Journal of King Saud University – Science (2013) **25**, 217–228

King Saud University
Journal of King Saud University – Science
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ORIGINAL ARTICLE

Supply-side approaches to the economic valuation of coastal and marine habitat in the Red Sea

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Received 18 October 2012; accepted 25 February 2013
Available online 7 March 2013

KEYWORDS

Ecosystem service;
Supply-side valuation;
Traditional fishery;
Red Sea;
Coral reef;
Bio-economics

Abstract The degradation of natural fish habitat in the ocean implies lost economic benefits. These value losses often are not measured or anticipated fully, and therefore they are mainly ignored in decisions to develop the coast for industrial or residential purposes. In such circumstances, the ocean habitat and its associated ecosystem are treated as if they are worthless. Measures of actual or potential economic values generated by fisheries in commercial markets can be used to assess a conservative (lower-bound) value of ocean habitat. With this information, one can begin to compare the values of coastal developments to the values of foregone ocean habitat in order to help understand whether development would be justified economically. In this paper, we focus on the economic value associated with the harvesting of commercial fish stocks as a relevant case for the Saudi Arabian portion of the Red Sea. We describe first the conceptual basis behind supply-side approaches to economic valuation. Next we review the literature on the use of these methods for valuing ocean habitat. We provide an example based on recent research assessing the bioeconomic status of the traditional fisheries of the Red Sea in the Kingdom of Saudi Arabia (KSA). We estimate the economic value of ecosystem services provided by the KSA Red Sea coral reefs, finding that annual per-unit values supporting the traditional fisheries only are on the order of $7000/km^2. Finally, we develop some recommendations for refining future applications of these methods to the Red Sea environment and for further research.

1. Introduction

Humans depend upon the natural resources of the Red Sea, including its fish stocks (PERSGA, 2002). Red Sea fish stocks are exploited for both subsistence and commerce. They may also be used for recreation (Gladstone et al., 2012). Economic value is generated by all of these activities.

While humans have been living and using the resources of the Red Sea coast for many millennia, development has become more extensive–even industrialized–in recent years, especially along the Red Sea coast of the Kingdom of Saudi Arabia

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Peer review under responsibility of King Saud University.

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http://dx.doi.org/10.1016/j.jksus.2013.02.006

(KSA). In some cases, this development has led to the degradation of natural fish habitat, including the loss of mangrove wetlands, seagrass beds, and coral reefs (Kotb, 2010; Gladstone et al., 2006). Moreover, coastal development can lead to increased sedimentation due to erosion and to nutrient releases from industrial effluents or sewage disposals. Sediments and nutrient loads affect water quality adversely, thereby further degrading fish habitat (El Sayyed, 2008).

The degradation or loss of natural fish habitat implies losses in economic values. Commercial, subsistence, and recreational fisheries are all affected adversely. In most cases, this loss in value is not measured or anticipated fully, and therefore it is often ignored in decisions to develop the coast. In effect, the ocean habitat, here including coastal wetlands, the seabed and its flora, coral reefs, ocean waters, and the associated ecosystem, is treated as if it may be worthless (*i.e.*, as if it has no price).

Importantly, measures of the economic value generated by fisheries can be used to estimate the value of the ocean habitat that supports fish stocks. These measures are commonly known as "supply-side" or "productivity" approaches to habitat valuation (Barbier, 2007; McConnell and Bockstael, 2005). These measures can be utilized to impute a conservative (lower bound) value on ocean habitat. (This value is conservative because ocean habitat may be a source of value for other ocean uses, including recreation and passive, non-market benefits.) With this information, the value of coastal development can be compared to the value of potentially foregone ocean habitat in order to determine whether the development would be justified economically.

In this paper, we focus on the economic value associated with the exploitation of commercial fish stocks as the most relevant case for the Saudi Arabian portion of the Red Sea. Similar methods may apply to recreational fisheries (Bell, 1997) or, more broadly, to other uses of the ocean or functions of habitat (Barbier et al., 2011). The precise sources and measures of economic value may depend upon the type of use under consideration, however (Barbier et al., 2008).

