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Factors contributing to technical efficiency in a mixed fishery: Implications in buyback programs

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ABSTRACT

Understanding the factors that define technical efficiency in a fishing fleet is a requirement for the implementation of management strategies, such as buybacks. The goal of this study was to evaluate the efficiency of a semi-industrial fleet operating in the Bank of Campeche, Mexico. The reduction in the catches of main target species necessitates the implementation of management alternatives to reduce the current fishing pressure. A stochastic frontier analysis model was used to evaluate the efficiency and the factors that influence efficiency of four fleet segments defined by fishing gear. Five variables were included: days at sea, crew size, engine power, month and year. Data was retrieved from logbooks that had recorded details of a total of 5497 fishing trips that had taken place during the seasons of 2005, 2012 and 2014. Interviews were also conducted in the Yucatan coast to explore the skippers' perspectives on the factors that influence fleet efficiency. The results were different between fleet segments, both in estimated efficiencies as significant variables. The difficulty of establishing global targets of fishing effort reduction, through buybacks, for a mixed fleet, with different gears, different target species and different performance is discussed.

1. Introduction

The overcapacity of fishing fleets is a phenomenon that has been spreading all over the world [1], and although this problem and its economic and social implications are recognized [2], the debate regarding how to control the factors that contribute to the overcapacity of the fleets continues to date. FAO [3] defines fishing capacity as the quantity of catch produced within a period by a vessel or fleet, with the optimum use of inputs and the stock conditions. Such capacity has regularly been measured in terms of number of vessels, number of licenses, gross register tonnage (GRT) or power of vessel engines. However, the fishing operations of a fleet can vary depending on other factors (number of days at sea, number of hauls or hooks, size of the crew, etc.) [4]. Quimbar-Acosta [5] indicates that there are signs of overcapitalization of fisheries when a marginal unit of increase in the effort causes the reduction in individual productivity of the vessels, even when the global production is stable. Hence, overcapacity results in an underuse of inputs (capital, labor) in order to efficiently produce the levels of capture observed [6].

Amongst the conditions that are considered to contribute to the overcapacity of a fleet there exist: a lack of mechanisms to regulate fishing effort, an absence of property rights, open access systems and management strategies that incite overcapitalization, such as subsides [6]. Given the absence of regulation mechanisms, fishermen invest in their vessels and increase their efforts in order to increase the quantity of catch. The additional effort is often profitable in the short term, but it can have a negative impact in the long term depending on the conditions of the exploited stock and the number of operating units [7]. The increase in this phenomenon and the decline of diverse fishing stocks worldwide require a constant revision of the management system in order to put forward congruent adaptations to these changes. Adaptations related to the control of the fishing effort, such as the retirement of the vessel program and the sale of license for gear and resources, have become a great importance to many countries of Europe, Australia, and North America [8], however the goals have not always been achieved and in some cases the programs have resulted in controversy due to the lack of an evaluation of fleet efficiency before and after the implementation of these programs [9].

This study presents some examples of buyback programs and discusses the advantages of the programs within different contexts. Subsequently, the characteristics of the Campeche Bank fishery are used to describe the overcapitalization problem of a fleet, where the possibility of introducing a buyback program has been explored by local authorities and the fishing industry, due to the decreasing capture of

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main resources. Finally, the results derived from the stochastic frontier model, used to evaluate the efficiency of the fleet, are discussed in the context of the buyback programs in the fisheries that operate in the Campeche Bank.

1.1. Buyback programs and fishing effort control

Vessel buyback has been widely used in some regions (like Europe) to promote the improvement of the sustainability of fisheries (when overexploited stocks are evident), and increase economic efficiency while promoting the transition to rights-based management or providing disaster relief (hurricanes, storms). This type of program has also been considered as a compensation for conserving biodiversity (implementation of protected areas for instance). Nonetheless, the results of such programs vary in different fisheries around the world [1,10]. Most authors have argued that buyback schemes might not be enough to address overcapacity and overfishing, as they could generate expansion in fishing efficiency by either increasing investments in those vessels that remain active or increasing the use of uncontrolled inputs and technical progress [8,11]. It is also important to recognize that other factors also influence the efficiency of vessels, such as the skill of skippers and crew members, which can move amongst vessels [12].

