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, *M. 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 *A. 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.

Key words: Catch per unit effort (CPUE), Effort reduction, Evaluation of closures, Ex-vessel price, fisheries management, management measures, and trawl fishery.

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 (Lleonart 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 reproductive 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 (Lleonart 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 (Lleonart 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) (Lleonart 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 (Lleonart and Franquesa, 1999); (iii) the market for some luxury species becoming devoid of highly appreciated local products (Guillen and 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) (Lleonart and Franquesa, 1999); also it generates some logistic problems (Guerra-Sierra and Sánchez-Lizaso, 1998; Lleonart 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 *et al.*, 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 hours/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 to 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 102187 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, nMDS and SIMPER (Samy-Kamal *et al.*, 2014; 2015). 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 capture differences between vessel characteristics; and the "individual *Vessel*" was also used as an alternative in case if technical factors were not significant. Regarding the "individual *Vessel*" factor in the analysis of Mediterranean fisheries CPUE, various authors have used vessel factor, grouped into categories according to their technical characteristics (Goñi *et al.*, 1999), while others have used the "individual *Vessel*" factor (Maynou *et al.*, 2003; Sbrana *et al.*, 2003). In the Mediterranean small and medium-scale fisheries, the experience and skills of the fishermen determine and influence the result of fishing operations. This fact justifies that it is more appropriate to include the factor "individual *Vessel*" in the models separately, rather than grouped into categories (Maunder and Punt, 2004). The "individual *Vessel*" factor includes other factors that are not directly related to the technical characteristics of the vessels, but that may influence catch rates (Maynou *et al.*, 2003). The initial model applied contains all factors, considering *Year*, *Month* and *Vessel* as factor, while *TL* and *GT* as variables: CPUE ~ $Year + Month + TL + GT + Vessel$

The GLM was conducted on the total CPUE (kg · vessel^{-1} · day^{-1}) as well as the CPUE of each target species (*Mullus* spp., *M. merluccius*, *N. norvegicus* and *A. antennatus*) in their respective métier. When the data was asymmetric, log transformation was made to correct the extreme data and the constant K was added to the catch rate to account for zero observation, where: K is 10% of the mean CPUE. For each case, i.e. total CPUE and by each target species, the best model were fitted with a stepwise selection procedure by exact Akaike Information Criterion (AIC; Akaike, 1974), and factors that were not significant were eliminated from the model. The AIC determines between adding or excluding each variable, creating a balance between the variability explained by each factor and the degrees of freedom introduced in the model (Akaike, 1974). After the models were fitted, the significance of each factor was analysed using F-values. Finally, we derived calibration coefficients by back-transforming the parameter estimates (Quinn and Deriso, 1999) and transformed CPUE data by dividing the raw CPUE by the appropriate coefficient.

2.4. Analysis of Variance

To analyse the biological and economic effect of closure at the home/closed port, data of five years, where the closure occurred in early and late summer, were selected for the analysis (Table 2), in which two weeks before and two weeks after the closure were used. For the economic effect at the neighbour/open port, two weeks before, two weeks during and two weeks after the closure data were compared. Analysis of Variance (ANOVA) was used to test for significant differences in total standardized CPUE (kg · vessel^{-1} · day^{-1}) and standardized CPUE of target species by métier (biological effect), and first sale price of target species (euro · kg^{-1}) at home and neighbour/open port (economic effect) (Underwood, 1997). The experimental design for the biological analysis consisted of three factors: *Closure* (fixed); *Season* (fixed and orthogonal); and *Year* (random and orthogonal). The same experimental design was used for the economic analysis, replacing the factor *Season* by the factor *Port*. An even numbers of samples were randomly selected to maintain balanced data within each level of the factors considered in the experimental design. However, métiers are known to exhibit seasonality, in many occasions "disappearing" in some years (during the studied two weeks before and after the closure). Therefore, levels number of factor *Year* and minimum samples used to balance the model varied (Table 3). The temporal factor *Year* was considered as orthogonal to separate the inter-annual variations from the effect of the closure. Factor *Season* was used to separate the effect of season from closure, while factor *Port* accounted for the relation between both ports and first sale price of target species. When the ANOVA F-test was significant, post hoc analyses were conducted using Student-Newman-Keuls (SNK) multiple comparisons (Underwood, 1981). Before ANOVA analysis, Cochran's test was used to test for homogeneity of variance (Cochran, 1951). When significant heterogeneity was found, the data were transformed by $\sqrt{(x + 1)}$ or $\ln(x + 1)$. When transformations did not remove heterogeneity, analyses were performed on the untransformed data, with the F-test α-value set at 0.01 (Table 5 and 6), since ANOVA is more restricted to departures from this assumption, especially when the design is balanced and contains a large number of samples/treatments (Underwood, 1997). All analysis (ANOVA and GLM) were conducted by R statistical computing software (R Development Core Team, 2010) and the R's package GAD (Sandrini-Neto and Camargo, 2011).

3 Results

3.1. Data standardization

The GLMs were able to separate the percentage of data variability that do not account for abundance. The variability explained by the model were between 27.51% and 55.20% for total CPUE and target species CPUE of Red mullet, European hake and Norway lobster métiers (Table 4). The factor *Vessel* contributed to separate the highest percentage of deviance in CPUE in most cases (e.g. 38.30% for *M. merluccius* CPUE). In addition, factors *Month* and *Year* also were highly significant in most cases (e.g. 15% for Norway lobster CPUE), which clearly captured the temporal variability in the catchability of the target species. In contrast, the explained variance in Red shrimp métier was about 23 to 33% (Table 4). This suggests that factors other than the used variables cause most of the variability within the CPUE data. In this métier, technical factors as well as *Vessel* account for the most (i.e. 31% for the total CPUE) of the explained variability. The models within the last 5 AIC values of the best model, in each case, are reported in Appendix 1. Also the resulting coeffecients used for standardization are reported in Appendix 2 and 3.

3.2. Biological effect

In general, trends in CPUEs were higher after the closure, except for the Red shrimp métier. For total landings and *Mullus* spp. of Red mullet métier, significant higher CPUEs were observed after the closure in both seasons, early and late summer (Fig. 2a and 2b) (Table 5).

Slightly increasing trends of CPUEs were observed after the closure in total landings and *M. merluccius* of European hake métier, in both seasons (Fig. 2c and 2d). For total landings, significant inter-annual variations were detected, while no effects were observed for the closure (Table 6). *M. merluccius* CPUE showed significant two-way interactions between *Closure* and *Year*, as well as between *Season* and *Year* (Table 6). In SNK comparisons, significant higher CPUE after the closure were detected in 2006 and 2007.

For Norway lobster métier, clear increasing trends were observed after the closure at both total and target species levels (Fig. 2e and 2f), but this difference was only significant for total landings (Table 6).

On the contrary, decreasing trends of CPUEs in Red shrimp métier were observed after the closure mainly in early summer (Fig. 2g and 2h). At species level, *A. antennatus* CPUEs significantly decreased after the closure in both seasons (Table 6). For the total landings the two-way interaction between *Closure* and

Season was significant (Table 6). In SNK comparisons, significant lower CPUEs were obtained after the closure in early summer, while CPUEs in late summer were similar before and after the closure.

3.3. Economic effect

For the first sale price of *Mullus* spp. at the home/closed port, a slight decrease was observed in Dénia in contrast to a slight increase in La Vila Joiosa (Fig. 3a). In ANOVAs, the two-way interaction of *Closure* and *Port* was significant (Table 5). In SNK comparisons, price decreased significantly after the closure in Dénia, while no differences were detected in La Vila Joiosa. At neighbour/open port, a mild decreasing trend was observed by the closure at both ports (Fig. 3b). In ANOVAs, the three-way interaction was significant (Table 5), where the price in La Vila Joiosa was significantly higher before the closure (in Dénia) than during and after the closure in the 3 years studied (Fig. 3b). In Dénia, the same differences were detected but only in 2010.

For *M. merluccius*, home/closed port prices showed a small reduction after the closure in Dénia and similar prices in La Vila Joiosa (Fig. 3c). ANOVAs indicated that the interaction between *Closure* and *Year* was significant (Table 6), showing higher price before, as opposed to after, the closure only in 2006. Inter-annual variation was detected as the interaction between *Port* and *Year* was also significant. At neighbour/open port, slight increase of prices was observed in Dénia during the closure in La Vila Joiosa and vice versa (Fig. 3d), although ANOVA did not show any significant differences (Table 6).

