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# Impact of reducing investment disincentives on the sustainability of the Moreton Bay prawn trawl fishery

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ABSTRACT

The Moreton Bay prawn trawl fishery is one of Queensland's oldest commercial fisheries, but is currently economically unsustainable. The fishery is characterized by a mix of large and small vessels, with the small vessels facing different licensing and boat replacement restrictions to the large. Industry have proposed the removal of the current two-for-one boat replacement policy that affects the smaller vessels to encourage investment and replacement by larger vessels, although there is concern by managers about the impact of this on total fishing effort and sustainability of the stocks, despite the existence of a total cap in vessel capacity units. We estimate the impact of removing the boat replacement policy for the smaller vessels on fleet performance and total fishing effort, and find that removing the boat replacement policy is unlikely to result in a substantial increase in fishing effort due to the existence of a vessel unitization scheme.



## 1. Introduction

Excessive capital investment is a significant contributing factor in the overexploitation and depletion of fisheries resources. Measures are often in place to prevent additional investment in many fisheries managed using input controls. However, these controls can also negatively impact on economic performance in the fishery. As a consequence, understanding investment behavior in fisheries and how this may be influenced by management policy is of critical importance to regulators when planning changes to regulatory instruments. Whilst there is a substantial body of theoretical work on this subject (e.g. Charles, 1983; Sumaila, 1995; Tidd et al., 2011; van Putten et al., 2012), there are markedly fewer examples of empirical studies, particularly at the firm level (Nøstbakken et al., 2011). Using data for a trawl fishery on the east coast of Australia, this paper contributes to empirical work in this area of research by assessing how capital investment and capacity will respond to a change in management measures.

The fishery of interest in this study is for prawns in Moreton Bay, one of the oldest fisheries in Queensland, Australia. Several commercial fisheries exist in Moreton Bay, of which the prawn trawl fishery is the most valuable. Fifty seven vessels actively fish in the Bay at least once over the year, targetting four main prawn species – greasyback generally referred to as Bay prawns (*Metapenaeus bennettae,*), banana (*F. merguiensis*), brown tiger (*Penaeus esculentus*) and eastern king (*Melicertus plebejus*). Fishers are also permitted to target Moreton Bay bugs (*Thenus* spp.) and squid (*Loligo* spp.) and retain incidental catches of several other species, including cuttlefish (*Sepia* spp.), mantis shrimp (*Oratosquilla* spp.) and octopus (*Octopus* spp.), although these comprise only a minor proportion of the total catch value. The gross value of production of the prawn trawl fleet over recent years has averaged around $6 m a year, of which 20% is derived from the non-prawn species (Wang et al., 2015),

While only 57 vessels actively fish in the Bay, a total of 72 vessels hold endorsements (known as "symbols") to operate in the Bay, resulting in substantial latent fishing effort. Two types of symbols exist for vessels operating in the Moreton Bay trawl fishery: a "T1/M1" (47 vessels), which allows vessels to operate both outside the Bay (the T1 component) as well as inside the Bay (the M1 component), and a M2 symbol (25 vessels) that allows fishers to operate only within the Bay (DAFF, 2013). Of the 57 vessels actively fishing in the Bay, 37 held T1/M1 symbols and 20 held M2.

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All vessels can only operate at night, and are prohibited from operating on weekends (primarily to reduce conflicts with recreational fishers and other recreational users of the Bay). The T1/M1 vessels are also subject to a transferable effort quota system, and utilize effort units when fishing either inside or outside the Bay. The effort units place a limit on the total number of nights a T1/M2 vessel can operate, although vessels can purchase additional effort units if required as effort units are transferable. M2 vessels are not managed under the transferable effort quota system so can potentially fish up to five nights per week.

Total fishing capacity in the fishery is capped through a unitization system in the form of "hull units". Each vessel is assigned a number of hull units based on the under deck volume of the boat, which is a function of vessel length, beam and depth (O'Neill and Leigh, 2006). All vessels endorsed for Moreton Bay are limited in size to a maximum of 14 m, with the M2 vessels being on average (roughly) half the size of the T1/M1 vessels. Fishers need to purchase the required additional hull units from other fishers to replace a boat with a larger vessel. The M2 vessels are also subject to boat replacement restrictions, namely that an additional M2 license needs to be surrendered if an existing M2 vessel is modified or replaced (*Fisheries (East Coast Trawl) Management Plan 2010*, §99). That is, a two-for-one boat replacement policy as well as a unitization system.

The industry has come under increasing financial pressure over recent years. In particular, falling prawn prices over much of the last decade (Fig. 1) has seen a substantial reduction in fishing effort in both Moreton Bay (Fig. 2) and the broader East Coast Trawl Fishery (ECTF). This fall in price is largely attributable to increased supply of imported farmed prawns on the Australian market.[1]

The fishery has also been subjected to a decrease in the available area to fish. In 2009, the Moreton Bay Marine Park expanded from 0.5% of the total Bay area to 16%, with prohibitions on trawling in this expanded area. A structural adjustment package was introduced to compensate the industry (Sen, 2010), although this only removed four active prawn trawl licenses. Total catches in the Bay have remained relatively constant for most species despite the falling effort, resulting in increasing catch rates for the key species. However, around two thirds of fishers in the Bay (including non-trawl as well as trawl fishers) believe their income has been adversely affected by the rezoning of the Marine Park (van de Geer et al., 2013).