In some countries, a trend has been observed, in which vessel owners tend to sell older vessels [6]. Owners tend to replace old vessels or technology with newer versions when they are financed by government funding programs, which allows them to reinvest in the activity, thereby increasing the fisheries inputs and vessel capacity if other control efforts are not in place [13]. Pappas [14] suggested that buyback programs are usually a temporary solution for fishing effort and capacity control and supplementary approaches should be implemented, such as limited open seasons or quota catches. Pascoe et al. [11] indicated that although there was a decline in the number of vessels through buyback programs between 1995 and 2007 in the Australia's northern prawn fishery, the removal of older vessels as well as the replacement with newer ones, resulted in an increase in technical efficiency. Despite the concurrent conclusion regarding the effect of buyback programs on the reduction of capacity, there are few studies in the literature that assess the long-term success or failure of such programs [10]. Importantly, the effect of different contexts and how these programs are implemented can determine whether the scheme will be successful. In Yucatan, fishermen associations and permit holders have been promoting the implementation of a buyback program for the semi-industrial fleet of Yucatan in order to reduce overfishing problems of the main groundfish resources and to improve profitability of fishing trips. However, in Mexico there are no studies that diligently analyze the success of these programs (like in the case of the shrimp fleet in the Gulf of Mexico and the Pacific, where applied) in terms of the cost-benefits and sustainability, to evaluate the viability of implementation in other fisheries [15]. Furthermore, the levels of efficiency of the fleet, which could be incorporated into these programs, are unknown. This presents potential difficulties to implement effective effort reduction programs because the reduction in effort is measured when the vessels leave the fleet, hence the vessel is the most common unit to measure reduction, but its actual efficiency is unknown. Even greater complexity arises when the fisheries are multi-species, which is the case for the semi-industrial fleet of Yucatan that operates in the Campeche Bank.

Vessel buyback programs aim to remove or reduce overcapacity. Technical efficiency is one component of fishing capacity. Buybacks can fail to reduce the anticipated amount of fishing capacity if there is a sizable overhang of technical efficiency that can increase in response to the buyback or due to other factors. The purpose of this paper is to estimate technical efficiency of a semi-industrial fleet operating in the Campeche Bank, Mexico, identify the most efficient vessels, and to establish the variables that define such efficiency. Results from this study are discussed within the context of the buybacks programs.

1.2. Fisheries background

The semi-industrial fleet of Yucatan operates in the Campeche Bank and is composed of 510 vessels [16]. These vessels are heterogeneous in terms of length (13–24 m), hull material (wood, iron or fiberglass) and engine power (115–500 Hp); in addition, they are equipped with navigation instruments (Global Positioning System, Long Range Navigation, echo-sounder). The fleet uses different fishing gears according to the target species given that there are fishing licenses for several resources (groundfish, octopus or lobster). Therefore, skippers alternate the use of such license, changing fishing gears and methods, according to regulations (access), climatic conditions and their preferences [17].

The analyzed fleet, catches a mixture of approximately 30 species principally groundfish resources that belong to Serranidae and Lutjanidae family; the fleet also directed its efforts to two species of octopus [17]. Octopus are captured using a ‘dinghy’ and a ‘jimba’ (DJ); the vessel act as a mothership and the fishermen operate from an individual vessel of 3 m without motor (dinghy) that is equipped with two bamboo poles (jimbas), from which bait lines hang (mainly crab). Another fleet segment used dinghy with short longlines (DSL) for groundfish species, analogous to DJ, the vessel acts as mothership and the fisherman operate in an individual dinghy equipped with a short longline comprising 80–100 fish hooks. Other vessels used the gear longline (LL) a fishing gear that consists of a hydraulic reel with a mother line and multiple hooks for catching groundfish. Ultimately, some vessels use a system locally known as bicycle (B) to catch mainly red snapper; it consists of a line from which four to six hooks hang and the catch can be retrieved with the help of a pulley.

The management strategies present in the Yucatán fishery aim to regulate the composition and quantity of the catch through restrictions in fishing gear, season closures, minimum catch sizes and total catch quotas depending on the species [18] (Table 1).

Despite these regulations, in the last 20 years a decrease in the landings of *Epinephelus morio* and *Lutjanus campechanus* has been reported in Yucatan, as shown in Fig. 1. While the population of *E. morio* has been classified as overexploited [19], in the case of octopus, which represents two species (*Octopus maya* and *O. vulgaris*) irregular fluctuations can be observed (Fig. 1). *O. maya* is considered to be at its maximum level of exploitation, whereas no formal evaluations exist for *O. vulgaris* [20].

2. Material and methods

2.1. Study site

The Bank of Campeche is an area located in the north of the Yucatan

Table 1
Authorized regulatory measures for the capture of four main commercial marine species in the Bank of Campeche [18].

Resource	Season closure	Minimum legal size	Fishing gear	Total allowable catch (TAC)
Grouper	Feb15th –Mar ^{15th}	36 cm, total length	Hook (short longline, longline, bicycle)	
Snapper	Feb 1st-March 31st		Hook (bicycle, long line)	
Octopus	Dic 16th – Jun 31st	110 mm mantle length	Dinghy and line	*O. maya*, 10,000–13,000 t.
Lobster	Jul 1st - Feb 28th	135 mm abdominal length, 74.6 mm cephalothorax length, 223 mm total length	Steel hook (hookah, traps, free diving)	*Panulirus argus*, 495 t.

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