For *N. norvegicus*, at home/closed port, similar mean prices were observed in Dénia before and after the closure, in contrast to a slight decrease in La Vila Joiosa (Fig. 3e). In ANOVAs, the three-way interaction was significant (Table 6). Mean prices were significantly higher in Dénia before the closure only in 2007 and 2010, while in La Vila Joiosa, such differences were not significant (Fig. 3e). At neighbour/open port, higher mean price in Dénia was observed during the closure in La Vila Joiosa (Fig. 3f). The opposite was evident in La Vila Joiosa, as prices decreased during the closure in Dénia. No effect was detected in ANOVA for closure or port, while inter-annual significant differences were present (Table 6).

Finally for *A. antennatus*, at home/closed port, a clear price reduction was observed in Dénia after the closure, while a small increase was observed in La Vila Joiosa (Fig. 3g). In ANOVAs, there were significant two-way interactions between *Closure* and *Year*, as well as between *Closure* and *Port* (Table 6). Three years showed significant lower mean price after the closure. Price also decreased after the closure in Dénia, while no significant differences were detected in La Vila Joiosa (Fig. 3g). At neighbour/open port, a clear higher mean price in Dénia was observed during the closure in La Vila Joiosa (Fig. 3h), while a small decreasing trend was detected in La Vila Joiosa. The three-way interaction was significant (Table 6). Higher mean price in Dénia was observed during, after and before the closure in La Vila Joiosa, in all years (Fig. 3h). However, prices in La Vila Joiosa did not show any effect by the closure in Dénia.

4 Discussion

The resumption of fishing activity, in both study ports, did not always result in higher CPUE after the closure. Generally, increasing trends were observed in Red mullet, European hake and Norway lobster métiers at both total and target species CPUEs. However, the statistical analysis revealed significant differences only for total landings and *Mullus* spp. CPUE of Red mullet métier, *M. merluccius* CPUE (in two years) and the total landings of Norway lobster métier. On the contrary, Red shrimp métier showed a negative effect of significantly lower CPUE at both total landings (in early summer) and *A. antennatus* CPUE. In economic terms, market prices of the main target species have decreased or shown no changes after the closure at home/closed and neighbour/open ports. The only exception was the increased *A. antennatus* price in Dénia during the closure in La Vila Joiosa.

Standardized catch rates assumes that the total length, gross tonnage and individual vessel were able to separate a large percentage of the variability of the data is not directly attributable to variations in abundance. While the year, month and vessel mainly explained the total variance percentages ranging between 23% (in the case of Red shrimp metier) and 55% (in European hake metier). Nevertheless, these percentages are very high despite considering daily CPUE data instead of monthly average. The percentages obtained by the models reflect the suitability of the selected factors. One way to decrease the variability of the data, and therefore increase the variability explained by the model, is to aggregate the data on a temporary basis; for example, monthly (Goñi *et al.*, 1999; Maynou *et al.*, 2003). For our case of study, such aggregation was not useful because we wanted to see differences in CPUE to the lower time scale, so we decided to keep the analysis on daily basis. More research is needed on individual species, fishing technology, and the environment to determine what factors are most influential in determining CPUE. Mahévas et al. (2011) observed that the importance of the skipper/crew experience effect is weaker than the technical effect of the vessel and its gear. Also reported that, other information (e.g. length of headline, weight of otter boards, or type of groundrope) should be taken into account to improve the modelled relationships between CPUE and the variables that measure relative fishing power (Mahévas et al., 2011). Other factors such as the swept area, doors open, travelled distance, gear depth may greatly influence catch rates. However, we did not have these data, so it could not be included.

Fishing closures during spawning season can most likely reduce fishing mortality if the spawning stock is more aggregated during the spawning season than at any other time of the year; however, in a multi-specific fishery, this not the case of all target species. The spawning seasons of the four main target species are summarized in Table 1. Adjusting the closure to benefit all target species in multi-specific fisheries is difficult. Changes were observed in the CPUE of three main target species, as *Mullus* spp. and *M. merluccius* increased after the closure, while *A. antennatus* decreased. A rise in total landings of Red mullet and Norway lobster métiers has been also observed. The European hake *M. merluccius* represents a spawning period extending almost throughout the year that is interpreted as an adaptive strategy to maximize the survival of early life cycle stages (Martin *et al.*, 1999; Domínguez-Petit, 2008). This large-scale spawning period has favoured the observed benefits. The reproduction of Red mullet Mullus spp. (both *Mullus barbatus* and *Mullus surmuletus*) in the western Mediterranean occurs mainly between spring and summer, almost exclusively from May to July (Relini *et al*., 1999; Voliani, 1999; Sieli *et al*., 2011) which also has favoured the observed increase. In contrast, the spawning period of *A. antennatus* occurs between the months of May to October, but is more intense in July and August (Demestre, 1995; García Rodríguez and Esteban, 1999). Although the spawning period concurs with the closure in early summer, decreased catches have been observed.

Moreover, a short closure period (one month) cannot substantially raise biomass due to an increase of the abundance of individuals; while it could be solely due to the increase of fish weight. An explanation of the increased CPUE after one month of closure is linked to rapid-growing species, observed in *Mullus* spp., *M. merluccius* (Piñeiro and Sainza, 2003) and total landings of Norway lobster métier, where species such as *Micromesistius poutassou* and *Phycis blennoides* are abundant (Samy-Kamal *et al.*, 2014). But these closures are too short to affect benthic communities, where these processes, recruitment and growth take place much more slowly (Demestre *et al.*, 2008). From another perspective, Bas (2006) argued that the effect of closure, reflected in an increase of catches following resumption of the activity, is more likely due to species' behavior. The absence of fishing activity changes the species' behavior to move around freely, thus occupying more places, having previously been accustomed to escaping into marginal places during the fishing activity (Bas, 2006). After reopening the fishery, it is likely these species are more susceptible to being caught. This is more evident in limited fisheries, such as continental-shelf métiers, especially for fishes (e.g. *Mullus* spp. and *M. merluccius*) as they are more mobile than benthic communities which could be another explanation of the results obtained here. Similar changes in fish behaviour after closure have been reported elsewhere (Jupiter *et al*., 2012; Januchowski-Hartley *et al*., 2014). For instance, Jupiter et al. (2012) observed that the main observed impact of the closure was the decline of large-bodied species. This has reflected in differences in community composition as well as the prevalence of small herbivores species, as a consequence of a decline in territorial aggression from the removal of large species (Jupiter *et al*., 2012). Also they suggested that the substantial benefits to fisheries from closures, when occurred, can be removed in a very short time period through focused fishing efforts. Similarly, in the Gulf of Alicante, Samy-Kamal et al. (2014) have observed peaks in the fishing effort intensity in both August and October are mainly associated with the reopening of the fishery after the temporal closure.

In the short term, a closure may also involve losses, such as those derived from a reduction in sales or loss of markets (Lleonart and Franquesa, 1999). Prices are a function of supply and demand, and are influenced by fish size, species, consumer preferences, fish quality and the catch quantity-demand function (McClanahan, 2010). Prices of most target species decreased by the closure, which may be related to loss of market due to shortage in the supply after a month of closure. The economic effect of closure at the neighbour/open port was not so evident, except for the increase of *A. antennatus* price in Dénia during the closure in La Vila Joiosa. This is explained as closure might produce more demand on the market at Dénia where *A. antennatus* is the main target species.

According to the results obtained here, the closure has one apparent benefit, which is the overall reduction of fishing effort for that specified period. The seasonal closure reduces the fishing effort (fishing pressure) about 8.33% (one month per year) of the annual effort, which is the only apparent benefit. Despite this, choosing the suitable timing to schedule closure during the spawning season of the main target species is difficult; it would bring up some biological positive effects on some target species (e.g. *Mullus* spp. and *M. merluccius*). Notwithstanding, these increases in catches after the closure are so far to compensate the lost catches by stopping the activity for a whole month. In addition, closures more likely lead to unavoidable reduction in market prices of many target species. An effective management measure should be easily applied, as in the case of seasonal closure, and be able to ensure enough net contribution to the income of fishers. At the same time, an economically consistent closure should be applied without subsidies and be accepted by the fishing community; otherwise, it will convert into a structural compensation and will lose its economic sense (Lleonart and Franquesa, 1999). Despite these reductions in prices, the wide acceptance of seasonal closure as a management measure by the fishing community is mainly because it is subsidized by the administration. An alternative management measure, based on effort reduction in input-controlled Western Mediterranean multi-specific fisheries, could target a day per week (other than weekend) when market prices of target species are lower (Guillen and Maynou, 2014; Samy-Kamal *et al.*, 2015b). This would result in the double annual amount of effort reduction, as well minimize the short-term negative economic effect of seasonal closure on market prices and therefore on fishers' income. Also, it is more acceptable by the fishing community to stop fishing for one day than a whole month, and can be easily applied without additional costs of subsidies.

