



Effects of seasonal closures in a multi-specific fishery



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ABSTRACT

In input-controlled multi-specific fisheries, seasonal closure has little biological rationale as a management measure, because it is difficult to adjust such closure for many target species and, in most cases, they are adopted for economic purposes. We aimed to determine effects of closure in biologic and economic terms, using 10-year landing data from two representative trawling ports of the Western Mediterranean: Dénia and La Vila Joiosa. Analysis of Variance (ANOVA) was used to detect significant differences, before and after the closure, in standardized catch per unit effort (CPUE) at different seasons and sale prices at home/closed and neighbour/open ports. ANOVAs showed significantly higher CPUE after the closure for total landings and *Mullus* spp. of the Red mullet métier, *Merluccius merluccius* CPUE (in two years) and the total landings of the Norway lobster métier. On the contrary, significant lower values were observed after the closure for total CPUE (in early summer) and *Aristeus antennatus* of Red shrimp métier. Similar CPUE was observed at all levels when the closure took place in late summer. In economic terms, market prices of target species have decreased or shown no changes after the closure at home/closed and neighbouring/open ports. The only exception was the significant increase of the price for *A. antennatus* in Dénia during the closure in La Vila Joiosa. Depending on its timing, the closure would highlight some positive biological effects on some target species. However, closure leads to an unavoidable reduction in most of target species prices. An alternative management measure that is based on effort reduction in input-controlled multi-specific fisheries could ban one day per week when market prices of target species are lower.

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1. Introduction

A large number of fish stocks are overexploited in Mediterranean multi-specific fisheries, and reductions of fishing mortality on these stocks are often recommended (FAO, 2011). Fishing mortality is normally reduced through effort reductions, which can mainly be done by decreasing the number of vessels or the fishing days. The adoption of closed fishing seasons is one of the simplest measures used in the management of fisheries. Closure means a complete cessation of fishing activity for a certain period, which results in a reduction of annual effort (Leonart and Franquesa, 1999). This management strategy is mainly based on effort control which reduces fishing intensity and protects target stock from mortality at a specific stage of the life history, i.e. when a species aggregates in an area or in a specific season to spawn (Horwood et al., 1998; Dinmore et al., 2003). This approach also can help repro-

ductive success and support recruitment (Arendse et al., 2007). However, it is well-known that in multi-species fisheries, such as the Mediterranean Sea, there are many target species with different recruitment and reproduction periods. Consequently, a particular period may help the recruitment or the reproduction of certain species and not others (Leonart and Franquesa, 1999). Therefore, in Mediterranean multi-specific fisheries, the adoption of closure, in some cases, is based on economic purposes in agreement with fishermen (Leonart and Franquesa, 1999).

From an economic perspective, a temporary/seasonal closure may have short-term benefits to fishermen: (i) the reduction of operating costs; (ii) financial compensation arising from the recovery of stocks where fishing has ceased; and (iii) compensation subsidies (if the administration funds the closure) (Leonart and Franquesa, 1999). However, ceasing the fleet for long periods (e.g., monthly closure) results in serious logistical and economic problems, namely: (i) fishermen unemployment during the closure period; (ii) "border effect" the result of imbalances between the fleet activity belonging to adjacent ports without closure (Leonart and Franquesa, 1999); (iii) the market for some luxury species becoming devoid of highly appreciated local products (Guillen and

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Maynou, 2014); (iv) imbalances in market price due to the irregular supply of fish to the market (Guerra-Sierra and Sánchez-Lizaso, 1998); and (v) rise in administration cost in the form of state subsidies.

Closure in Mediterranean multi-specific fisheries have a little biological rationale because it is very difficult to adjust the closure to reproductive periods of many target species (Table 1) (Leonart and Franquesa, 1999); also it generates some logistic problems (Guerra-Sierra and Sánchez-Lizaso, 1998; Leonart and Franquesa, 1999; Guillen and Maynou, 2014). The closures are not intended to protect spawning stock at a vulnerable point in their life cycle, thereby enhancing the probability of sustaining recruitment; rather, they are adapted generally for economic purposes and reducing effort intensity. Closures can be justified in multi-specific fisheries if it results in substantial biological or economic benefits, other than effort reduction. These benefits can be seen by increases in landings (e.g., in kg or in first sale price) that compensate some of the previously mentioned problems. Otherwise, effort reduction can be achieved by adopting other less-problematic management measures rather than closure, i.e., reduction of fishing days or hours.