Concerns have been raised by the industry about the continuing economic viability of the fishery in the face of potential future prawn price reductions and their reduced access. Moreton Bay M2 holders have expressed concerns in particular that cost associated with the current two-for-one boat replacement policy is preventing them from restructuring their fishing capital to achieve cost savings in light of the decline in prawn prices. As the effort of this fleet is not restricted (unlike the T1/M1 fleet), there is a concern by managers that a subsequent increase in average vessel size would have a detrimental effect on stocks and potentially the future economic performance of the fishery. The aim of this study was therefore to assess the potential impacts of relaxing the existing "two-for-one" boat replacement policy on catch and effort.

## 2. Methods and data

Effort is a complex "input" that consists of numerous observable and less tangible components (Pascoe and Coglan, 2002; Squires, 1987). Effort in a fishery can increase through three potential sources when vessels are replaced. First, larger vessels are usually more productive than smaller vessels due to their larger engines and ability to use more fishing gear per unit of time, so changing vessel size can increase effective fishing effort. Second, vessel efficiency can change through vessel replacement as new technologies and vessel designs can also result in higher catching ability. And thirdly, fishers may physically fish for more time (i.e. more hours or days) in response to the higher profits derived from the more productive and efficient vessel.

The analysis involved three stages to capture these aspects associated with vessel replacement. First, using logbook and boat registry data, the relationship between inputs (vessel characteristics and fishing time) and outputs (catch) was derived through the estimation of stochastic production frontiers. These data also provided information on the distribution and drivers of technical efficiency in the fishery. In a second stage, the information on technical efficiency was linked to economic data on vessels in the fishery (see supporting information for details) to estimate marginal profitability and examine the responsiveness of effort production to economic performance of the fleet. Finally, the potential impact of removal of the boat replacement policy on effort production and catch was assessed through combining the previous analyses.

### 2.1. Relationship between inputs and outputs

Defining the relationship between inputs and outputs generally involves the estimation of some form of production function, where catch is modeled as a function of fixed and variable inputs. Predominantly in fisheries, this is estimated using a stochastic production frontier approach, allowing for individual vessel heterogeneity to be captured through an inefficiency component. Ignoring this heterogeneity may result in biased parameter estimates (Kumbhakar, 2001). A range of potential stochastic production frontier functional forms exist, including the translog (Christensen et al., 1973), Cobb-Douglas and constant elasticity of substitution (CES), where the last two are effectively special cases of the translog. The translog production frontier (Aigner et al., 1977; Meeusen and Van den Broeck, 1977) is given by:

$$\ln y_i = \beta_0 + \sum_k \beta_k \ln x_{k,i} + 0.5 \sum_k \sum_l \beta_{k,l} \ln x_{k,i} \ln x_{l,i} - u_i + \varepsilon_i \quad (1)$$

where $y_i$ is the quantity of output produced (e.g. catch weight or revenue, in this case revenue) by vessel $i$, $x_k$ and $x_l$ are the inputs to the production process (e.g. days fished), $u$ is a one sided error term ($u \geq 0$) representing the level of inefficiency of the vessel, and $\varepsilon$ is a random error term, assumed IID. The technical efficiency (TE) of the i-*th* sample vessel, denoted by $TE_i$ is given by $TE_i = exp(-u_i)$. Alternative functional forms (e.g. the Cobb-Douglas production frontier, given by restricting the $\beta_{k,l}$ terms to zero) can be tested against the translog using the likelihood ratio test and accepted if found to be more appropriate.

Standard fisheries models generally assume a linear relationship between fishing effort and catch for a given level of biomass (Clark, 1990; Hannesson, 1993), where fishing effort is a function of both variable and fixed inputs (Squires, 1987). The most common variable input is some measure of time fished (e.g. Fousekis, 2002; Kirkley et al., 1995; Orea et al., 2005; Pascoe and Coglan, 2002),[2] reflecting the rate of capital utilization. Fishing time is not an input per se in neoclassical production theory, but is an important component of the fisheries production process, and one that is often the

[1] Most of the species caught in the fishery are also caught in other Australian fisheries and/or farmed locally, so the ability of fishers to control prices – even at the fleet level – is minimal, and prices are hence considered exogenous.

[2] Some studies have employed man-hours and/or fuel use as a measure of variable inputs (e.g. Squires, 1987), which are a function of time. Crew numbers and fuel consumption per day is often correlated with the size of the boat or engine, so the use of these as variable inputs may confound the effects of variable and fixed inputs.