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7 Tables

Table 1. Spawning (gray cells) periods of the main target species: *Mullus* spp. *Merluccius merluccius*, *Nephrops norvegicus* and *Aristeus antennatus* by month.

Target species	**January**	**February**	**March**	**April**	**May**	**June**	**July**	**August**	**Septembe**	**October**	**November**	**December**	**Reference**
***Mullus* spp.**					■	■	■						(Relini *et al.*, 1999; Voliani, 1999; Sieli *et al.*, 2011)
Merluccius merluccius	■	■	■	■	■	■	■	■	■	■	■	■	(Martin *et al.*, 1999; Domínguez-Petit, 2008)
Nephrops norvegicus								■	■	■	■	■	(Sarda, 1991)
Aristeus antennatus					■	■	■	■	■	■			(Demestre, 1995; García-Rodríguez and Esteban, 1999)

Table 2: Temporal/seasonal closures of trawling fisheries in Dénia and La Vila Joiosa ports during the studied 10 years (2002-2011). Shaded years were used in the analysis of variance (ANOVA).

Year	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**2008**	**2009**	**2010**	**2011**
Dénia	June	June	Sep.	June	Sep.	Sep.	15th Sep. to 15th Oct.	June	Sep.	15th Jan. to 15th Feb + Oct.
La Vila Joiosa	May	May	June	May	June	June	June	Jan.	June	Sep.

Table 3: Number of samples and levels per factor used in analysis of variance (ANOVA). Dash (–) indicates that the factor was not used in the analysis, because of the lack of data to balance the model.

The analysis		Levels per factor			Number of Samples	
	Métier	**Closure**	**Season or Port**	**Year**	**Random samples per level**	**Total samples**
Biologic effect	Red mullet	2	2	–	9	36
	European hake	2	2	3	24	288
	Norway lobster	2	2	3	3	36
	Red shrimp	2	2	5	29	580
Economic effect	Red mullet	2	2	–	10	40
	European hake	2	2	3	24	288
	Norway lobster	2	2	4	3	48
	Red shrimp	2	2	5	29	580
Border effect	Red mullet	3	2	3	4	72
	European hake	3	2	2	25	300
	Norway lobster	3	2	2	3	36
	Red shrimp	3	2	5	38	1140

Table 4: Analysis of deviance table for generalized linear models (GLMs) fitted to total CPUE and target species CPUE for the four métiers (from 2002 to 2011) in Dénia and La Vila Joiosa. Df.: degrees of freedom; Res. Df.: residual of degree of freedom; Resid. Dev.: residual deviance; Dev. ex (%): deviance explained; F: F value. Factors are arranged according to the percentage of explained deviance.

Métier	Model	Df.	Deviance	Res. Df.	Resid. Dev	Dev. ex (%)	F
Red mullet Dénia	Total CPUE					27.51%	
	NULL			15422	3868.448		
	Vessel	61	599.9565	15339	2804.116	15.51%	53.80108***
	Month	11	162.6728	15402	3551.041	4.21%	80.89528***
	Year	9	154.7339	15413	3713.714	4.00%	94.04682***
	TL	1	132.1933	15401	3418.848	3.42%	723.1202***
	GT	1	14.77506	15400	3404.073	0.38%	80.82214***
	Mullus spp. CPUE					30.99%	
	NULL			15422	14912.12		
	Month	11	2104.157	15402	12270.94	14.11%	285.1197***
	Vessel	61	1263.461	15339	10290.94	8.47%	30.87265***
	Year	9	537.0255	15413	14375.1	3.60%	88.93942***
	GT	1	437.5996	15400	11554.4	2.93%	652.2571***
	TL	1	278.9381	15401	11992	1.87%	415.7668***
European hake	Total CPUE					34.63%	
	NULL			42528	9099.015		
	Vessel	75	1188.273	42431	5948.143	13.06%	113.0204***
	Year	9	1038.993	42519	8060.022	11.42%	823.5158***
	TL	1	755.4386	42507	7168.982	8.30%	5388.911***
	Month	11	135.6011	42508	7924.42	1.49%	87.93717***
	GT	1	32.56546	42506	7136.416	0.36%	232.3052***
	M. merluccius CPUE					55.20%	
	NULL			42528	30597.13		
	Vessel	75	11718.92	42431	13707.77	38.30%	483.6629***
	TL	1	3104.386	42507	25690.29	10.15%	9609.309***
	Year	9	987.8003	42519	29609.33	3.23%	339.7372***
	Month	11	814.6563	42508	28794.67	2.66%	229.2441***
	GT	1	263.5967	42506	25426.69	0.86%	815.9365***
Norway lobster	Total CPUE					45.10%	
	NULL			5151	4481.877		
	Vessel	56	1190.241	5075	2460.75	26.56%	43.83444***
	Year	9	701.9692	5142	3779.908	15.66%	160.8585***
	Month	11	128.9173	5131	3650.991	2.88%	24.17058***
	N. norvegicus CPUE					31.35%	
	NULL	NA	NA	5151	4027.901		
	Vessel	56	716.9815	5074	2765.098	17.80%	23.49416***
	Year	9	262.459	5142	3765.442	6.52%	53.51295***
	Month	11	208.4196	5131	3557.023	5.17%	34.76848***
	TL	1	74.94319	5130	3482.079	1.86%	137.522***
Red shrimp	Total CPUE					33.70%	
	NULL			26798	14815.38		
	Vessel	56	3021.415	26720	9822.623	20.39%	146.768***
	TL	1	1241.442	26777	13327.09	8.38%	3377.034***
	GT	1	483.0545	26776	12844.04	3.26%	1314.029***
	Year	9	162.7068	26789	14652.68	1.10%	49.17816***
	Month	11	84.14181	26778	14568.53	0.57%	20.8079***
	A. antennatus CPUE					23.07%	
	NULL			26798	13600.61		
	Vessel	56	1770.153	26721	10462.11	13.02%	80.73395***
	GT	1	741.8277	26777	12232.27	5.45%	1894.682***
	Year	9	383.5055	26789	13217.1	2.82%	108.8335***
	Month	11	243.0086	26778	12974.09	1.79%	56.42379***

Table 5. Results of analysis of variance (ANOVA) with 2 factors (C: closure; S: season) for biologic effect (the total CPUE of Red mullet métier and *Mullus* spp. CPUE). With 2 factors (C: closure; P: port) for economic effect (price at home/closed port) and with 3 factors (C: closure; P: port; Yr: year) for price at neighbour/open port. Df: degrees of freedom; MS: mean square; F: F value. Levels of significance were *p <0.05, **p <0.01 and ***p <0.001. Dash (–) indicates that there is no transformation. (a) indicates that there is no homogeneity of variance, the levels of significance being *p <0.01; **p <0.001.