We describe first the conceptual basis behind supply-side approaches to valuation. Next we review the literature on the use of these methods for valuing ocean habitat. We consider an example based on recent research assessing the bioeconomic status of the traditional fisheries of the Red Sea in the Kingdom of Saudi Arabia. Finally, we develop some recommendations for the application of these methods to the Saudi Arabian Red Sea environment.

2. Commercial fisheries and resource rents

The commercial harvesting of fish stocks results in the production of seafood as an economic commodity. Using a commercial fishing technology, sometimes referred to as a "black box," fishermen produce seafood by combining factors of production, including labor, experience and knowledge, fishing vessels, fuel, nets, bait, ice, and other inputs (Fig. 1). Fish as seafood may be sold as it is or processed for value-added.[1]

Economic surpluses result from the harvest of fish stocks. In a well-managed fishery, these surpluses are distributed between fishermen (as producers) and seafood consumers. Taken together, producer and consumer surpluses are the economic measure of value for a commercial fishery (Fig. 2a). Producer surplus is equivalent to the revenues earned from selling catch net of all costs of fishing. Producer surplus is represented by the area below price and above the supply schedule. Consumer surplus is evaluated as what consumers are willing to pay for seafood, less what they actually pay in the market. Consumer surplus is represented by the area below the demand schedule and above price.

One element of the producer surplus is known as the "resource rent." Resource rent is the cost of fish utilized as an input in the production of seafood as a commodity. Resource rent implies that fish have a price, although nature does not charge fishermen this price when fish are removed from their habitat. Because fish both grow and reproduce, the removal of fish from the ocean by harvesting imposes a dynamic cost that depends upon the size of the relevant population; it is this "user cost" that comprises resource rent.[2] Because this price is

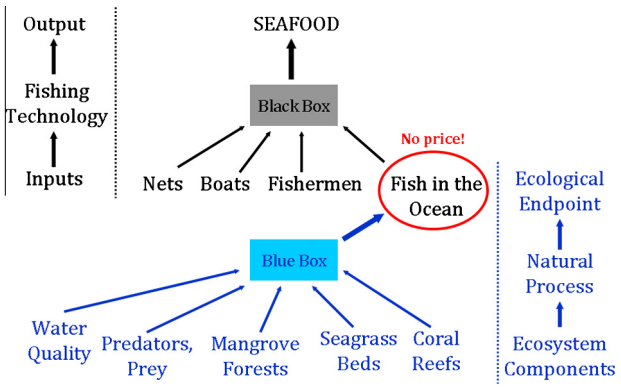

Figure 1 Economic and ecological production functions.

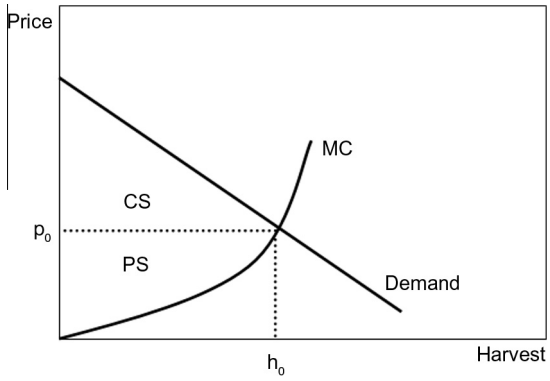

Figure 2a *Well-managed* (rationalized) fishery with price equal to marginal cost (MC). The market equilibrium occurs at price, p_0, and harvest, h_0. Both consumer surplus (CS) and producer surplus (PS) are realized. If all fishing vessels are identical, in terms of both capital and labor (including fishing skills and knowledge), then the producer surplus comprises the resource rent.

[1] Artisanal fishermen may harvest fish for subsistence purposes. Although such fish do not enter a formal market, they are still to be regarded as an economic commodity.

[2] The resource rent can be interpreted as the value of the ecosystem "service" as embodied in wild fish stocks, *per se* (see below). This review is focused more generally on measures of the value of the ecosystem or habitat that supports wild fish stocks.