Ocean & Coastal Management 145 (2017) 1–13

Contents lists available at ScienceDirect

Ocean & Coastal Management

journal homepage: www.elsevier.com/locate/ocecoaman

The forgone benefits of discarding fish in the Gulf of California shrimp fishery

Alonso Aguilar Ibarra

Environmental Economics Research Unit D-209, Instituto de Investigaciones Económicas, UNAM, Circuito Mario de la Cueva, Ciudad Universitaria, Mexico City, CDMX 04510, Mexico

ARTICLE INFO

Article history:
Received 21 October 2016
Received in revised form
27 April 2017
Accepted 28 April 2017

Keywords:
Shrimp trawling
Fish discards
Meta-analysis
Environmental valuation
Gulf of California

ABSTRACT

Fish discards represent a large share of harvested biomass in shrimp fisheries. The aim of this paper is to propose a methodology for valuing discards of both commercial and non-commercial fish species discarded in the Gulf of California shrimp fishery, by estimating the monetary value of forgone fish biomass. The value of commercial fish species was carried out by using growth and population models, in order to simulate the biomass that, if left in the ocean instead of being harvested at Age 0, could reach an optimal fishing size. Using deflated ex-vessel prices, the present value of commercial species hypothetically harvested at an optimal age, was computed. The value of non-commercial fish species represented the forgone benefits of not using discarded biomass for producing fishmeal. Hence, the estimated value of fish diversity discarded in trawling operations in 2013 would range between USD 60.80 million and USD 103.4 million. This estimate is one of the first attempts to give an economic value to both commercial and non-commercial discarded fish biomass. Hopefully, the methodology here proposed will serve as inspiration for further research in economic valuation of marine biodiversity.

1. Introduction

Major consequences of overfishing comprise the loss of taxa (Worm et al., 2006) and the shift of trophic levels (Pauly et al., 1998). Closely linked to this problem and, albeit less analyzed, is the illegal, unregulated and unreported (IUU) level of catches (Zeller and Pauly, 2005; Davies et al., 2009; Keledjian et al., 2014). According to Ainsworth and Pitcher (2005), discarded bycatch is the largest component of IUU worldwide.

The terms discards and bycatch are often confusing. In the present study, the concept of discards is adopted following Kelleher (2005) and Gillet (2008): “Discards, or discarded catch, are that portion of the total organic material of animal origin in the catch, which is thrown away or dumped at sea, for whatever reason”. Kelleher (2005) points out that the average discarded total catch in trawling fisheries around the globe is about 62%, but it may reach up to 96% in some regions. Thus, assessing the effects of discards becomes an important coastal and marine management issue (Gillet, 2008).

The ecological impact of discards by trawling (i.e. biomass removals) has been frequently addressed (e.g. Harrington et al., 2005; Kelleher, 2005), however, only few studies have assessed the economic loss of such impact. Indeed, the economic valuation of impacts on marine biodiversity is relevant for coastal management, as well as for marine conservation programs (Beaumont et al., 2008; Nijkamp et al., 2008; Mangi et al., 2011; Börger et al., 2014).

Shrimp fisheries are one of the main sources of fish discards (Earys, 2007; Gillet, 2008; Davies et al., 2009) but, at the same time, generate significant earnings which foster regional development in a number of tropical and subtropical countries, such as Mexico (Meltzer et al., 2012). This is a challenge that needs to be faced with sustainable practices. Yet, fisheries are poorly managed in Mexico: in a study of 53 fishing nations, Mondoux et al. (2008) ranked Mexico in the 42th place, according to several fisheries sustainability indicators. Poor management not only negatively influences marine habitats, but also the shrimp industry, due to the lack of both adaptation strategies against climatic change and sustainable fishing practices (Ibarra et al., 2013). Furthermore, Cisneros-Montemayor et al. (2013) estimated an average of 404 thousand tons of unreported discards per year (1950–2010) in marine Mexican fisheries, which represents about 51% of the total officially reported in the same period.

E-mail address: aaibarra@unam.mx.

http://dx.doi.org/10.1016/j.ocecoaman.2017.04.011
0964-5691/

Thus, the aim of this paper is to provide a methodology for economic valuation and a monetary estimate of both commercial and non-commercial discarded fish species in a Mexican trawling shrimp fishery. The chosen area to analyze is the Gulf of California (GoC) because it is one of the most relevant areas in the Eastern Tropical Pacific for both marine biodiversity and fisheries production (Erisman et al., 2010). Hence, the following sections deal with the background of the GoC shrimp fishery. Next, the methods are explained in three calculation modules: in the first one, estimation of proportions of commercial and non-commercial discarded fish species from actual offshore shrimp landings records is described; the second module details on the monetary valuation of discarded non-commercial fish species, and the third module deals with the monetary valuation of discarded commercial fish species. Next, results are presented, followed by their analysis and discussion. Conclusions and references close the paper. The appendix completes the information on the nature and processing of the data used for the analyses.

2. The Gulf of California shrimp fishery

The Gulf of California (also known as Sea of Cortez) is located in NW Mexico, and it comprises an area of 257 thousand square km, with a length of 1600 km, and an average width of 200 km (Garcia and Gomez, 2005). According to Erisman et al. (2010), it is one of the most important fishing areas in the Eastern Tropical Pacific. This is so because it is an area of high ecological productivity that results in a rich marine biodiversity (Garcia and Gomez, 2005; Brusca, 2010). This high diversity is expressed in both endemic species and local habitats (e.g. Enríquez-Andrade et al., 2005; Lluch-Cota et al., 2007) that support a number of ecosystem services, such as waste dilution, habitats for biodiversity, food production, and recreation (Aburto-Oropeza et al., 2008b).