Biologic effect	**Red mullet métier**							
	Total landings				***Mullus* spp.**			
	Sources of variation	**Df**	**MS**	**F**	**Df**	**MS**	**F**	**F versus**
	C	1	4236489	8.122056**	1	3.993067	4.791531*	Residual
	S	1	278654.2	0.534227	1	0.043237	0.051883	Residual
	C×S	1	272485.2	0.522399	1	0.625955	0.751122	Residual
	Residual	32	521603.1		32	0.833359		
	Transform.		–			Ln(x + 1)		

Economic effect	***Mullus* spp. price**									
	Home/closed port					**Neighbour/open port**				
	Sources of variation	**Df**	**MS**	**F**	**F versus**	**Sources of variation**	**Df**	**MS**	**F**	**F versus**
	C	1	3.10	1.19	Residual	C	2	67.67	11.67	C×Yr
	P	1	192.93	74.40**	Residual	P	1	45.00	3.12	P×Yr
	C×P	1	59.56	22.97**	Residual	Yr	2	58.86	12.98**	Residual
	Residual	36	2.59			C×P	2	48.06	2.84	C×P×Yr
	Transform.		–a			C×Yr	4	5.80	1.28	Residual
						P×Yr	2	14.44	3.18	Residual
						C×P×Yr	4	16.91	3.73*	Residual
						Residual	54	4.53		
						Transform.			–a	

Table 6. Analysis of variance (ANOVA) results with 3 factors (C: closure; S: season; Yr: year) for biologic effect (total CPUE by métier and target species CPUE), and with 3 factors (C: closure; P: port; Yr: year) for economic effect (the first sale price at home/closed and neighbour/open ports) of the target species *Merluccius merluccius*, *Nephrops norvegicus* and *Aristeus antennatus*. Df: degrees of freedom; MS: mean square; F: F value. Levels of significance were *p <0.05, **p <0.01 and ***p <0.001. Dash (–) indicates that there is no transformation. (a) indicates that there is no homogeneity of variance, the levels of significance being *p <0.01; **p <0.001.

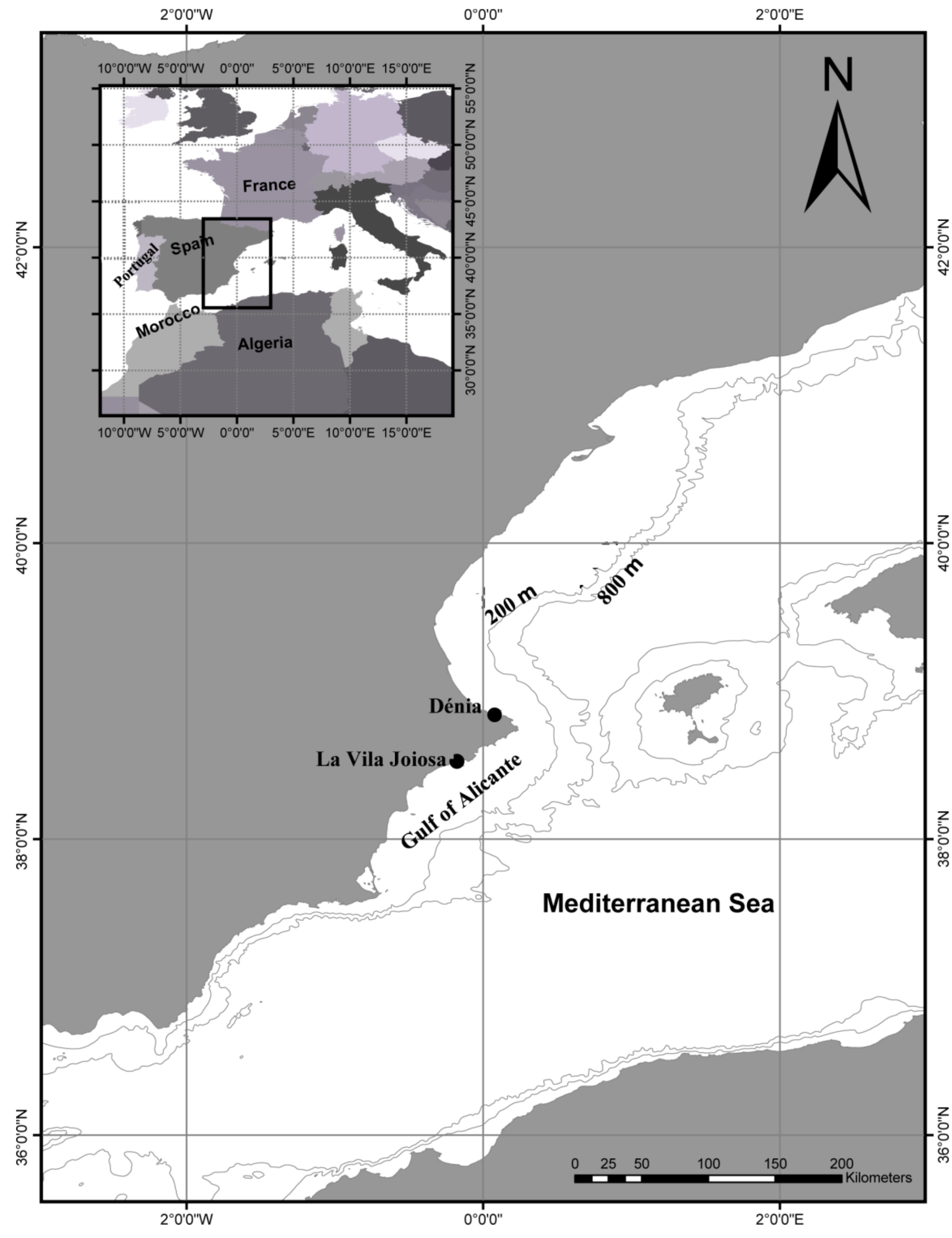
Biologic effect

Sources of variation	European hake métier						Norway lobster métier						Red shrimp métier						F versus
	Total landings			*Merluccius merluccius*			Total landings			*Nephrops norvegicus*			Total landings			*Aristeus antennatus*			
	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	
C	1	327799512.4	4.925897	1	50.08891	0.751939	1	92.68107	20.35351*	1	58.1988	4.856206	1	13715694	4.852378	1	657.3687	28.24121*	C×Yr
S	1	659835431.1	5.369455	1	37.84119	0.341613	1	66.03758	4.353176	1	46.17448	6.303008	1	14269001	4.643219	1	3006.823	3.209321	S×Yr
Yr	2	760896305.1	17.91913**	2	35.06301	3.524418	2	52.91542	2.726493	2	21.64308	2.114817	4	2084831	2.126182	4	532.1095	5.057912**	Residual
C×S	1	15482530.58	0.360144	1	4.785256	0.24667	1	0.194997	0.073356	1	39.74125	6.18646	1	14708996	48.42887*	1	717.1961	2.13177	C×S×Yr
C×Yr	2	66546154.89	1.567164	2	66.61301	6.695721*	2	4.553567	0.234625	2	11.98442	1.171037	4	2826592	2.882655	4	23.27693	0.221256	Residual
S×Yr	2	122886843.9	2.89399	2	110.772	11.13444**	2	15.16998	0.78164	2	7.325785	0.715827	4	3073084	3.134036	4	936.9032	8.905637**	Residual
C×S×Yr	2	42989851.74	1.012413	2	19.39944	1.949968	2	2.658219	0.136966	2	6.423908	0.627702	4	303723.7	0.309748	4	336.4322	3.197922	Residual
Residual	276	42462781.24		276	9.948594		24	19.40787		24	10.23402		560	980551.5		560	105.2034		
Transform.		–a			–a			√(x + 1)			–			–a			–a		

Economic effect

Sources of variation	*Merluccius merluccius* price						*Nephrops norvegicus* price						*Aristeus antennatus* price						F versus
	Home/closed port			Neighbour/open port			Home/closed port			Neighbour/open port			Home/closed port			Neighbour/open port			
	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	Df	MS	F	
C	1	96.45	3.20	2	84.87	89.51	1	4.82	0.01	2	4.05	0.04	1	6335.52	4.67	2	7326.20	8.48	C×Yr
P	1	6.22	0.22	1	213.03	41.42	1	103.02	1.79	1	831.44	9.52	1	69405.43	34.59*	1	107541.92	21.71*	P×Yr
Yr	2	89.51	23.54**	1	207.34	30.15	3	824.02	14.55***	1	1539.35	15.77***	4	982.10	5.13**	4	2796.53	10.15**	Residual
C×P	1	41.42	16.00	2	10.03	27.79	1	48.87	0.16	2	53.64	0.17	1	15113.25	23.56*	2	11666.11	10.66*	C×P×Yr
C×Yr	2	30.15	7.93**	2	19.72	89.51	3	349.46	6.17**	2	92.19	0.94	4	1356.09	7.08**	8	863.44	3.13*	Residual
P×Yr	2	27.79	7.31**	1	313.37	41.42	3	57.56	1.02	1	87.32	0.89	4	2006.75	10.48**	4	4952.58	17.98**	Residual
C×P×Yr	2	2.59	0.68	2	19.78	30.15	3	306.03	5.40**	2	308.15	3.16	4	641.51	3.35	8	1094.36	3.97**	Residual
Residual	276	3.80		288	4.83	27.79	32	56.64		24	97.63		560	191.47		1110	275.45		
Transform.		–a			–a			–			–			–a			–a		

8 Figure legends



609 Figure 1: Map of the study area (SW Mediterranean) showing the location of the two trawling ports La Vila Joiosa and Dénia (Spain).

