quantity of mining					
	River	Ocean		Mountain	Land	Total
		Total	Ongjin			
1992	47,517	15,546	–	37,072	1691	101,826
1993	44,405	18,122	12,705	39,474	4012	106,013
1994	43,084	21,339	14,441	37,483	7570	109,476
1995	35,393	23,086	14,331	35,717	10,488	104,684
1996	49,437	30,591	17,580	49,416	9585	139,029
1997	31,501	29,002	17,586	64,843	8487	133,923
1998	21,848	19,276	13,295	60,252	7078	108,454
1999	28,069	24,586	14,493	59,688	6790	119,133
2000	26,770	29,179	14,459	50,283	6133	112,365
2001	19,781	31,203	15,837	57,418	6443	114,844
2002	20,629	33,031	19,143	58,311	7274	119,629

Source: Korea Aggregates Association (2002) and Ministry of Construction and Transportation (MOCT).

Responding to concerns with the adverse environmental effects of marine mining, policies to address these concerns are being considered by the Ministry of Maritime Affairs and Fisheries (MOMAF), which is responsible for protecting Korea's marine resources. However, assessing the scope and scale of the external costs of marine mining raises complex issues, and an appropriate framework and data are needed to address these issues.

This paper provides the underlying concepts and illustrates a methodology involving a bio-economic model for estimating selected external costs to commercial fisheries from marine sand mining in Korea. We estimate the potential external costs on commercial fisheries of hypothetical marine sand mining, using as a case study the Ongjin District in northwest Korea (Fig. 1).

The area covered in this paper was selected because useful biological information on area fisheries was available (Han and Park, 2002, pp. 207–312), which allows us to illustrate the application of a bioeconomic model to assess prospective damages. The area supports considerable commercial fishing which is vulnerable to mining, including a valuable crab fishery, as we describe later in this paper. We emphasize that our case study area in Ongjin is not currently being actively mined. However, it does have sand resources and is located near an area of Ongjin which is heavily mined and collectively accounts for approximately 60% of the marine mining of sand in Korea (Korea Aggregates Association, 2002, p. 1).

For our analysis, we adapt the bioeconomic model and methods used in earlier research by the authors (Grigalunas et al., 1988, 1999, 2001a,b; Opaluch et al., 2003), to illustrate the estimation of damages to commercially harvested species from marine sand mining.¹ Damages are measured as the discounted in situ use value of the lost catch of commercially harvested fish.

¹ Recreational fishing is not included in the results presented herein because such activity is thought to be minimal and in any event is unavailable for the study area. However, the model can easily be extended to include such losses (see, e.g., Grigalunas et al., 2001a) should such issues later warrant attention.

Our results herein are limited to losses attributed to two environmental stresses from mining. One is the direct lost catch from entrainment of vulnerable commercial species in the sand–water slurry. The second is the lost catch and indirect reductions in catch which result from loss of forage species and food web effects from the temporary loss of productive bottom habitat because of mining.

Damages are measured for three distinct categories: short-term, long-term, and indirect effects, as defined below. Damages are assessed over time until the injured fish species recover to their pre-mining level. Collectively, the estimate of damages for the environmental stresses considered illustrate the shadow value (external cost) to commercial fishery resources harmed because of mining (Freeman, 2003).

Our use of a bio-economic model requires considerable biological as well as economic information. As always, economic data, such as the landed (dockside) price of fish, is more readily available than biological information, for example, data on species abundance and on the life history parameters for potentially affected species.

For abundance, we use the best available biological data, based on results from survey of Ongjin waters outside the currently mined areas (see nearby map) carried out from January 2001 to April 2002 (Han and Park, 2002, p. 207). Data were not available for some parameters, such as mortality. For this parameter, we use estimates for the same species or from very similar species in the United States.

In light of the many sources of uncertainty faced, a conservative or overstated-cost approach is adopted. Overstated costs can be particularly useful when assessing difficult and controversial issues; particularly if a policy yields net benefits even when external costs are purposely overstated. When choices must be made, we opt for assumptions which tend to overstate the costs to fisheries because of mining. Nevertheless, considerable uncertainty surrounds several variables used in our analysis; sensitivity analyses are used to provide some insight into how the results would change if the alternative input values or key assumptions are adopted.

Finally, special efforts are taken to make clear the model, data, and assumptions used in order to better enable the reader to assess the reasonableness of our approach and results. We emphasize that the results presented here are meant to be illustrative damages for the Korea sand mining case and may not reflect damages from mining in other areas.

In the sections which follow we describe the environmental issues – external costs – of concern; present the concepts, methods, and data used to assess external costs, and provide illustrative results for a Base Case and also show results for several sensitivity analyses. A summary and conclusions section reviews the analysis and key results, provides important qualifications, and outlines possible future directions for research on the costs to fisheries of marine sand mining.

2. Issues, concepts and model

This section reviews the environmental issues posed by marine mining, the core economic concepts involved in assessing damages, and the bio-economic model used to address the commercial fishery issues of concern.

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