The GoC hosts the main landing ports of shrimp harvest in Mexico, accounting for about 80% of total shrimp landings (Lluch-Cota et al., 2007) in five coastal provinces: Baja California (BC), Baja California Sur (BCS), Sonora (SON), Sinaloa (SIN) and Nayarit (NAY). The shrimp species therein caught are: white shrimp, blue shrimp and brown shrimp (Garcia and Gomez, 2005), with an annual value of about $500 million USD per year (CONAPESCA, several years).

Shrimp fishing season lasts from September through February. Shrimp trawlers carry out about six trips per fishing season, with an average of 26 days a trip, making three or four tows per day (Garcia and Gomez, 2005). The GoC shrimp fleet comprises about 1288 boats (CONAPESCA, 2011). Garcia and Gomez (2005) describe the GoC shrimp fleet as homogeneous, comprised by boats with steel hull, with 20 m in length, seven meters in width, electronic navigation equipment, 250–400 HP engines, and mechanical refrigeration system. The crew is, in general, comprised of six members.

Although the international price of a pound of shrimp is high (5–9 USD/lb), profitability of the fleet is a risky issue, due to climate variability but most of all, because of overcapitalization (Almendarez-Hernández et al., 2015) and poor financial management (Garcia and Gomez, 2005). In fact, the government grants subsidies in the form of aids for buying fishing gears, including nets and engines, and for artificially lowering fuel prices through the FIRA-FOPESCA funding program for fisheries (OECD, 2006).

Main fishery regulations for the offshore fishing fleet include closures in both space and time. The timing of the closures is set up each year according to the Federal fisheries research agency (INAPESCA), mostly during spring and summer. Furthermore, trawling cannot be carried out in a depth of 0–9 m and trawlers must use Turtle Excluders Devices (TEDs). The Upper Gulf of California is a natural reserve where any fishing activity is banned (DOF, 2012).

This fishery imposes severe anthropogenic pressure on the GoC ecosystem due to intensive trawling operations (Taylor et al., 2004; Meltzer and Chang, 2006; Lluch-Cota et al., 2007; Foster and Vincent, 2010; Foster and Arreguin-Sanchez, 2014). Indeed, trawling is performed on the seabed at a speed of two nautical miles per hour with nets of very low selectivity (Garcia and Gomez, 2005). In other words, nets sweep off the entire benthic ecosystem and all this biomass is lifted on board. Then, the crew sort shrimp apart from other organisms and all non-shrimp catch is discarded back to the sea. By the end of this process, all creatures (mostly fish) are already dead. For example, Gillet (2008) points out that about 133 thousand tons of bycatch is generated by Mexican shrimp fisheries every year. The largest share of discards reported in the GoC corresponds to fish diversity, ranging from 33% to 84% of the total captured biomass, as reported by Cisneros-Montemayor et al. (2013), López-Martínez et al. (2010), Madrid-Vera et al. (2007, 2010b) and Rodríguez-Romero et al. (2012). It implies more than 100 species of fishes, most of which are caught in small sizes (Garcia and Gomez, 2005; Foster and Vincent, 2010).

Except for TEDs, designed to liberate turtles, no specific regulations are set up for avoiding discards from shrimp trawling. Alternative uses of such wasted biomass are not put in practice by fishermen because, as Garcia and Gomez (2005) point out, the high operation costs of the fleet lead fishermen to seek for maximum profit by means of shrimp landings. Thus, any available space in the boat is devoted to stocking shrimp rather than lower-valued species. Lluch-Cota et al. (2007) regret the lack of analysis on the social and economic consequences, as well as the potential development of economic alternatives concerning shrimp trawling discards.

The sole study that estimated the economic impacts of the GoC shrimp fishery discards was conducted by Garcia and Gomez (2005). The authors estimated, making several assumptions, that the value of discards exceeded that of the shrimp value, ranging between $219–264 million a year (in 2000 USD). In the present study, it is proposed an alternative and more accurate methodology which could be applied for shrimp fisheries elsewhere, in order to assess the economic value of fish discards.

3. Methods

The estimation of the value of discards in the GoC shrimp fishery was obtained by computing the forgone benefits of fish species. This approach is based on the opportunity cost concept, which is frequently used in environmental economics valuation (Kaphengst et al., 2011). The basic idea is that economic value is assigned to the benefits of a forgone option. Therefore, the value here provided is not the opportunity cost *sensu stricto*, which requires a comparison of net benefits (benefits less costs) across alternatives. In fact, the forgone benefits might be interpreted as an upper bound of opportunity cost. This approach has been applied, for example, for valuing no-take areas (e.g. Smith et al., 2010; Adams et al., 2010) and for simulating the forgone profits in the Peruvian anchovy fishery which resulted from recruitment overfishing (Salvatteci and Mendo, 2005).

In the present study, a distinction was made between commercial and non-commercial fish species and, accordingly, different procedures were carried out for their economic valuation. Hence, the value of commercial species was obtained by calculating the forgone fishable biomass not left in the ocean for future harvest. In other words, this estimate indicates the value of the natural resource (i.e. fish stocks) in the environment, ready to be harvested. Such value does not take into account landing, transport or storage costs since it does not have to be considered as a real commercial alternative. It is just to put a value on an environmental asset. Correspondingly, the value of non-commercial fish species