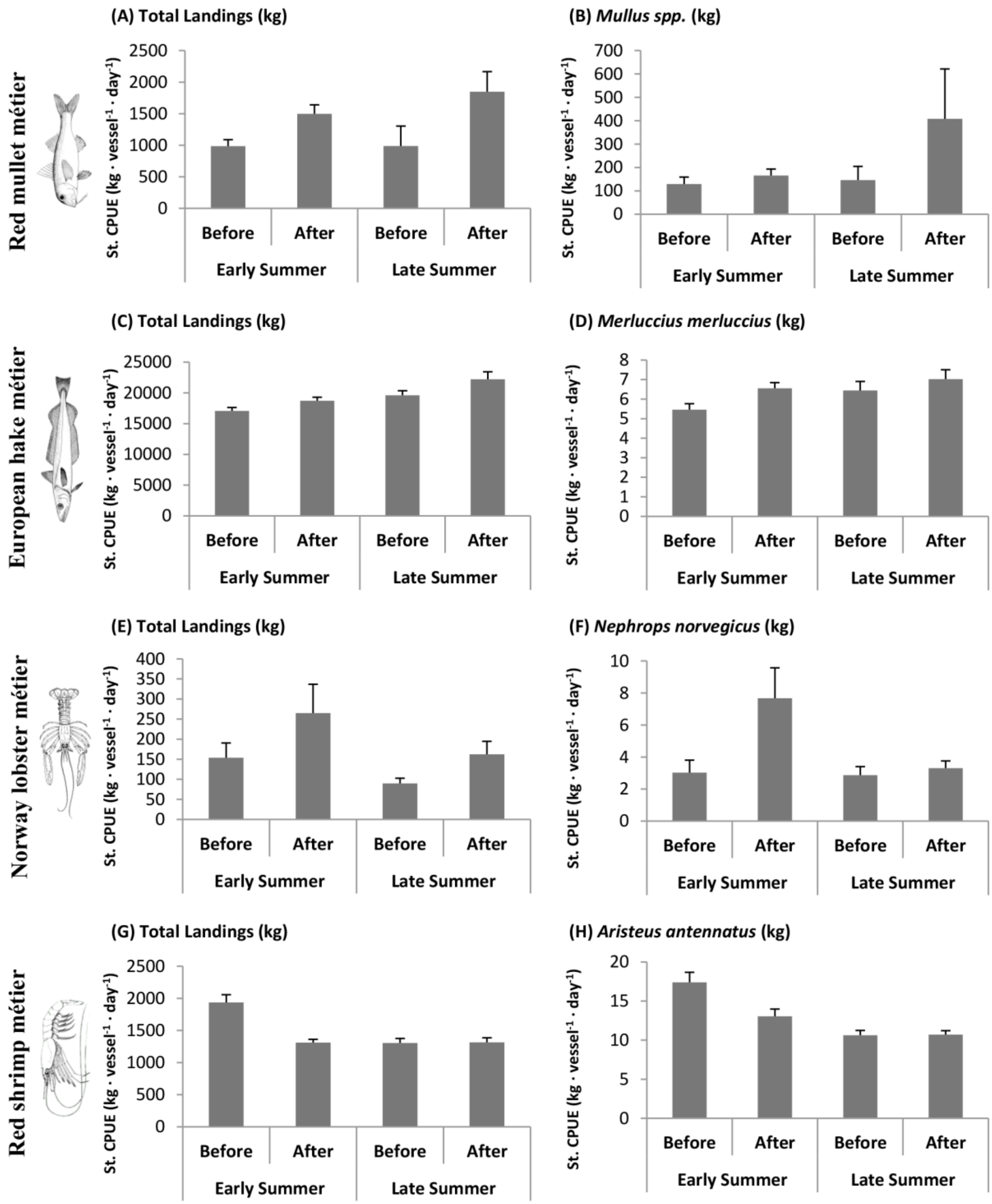


Figure 2: Mean CPUE (kg · vessel $^{-1}$· day^{-1}) and standard error of the total landings (left) of the four métiers: (a) Red mullet, (c) European hake, (e) Norway lobster), and (g) Red shrimp, and target species (right): (b) *Mullus* spp., (d) *Merluccius merluccius*, (f) *Nephrops norvegicus* and (h) *Aristeus antennatus*, during two seasons before and after the closure.

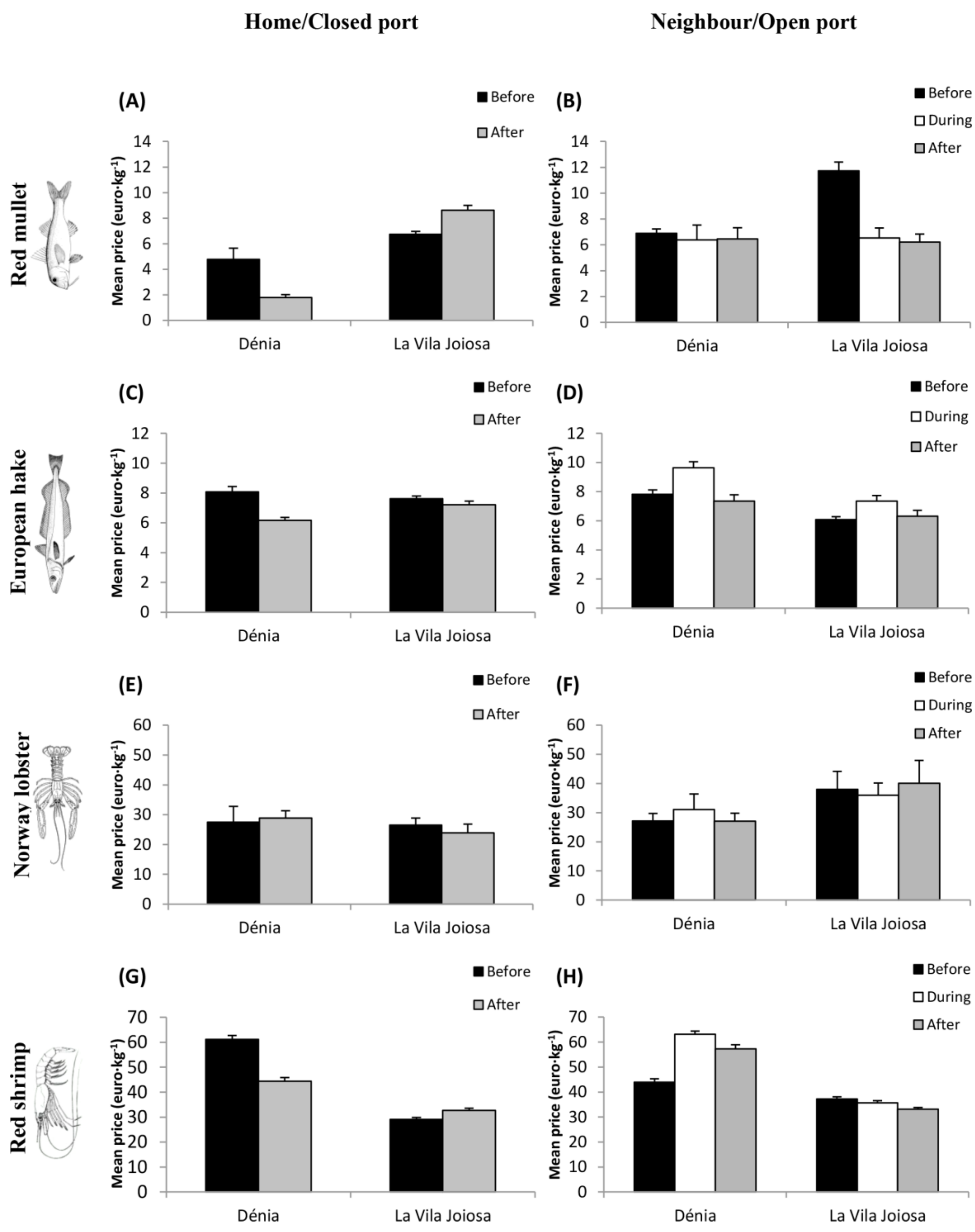


Figure 3: Mean first sale price (euro · kg^{-1}) and standard error of the main target species: (a,b) *Mullus* spp., (c,d) *Merluccius merluccius*, (e,f) *Nephrops norvegicus* and (g,h) *Aristeus antennatus* of the four métiers: Red mullet, European hake, Norway lobster, and Red shrimp in the two ports before and after the closure (left) and their mean prices at neighbour/open port before, during and after the closure (right).