Temporary/seasonal closures are widely studied in many fisheries throughout the world (e.g., Ye, 1998; Pipitone et al., 2000; Arendse et al., 2007; Shih et al., 2009). For instance, in the Gulf of Castellammare (NW Sicily, Mediterranean Sea), Pipitone et al. (2000) addressed that temporary closure based on year-round trawling bans, may prove useful especially for multispecies and multigear artisanal fisheries. Studies in the Western Mediterranean are limited to ecological effect on epibenthic communities (Demestre et al., 2008) and on catch composition in the Catalan Sea (Sánchez et al., 2007). In the Adriatic and the Catalan Seas, Demestre et al. (2008) reported a decrease of epibenthic faunal abundance with the resumption of fishing activity after the closure at both fishing grounds. Further in both Seas, the species composition of both the retained and discarded fractions was analysed by Sánchez et al. (2007), where in both fishing grounds the retained fraction was slightly higher in the high fishing intensity periods than in the low intensity ones. Thereby the effectiveness of specific temporary/seasonal closures as the most applied management measure for multi-specific fisheries should be rigorously evaluated in both biological and economic terms using long-term landings data. In addition, there are many target species with different recruitment and reproduction periods; thus the timing of the closure should be taken into account as suitable timing may or may not benefit particular species.

The aim of this work was to determine the effect of seasonal closure in biological (total landings and landings of target species) and economic (ex-vessel prices “first sale price” of target species) terms, in a commercial Spanish trawling fishery. The data were derived from two representative fishing ports (Dénia and La Vila Joiosa) in the Western Mediterranean.

2. Material and methods

2.1. Study area

This study was conducted in two ports, Dénia and La Vila Joiosa, located in the Southwestern Mediterranean Sea off the coast of Spain (Fig. 1). Along the gulf of Alicante, there are 12 fishing ports that have traditionally been important fishing activity locations. According to the number of trawlers, these two ports represent about 41% of the total trawlers operating on the Alicante coast (BOE, 2013). They can be considered quite representative of this area, given the similarity of the characteristics of the trawlers, and also have features similar to those operating in other areas of the Western Mediterranean (Samy-Kamal et al., 2014). The Mediterranean

trawl fishery in Spain is an input-controlled fishery, where effort is controlled by limiting the time at sea: fishing is permitted for 12 h/day from Monday to Friday, stopping the fishing activity completely on weekends (Maynou et al., 2006). The fishing activity is ceased normally for one month per year as seasonal closures, alternating the North ports (e.g., Dénia) with the south ports (e.g., La Vila Joiosa) to avoid the closure of the whole gulf at once (Table 2). The species *Mullus* spp. (Linnaeus, 1758), *Merluccius merluccius* (Linnaeus, 1758), *Nephrops norvegicus* (Linnaeus, 1758) and *Aristeus antennatus* (Risso, 1816) are the most targeted by fishermen and accounted for almost 60% of the total income and 24% of the total weight in the fishery (Samy-Kamal et al., 2014, 2015a). In regards to stocks, in general, the Mediterranean and Black Sea had 33% of assessed stocks fully exploited, while the great bulk (50%) overexploited (FAO, 2011). Almost all demersal fish and crustaceans stocks assessed were classified as overexploited including the four target species studied herein (FAO, 2011).

2.2. Data collection

Two different data sets were used, one for each port. Data records of daily auctions were obtained from the fishing guild of each port for 10 years (2002–2011). For each fishing day, data on species landing weight (kg) and its first sale value (€) were available by vessel. Sale value (revenue) is the result of quantity landed (kg) and ex-vessel fish price (price obtained by fishers per kg of landed fish). The sale value (€) of each target species was divided by its landings (kg) to calculate the first sale price per kg (ex-vessel fish price). Vessels with sporadic landings events (less than 3 years, and less than 3 months/year) within the ports were excluded from the analysis, considering only those vessels registered in the studied ports (home port) to avoid possible biases in the data. Most of the included vessels have had activity throughout the considered period. The total number of collected samples (vessel/day) was 102,187 fishing days. Technical characteristics of vessels within the analysis were obtained from the Census of Fleet Operations of the General Secretariat of Maritime Fisheries of Spain (BOE, 2013). Over the 10 years studied, a total of 93 different fishing vessels were listed in the official fleet register of Dénia and La Vila Joiosa (34 and 59 vessels, respectively). The bulk of the fleet is composed of vessels up to 23–25 m length, 40–80 GT, 40–60 GRT and 200–400 registered HP (Samy-Kamal et al., 2014).

2.3. Data standardization

For multi-specific fisheries, a preliminary analysis of the fishing tactics in the fishery is essential to clearly determine the real effort directed at the species under study (Maynou et al., 2003). Four principal métiers, Red mullet, European hake, Norway lobster and Red shrimp, were identified based on catch profiles and the main target species, using the multivariate analysis: cluster, *n*MDS and SIMPER (Samy-Kamal et al., 2014, 2015a,b). Catch rates were standardized to separate that large percentage of the variability of data not directly attributable to variations in abundance. To standardize the catch per unit effort (CPUE), generalized linear models (GLM) were used (Maynou et al., 2003; Maunder and Punt, 2004; Murawski et al., 2005). A minimum threshold of effort by vessel of 100 fishing days per year was considered; also, a selection of vessels operating in the fishery for more than 4 years was carried out with the intention of standardizing CPUE data from vessels that would be representative of the fishery. Once the selection of representative vessels was undertaken, a data matrix by métier was constructed with the variables required for analysis. The initial set of explanatory variables considered was: temporal variables (Year and Month) to capture temporal variations; technical variables (vessel's total length “*TL*” and gross tonnage “*GT*”) to

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