9 Appendixes

Appendix 1: Model selection procedure for the total CPUE and target species CPUE by métier shows the last 5 values based on AIC: Akaike Information Criterion.

Métier		Model	AIC
Red mullet	**Total CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	17646
		Year + Month + TL + Vessel	17648
		Year + Month + GT + Vessel	17649
		Year + TL + GT + Vessel	18328
		Year + Month + TL + GT	20514
		Final model: Year + Month + TL + GT + Vessel	17646
	***Mullus* spp. CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	37698
		Year + Month + GT + Vessel	37699
		Year + Month + TL + Vessel	37713
		Year + Month + TL + GT	39363
		Year + TL + GT + Vessel	39391
		Final model: Year + Month + TL + GT + Vessel	37698
European hake	**Total CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	37231
		Year + Month + TL + Vessel	37249
		Year + Month + GT + Vessel	37365
		Year + TL + GT + Vessel	37864
		Year + Month + TL + GT	44827
		Final model: Year + Month + TL + GT + Vessel	37231
	***M. merluccius* CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	72738
		Year + Month + TL + Vessel	72743
		Year + Month + GT + Vessel	72748
		Year + TL + GT + Vessel	75111
		Year + Month + TL + GT	98864
		Final model: Year + Month + TL + GT + Vessel	72738
Norway lobster	**Total CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	10972
		Year + Month + GT + Vessel	10970
		Year + Month + TL + Vessel	10971
		Year + Vessel	11309
		Year + Month	12890
		Final model: Year + Month + Vessel	10970
	***N. norvegicus* CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	11573
		Year + Month + GT + Vessel	11579
		Year + Month + Vessel	11578
		Year + TL + Vessel	11914
		Year + Month + TL	12648
		Final model: Year + Month + TL + Vessel	11573
Red shrimp	**Total CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	49315
		Year + Month + GT + Vessel	49328
		Year + Month + TL + Vessel	49348
		Year + TL + GT + Vessel	49625
		Year + Month + TL + GT	56390
		Final model: Year + Month + TL + GT + Vessel	49315
	***A. antennatus* CPUE**	**Initial model**: Year + Month + TL + GT + Vessel	51003
		Year + Month + TL + GT	55007
		Year + Month + Vessel	51014
		Year + GT + Vessel	51705
		Year + Month + GT	55080
		Final model: Year + Month + GT + Vessel	51003

Appendix 2: Estimates and standard error from a generalized linear model fitted to total CPUE of Red mullet, European hake, Norway lobster and Red shrimp métiers of the Dénia and La Vila Joiosa fleet from 2002 to 2011, incorporating the main effects of year, month, individual vessel (V), total length (TL), and gross tonnage (GT). Estimates express the difference between each level of the factors and the first level.

	Red mullet			European hake			Norway lobster			Red shrimp	
	Estimate	St. Error		Estimate	St. Error		Estimate	St. Error		Estimate	St. Error
January-2002-V1*	7.07186	0.597771	**January-2002-V1***	9.656441	0.435352	**January-2002-V1***	4.583586	0.080132	**January-2002-V1***	7.073531	0.395798
2003	0.11041	0.019005	**2003**	-0.10942	0.007868	**2003**	-0.1361	0.044144	**2003**	-0.18371	0.017303
2004	0.188618	0.017919	**2004**	0.004487	0.008064	**2004**	-0.30599	0.054124	**2004**	-0.12458	0.017152
2005	0.165329	0.018309	**2005**	0.047184	0.007911	**2005**	0.002079	0.046501	**2005**	-0.218	0.017578
2006	0.22317	0.017956	**2006**	0.258221	0.008148	**2006**	-0.09267	0.050718	**2006**	-0.11897	0.017294
2007	0.184024	0.017525	**2007**	0.243681	0.008434	**2007**	0.328391	0.060507	**2007**	-0.03435	0.017792
2008	0.110805	0.017831	**2008**	0.031407	0.008594	**2008**	0.572799	0.048904	**2008**	-0.13975	0.018235
2009	0.103101	0.0185	**2009**	0.184607	0.00881	**2009**	0.234122	0.052624	**2009**	-0.16039	0.017928
2010	0.022416	0.019279	**2010**	0.136223	0.008519	**2010**	0.281723	0.05344	**2010**	-0.14668	0.018287
2011	0.374201	0.019678	**2011**	0.410925	0.009123	**2011**	0.506367	0.054207	**2011**	-0.0799	0.019372
February	-0.08205	0.020278	**February**	-0.09036	0.008124	**February**	0.113957	0.046093	**February**	-0.03558	0.018455
March	-0.06781	0.021225	**March**	-0.08448	0.008164	**March**	0.084945	0.053479	**March**	0.021608	0.017793
April	0.037185	0.016849	**April**	-0.05975	0.00869	**April**	0.254477	0.04654	**April**	-0.05787	0.017893
May	-0.0829	0.017445	**May**	-0.06218	0.009141	**May**	0.1708	0.046284	**May**	0.055368	0.018204
June	-0.0611	0.020834	**June**	0.014633	0.010209	**June**	0.349405	0.049657	**June**	0.034456	0.021124
July	0.021947	0.018546	**July**	0.006692	0.008838	**July**	0.327895	0.044193	**July**	0.099216	0.018895
August	0.032735	0.017907	**August**	-0.00352	0.008079	**August**	0.027462	0.044215	**August**	0.035249	0.017518
September	0.131632	0.019016	**September**	0.042824	0.008593	**September**	-0.04956	0.055186	**September**	0.054111	0.019004
October	0.237714	0.015883	**October**	0.05409	0.009302	**October**	-0.04608	0.056719	**October**	-0.06315	0.01814
November	0.152178	0.015527	**November**	0.022037	0.009021	**November**	-0.24841	0.051445	**November**	-0.12019	0.017893
December	0.055481	0.016306	**December**	-0.00184	0.008779	**December**	-0.30529	0.050957	**December**	-0.12059	0.018102
TL	-0.04911	0.021058	**TL**	-0.16576	0.014223	**V2**	-0.72323	0.115607	**TL**	-0.05197	0.013348
GT	-0.01083	0.005465	**GT**	-0.00766	0.001697	**V3**	0.479193	0.407798	**GT**	-0.0202	0.003404
V2	-1.57139	0.23523	**V2**	-1.96404	0.155031	**V4**	0.804949	0.080595	**V2**	-1.54997	0.149858
V3	-0.2918	0.12924	**V3**	-0.37175	0.054455	**V5**	-0.05182	0.092091	**V3**	0.043625	0.354714
V4	0.518885	0.166694	**V4**	0.530009	0.034652	**V6**	0.086776	0.099816	**V4**	0.86607	0.059888
V5	-0.07767	0.116677	**V5**	-0.10206	0.042458	**V7**	0.28841	0.078119	**V5**	0.440276	0.608196
V6	-0.87758	0.190455	**V6**	-1.06699	0.116481	**V8**	-0.30065	0.091154	**V6**	-1.95054	0.213197
V7	-0.38938	0.148548	**V7**	0.547366	0.066859	**V9**	-0.04491	0.086092	**V7**	0.761746	0.109067
V8	-1.13945	0.273733	**V8**	-0.48568	0.038752	**V10**	0.25803	0.09587	**V8**	0.004159	0.046264
V9	-0.21623	0.194094	**V9**	-0.61766	0.075482	**V11**	-0.79281	0.157082	**V9**	-0.27647	0.070419
V10	-0.22052	0.192962	**V10**	-1.77034	0.16529	**V12**	0.482046	0.118198	**V10**	-0.95527	0.189903
V11	-0.53138	0.184921	**V11**	-0.81107	0.114278	**V13**	0.13246	0.102262	**V11**	1.256998	0.160018
V12	-0.45926	0.198441	**V12**	-0.68281	0.056551	**V14**	0.733662	0.082465	**V12**	-1.04204	0.103741
V13	-1.09132	0.215168	**V13**	-1.18217	0.121598	**V15**	-0.26919	0.084838	**V13**	2.112681	0.223202
V14	-0.72699	0.226572	**V14**	-1.27904	0.125781	**V16**	-0.26477	0.320924	**V14**	1.690243	0.121654
V15	-0.66681	0.230722	**V15**	-1.39181	0.143216	**V17**	0.852984	0.116207	**V15**	1.039277	0.115888
V16	-1.33402	0.26924	**V16**	-1.33913	0.131732	**V18**	0.147011	0.122959	**V16**	-0.987	0.116383
V17	0.819366	0.388719	**V17**	0.483063	0.109964	**V19**	0.902686	0.09372	**V17**	1.488695	0.133392
V18	0.251695	0.061339	**V18**	-0.48721	0.038473	**V20**	0.707068	0.088267	**V18**	0.851236	0.134201
V19	-1.09913	0.18277	**V19**	-1.69404	0.16926	**V21**	-0.48127	0.136609	**V19**	1.514216	0.161491
V20	-0.48375	0.177021	**V20**	0.985939	0.131471	**V22**	-0.20726	0.127817	**V20**	0.840393	0.052312
V21	0.018231	0.101613	**V21**	0.046496	0.022059	**V23**	-0.3557	0.097417	**V21**	-1.00018	0.085422
V22	0.679287	0.250559	**V22**	0.095082	0.062088	**V24**	0.605877	0.087908	**V22**	-0.06152	0.057306
V23	-0.80884	0.251565	**V23**	-1.63471	0.114901	**V25**	-0.35975	0.497525	**V23**	1.44478	0.611917
V24	-0.66952	0.183124	**V24**	-1.01445	0.113656	**V26**	0.171008	0.132799	**V24**	-0.63871	0.067384
V25	-0.27065	0.16956	**V25**	0.55535	0.090322	**V27**	0.948124	0.087982	**V25**	1.634847	0.178516
V26	-0.28325	0.153137	**V26**	-0.42827	0.042428	**V28**	0.318308	0.110422	**V26**	-1.05876	0.617841
V27	-0.28739	0.130495	**V27**	-0.09379	0.109409	**V29**	0.4662	0.087875	**V27**	0.372172	0.112329
V28	-0.38778	0.101666	**V28**	0.522516	0.086609	**V30**	-0.58218	0.193222	**V28**	1.643243	0.094761
V29	-0.50807	0.182614	**V29**	0.104598	0.065417	**V31**	0.091512	0.111168	**V29**	0.678454	0.086002
V30	0.388566	0.261588	**V30**	-1.87058	0.278836	**V32**	0.421484	0.293377	**V30**	0.157588	0.062676
V31	-0.04113	0.451055	**V31**	-0.93315	0.107094	**V33**	0.288668	0.11436	**V31**	0.164221	0.077028
V32	0.545119	0.136497	**V32**	-0.896	0.105722	**V34**	1.201244	0.086799	**V32**	1.256126	0.151485
V33	-0.17951	0.099361	**V33**	-0.54211	0.12665	**V35**	0.608679	0.148629	**V33**	0.005837	0.086438
V34	-0.20054	0.437297	**V34**	-0.43874	0.066759	**V36**	1.230548	0.082943	**V34**	1.178933	0.115601
V35	-0.2516	0.14805	**V35**	-0.35355	0.06445	**V37**	-0.06148	0.089036	**V35**	-0.13878	0.220789
V36	-0.09997	0.132498	**V36**	-0.89542	0.070359	**V38**	1.165579	0.410114	**V36**	1.77149	0.195481
V37	0.913105	0.250251	**V37**	0.650594	0.107705	**V39**	-0.31573	0.126535	**V37**	-0.85069	0.106028
V38	0.333546	0.150252	**V38**	-1.27258	0.128222	**V40**	-0.67725	0.318918	**V38**	-0.00864	0.43845
V39	0.307053	0.167149	**V39**	0.01609	0.039679	**V41**	0.930911	0.083781	**V39**	-0.29583	0.060816
V40	0.743139	0.360673	**V40**	0.311523	0.083646	**V42**	1.069781	0.084967	**V40**	-0.43337	0.076004
V41	-0.51584	0.16156	**V41**	0.620081	0.062955	**V43**	0.867595	0.100415	**V41**	0.726326	0.064763
V42	-0.27608	0.152334	**V42**	-0.39947	0.043626	**V44**	0.199618	0.084847	**V42**	1.125085	0.113342
V43	-1.10788	0.437453	**V43**	-0.43533	0.053201	**V45**	0.756225	0.076999	**V43**	1.310942	0.084165
V44	0.557192	0.139366	**V44**	-0.48607	0.103306	**V46**	0.792661	0.102558	**V44**	0.284848	0.054666
V45	0.763557	0.20421	**V45**	-0.41909	0.072557	**V47**	0.853505	0.107746	**V45**	1.201127	0.07482

V46	0.642105	0.172954	**V46**	0.945093	0.084183	**V48**	-0.84843	0.276182	**V46**	0.129186	0.133194
V47	-0.87218	0.268715	**V47**	-0.09271	0.033032	**V49**	-0.10503	0.109945	**V47**	1.827697	0.177322
V48	0.322836	0.116638	**V48**	0.511912	0.063145	**V50**	1.025268	0.089637	**V48**	-1.1529	0.165022
V49	-0.27462	0.152432	**V49**	0.374769	0.026801	**V51**	0.463401	0.08647	**V49**	-0.31327	0.078544
V50	-0.51516	0.168127	**V50**	1.312256	0.110126	**V52**	-0.3356	0.118343	**V50**	1.138536	0.061336
V51	-0.99492	0.196588	**V51**	-1.03398	0.100716	**V53**	0.20425	0.13186	**V51**	0.123192	0.041013
V52	-1.30585	0.315923	**V52**	-0.5112	0.082254	**V54**	-0.48609	0.173442	**V52**	-0.75423	0.059851
V53	-0.56049	0.264419	**V53**	-1.69549	0.135213	**V55**	0.147086	0.169926	**V53**	0.167799	0.040687
V54	-0.46262	0.152176	**V54**	-1.45223	0.375048	**V56**	0.643779	0.088854	**V54**	-0.77274	0.095025
V55	0.490569	0.137507	**V55**	0.514788	0.040571	**V57**	-0.36827	0.092285	**V55**	2.071713	0.086552
V56	-0.37812	0.431874	**V56**	0.688723	0.056675				**V56**	2.176502	0.237638
V57	-1.94661	0.308606	**V57**	0.771957	0.069469				**V57**	-0.25205	0.036005
V58	-1.02301	0.228507	**V58**	-1.59961	0.157384						
V59	0.278189	0.063655	**V59**	0.150669	0.027856						
V60	0.22543	0.118964	**V60**	0.165525	0.036936						
V61	-0.28146	0.1554	**V61**	-1.00704	0.091645						
V62	0.045715	0.126613	**V62**	0.750018	0.124638						
			V63	-1.39794	0.108433						
			V64	-1.72434	0.126711						
			V65	-2.20744	0.194583						
			V66	-1.48205	0.173938						
			V67	-0.75184	0.060701						
			V68	0.802976	0.040714						
			V69	0.098312	0.035173						
			V70	-1.80874	0.116122						
			V71	0.250967	0.084482						
			V72	0.258796	0.02098						
			V73	0.270801	0.020993						
			V74	0.786141	0.147262						
			V75	-0.40915	0.078858						
			V76	-0.28025	0.058564						

Appendix 3: Estimates and standard error from a generalized linear model fitted to CPUE of target species *Mullus* spp., *M. merluccius*, *N. norvegicus* and *A. antennatus* of the Dénia and La Vila Joiosa fleet from 2002 to 2011, incorporating the main effects of year, month, individual vessel (V), total length (TL), and gross tonnage (GT). Estimates express the difference between each level of the factors and the first level.

	***Mullus* spp.**			***M. merluccius***			***N. norvegicus***			***A. antennatus***	
	Estimate	**St. Error**		**Estimate**	**St. Error**		**Estimate**	**St. Error**		**Estimate**	**St. Error**
January-2002-V1*	4.515099	1.145155	**January-2002-V1***	1.834713	0.660896	**January-2002-V1***	0.625674	0.883577	**January-2002-V1***	2.297945	0.241546
2003	-0.13074	0.036407	**2003**	-0.30887	0.011945	**2003**	-0.13843	0.047006	**2003**	-0.12936	0.017709
2004	-0.27581	0.034327	**2004**	-0.24841	0.012242	**2004**	-0.45058	0.057454	**2004**	-0.101	0.017555
2005	0.006344	0.035075	**2005**	-0.18408	0.01201	**2005**	-0.30832	0.049493	**2005**	-0.29461	0.018006
2006	0.144605	0.034398	**2006**	-0.02204	0.01237	**2006**	-0.14682	0.053829	**2006**	-0.12942	0.017729
2007	0.20252	0.033573	**2007**	-0.02368	0.012803	**2007**	0.111465	0.064328	**2007**	-0.21702	0.018244
2008	0.009779	0.034159	**2008**	-0.23982	0.013047	**2008**	0.131691	0.052062	**2008**	-0.30223	0.018727
2009	-0.0186	0.03544	**2009**	0.200179	0.013374	**2009**	-0.02823	0.055955	**2009**	-0.3481	0.018399
2010	-0.16323	0.036932	**2010**	-0.10169	0.012932	**2010**	0.330465	0.05677	**2010**	-0.05952	0.018778
2011	-0.03888	0.037698	**2011**	0.014736	0.013849	**2011**	0.165268	0.057595	**2011**	-0.02636	0.019907
February	-0.29376	0.038847	**February**	-0.10937	0.012333	**February**	0.156413	0.048873	**February**	0.144047	0.019046
March	0.024265	0.040661	**March**	-0.20013	0.012393	**March**	0.114625	0.056732	**March**	0.195499	0.018363
April	0.286599	0.032278	**April**	-0.22438	0.013192	**April**	0.422227	0.049343	**April**	0.264682	0.018465
May	0.100915	0.03342	**May**	-0.06233	0.013877	**May**	0.477009	0.049081	**May**	0.306592	0.018787
June	-0.07007	0.039911	**June**	-0.01521	0.015498	**June**	0.69962	0.052658	**June**	0.121975	0.021792
July	0.068638	0.035529	**July**	0.163511	0.013417	**July**	0.647806	0.046911	**July**	0.032719	0.0195
August	-0.234	0.034304	**August**	0.199645	0.012264	**August**	0.282978	0.046886	**August**	-0.00048	0.018079
September	0.137473	0.036429	**September**	0.153593	0.013044	**September**	0.283261	0.058518	**September**	0.138805	0.019611
October	0.671113	0.030428	**October**	0.056566	0.014121	**October**	0.209951	0.060131	**October**	0.131308	0.01872
November	0.60953	0.029746	**November**	-0.02053	0.013694	**November**	0.313266	0.054561	**November**	0.025485	0.018464
December	0.253553	0.031237	**December**	-0.08417	0.013328	**December**	0.220973	0.054036	**December**	-0.00292	0.018681
TL	0.06528	0.040341	**TL**	0.076831	0.021592	**TL**	0.098632	0.037709	**GT**	0.012624	0.003511
GT	-0.04234	0.01047	**GT**	0.006937	0.002576	**V2**	0.3378	0.315463	**V2**	0.011267	0.110252
V2	-1.34254	0.450632	**V2**	-0.40668	0.235348	**V3**	-0.63894	0.442882	**V3**	-0.56313	0.364222
V3	-0.69709	0.247586	**V3**	0.685464	0.082667	**V4**	0.410432	0.085442	**V4**	0.243027	0.061773
V4	0.988761	0.319338	**V4**	0.252051	0.052605	**V5**	0.411429	0.205556	**V5**	-1.81836	0.626918
V5	-0.9095	0.223519	**V5**	0.648178	0.064455	**V6**	-0.08022	0.1095	**V6**	-1.47724	0.208991
V6	-1.32622	0.364856	**V6**	-0.46449	0.176827	**V7**	0.443722	0.103737	**V7**	-0.09778	0.111635
V7	-1.21496	0.284575	**V7**	-0.02604	0.101497	**V8**	-0.19837	0.09682	**V8**	-0.01898	0.042316
V8	-1.39766	0.524392	**V8**	-0.33143	0.058828	**V9**	0.515025	0.267519	**V9**	0.456494	0.072669
V9	-0.73455	0.371828	**V9**	0.309991	0.114587	**V10**	-0.36593	0.121257	**V10**	-1.64822	0.171892
V10	-1.62913	0.369659	**V10**	0.295297	0.250922	**V11**	-0.64094	0.218027	**V11**	-0.29872	0.162402
V11	-0.72953	0.354256	**V11**	0.5011	0.173482	**V12**	0.335415	0.141594	**V12**	0.237644	0.0929
V12	-0.76899	0.380156	**V12**	-0.60199	0.085849	**V13**	-0.07212	0.108811	**V13**	-0.41868	0.228137
V13	-1.11483	0.412199	**V13**	0.516281	0.184594	**V14**	0.400988	0.087926	**V14**	-1.56083	0.125523
V14	-1.1238	0.434046	**V14**	0.241644	0.190945	**V15**	0.168529	0.226396	**V15**	-0.34088	0.119597
V15	-0.97548	0.441996	**V15**	-0.20976	0.217412	**V16**	0.124958	0.390606	**V16**	0.242676	0.097382
V16	-2.76035	0.515786	**V16**	0.176269	0.199979	**V17**	-0.15259	0.12951	**V17**	0.138682	0.136287
V17	2.096412	0.744672	**V17**	-1.32703	0.166934	**V18**	-1.05623	0.149834	**V18**	-0.30069	0.134785
V18	-0.6897	0.117508	**V18**	0.441562	0.058404	**V19**	0.514038	0.099959	**V19**	-0.46193	0.166653
V19	-1.23826	0.350134	**V19**	-1.56549	0.25695	**V20**	0.12624	0.113752	**V20**	0.522748	0.047871
V20	-0.83153	0.339122	**V20**	-0.00706	0.199583	**V21**	0.334641	0.221302	**V21**	0.189339	0.062403
V21	0.0088	0.194661	**V21**	-0.80817	0.033488	**V22**	-0.30048	0.14902	**V22**	-0.10336	0.0536
V22	0.953596	0.479998	**V22**	-0.58581	0.094255	**V23**	0.14239	0.159957	**V23**	-1.70032	0.630886
V23	-1.7592	0.481926	**V23**	-0.92837	0.174428	**V24**	-0.06634	0.097428	**V24**	-0.2589	0.053187
V24	-1.50679	0.350813	**V24**	-0.97115	0.172538	**V25**	-1.33347	0.586484	**V25**	-0.00401	0.183463
V25	-0.42173	0.324829	**V25**	-0.33077	0.137116	**V26**	0.203269	0.157382	**V26**	-2.10677	0.630482
V26	-1.01588	0.293365	**V26**	0.160502	0.064408	**V27**	0.778847	0.093397	**V27**	-0.40675	0.113958
V27	-1.06238	0.249991	**V27**	-1.66893	0.166091	**V28**	-0.46396	0.133913	**V28**	0.606904	0.097782
V28	-0.93751	0.194763	**V28**	-0.60676	0.131479	**V29**	0.33156	0.126101	**V29**	-0.00856	0.084614
V29	-1.37123	0.349835	**V29**	-1.0938	0.099308	**V30**	-0.54293	0.206548	**V30**	0.25744	0.056472
V30	0.732282	0.501126	**V30**	-2.42825	0.423294	**V31**	0.471101	0.155244	**V31**	-0.28124	0.078526
V31	-1.36178	0.86409	**V31**	0.806884	0.162576	**V32**	-0.70412	0.319988	**V32**	-1.87865	0.151545
V32	-0.25415	0.261489	**V32**	0.083246	0.160493	**V33**	-0.06217	0.147741	**V33**	-0.34891	0.08415
V33	-0.1983	0.190346	**V33**	-1.94454	0.192265	**V34**	0.765027	0.09251	**V34**	0.096324	0.1193
V34	-2.62725	0.837733	**V34**	0.376265	0.101345	**V35**	-0.55772	0.157602	**V35**	-0.27237	0.227855
V35	-0.39935	0.283621	**V35**	-0.84198	0.097839	**V36**	0.549602	0.094978	**V36**	-0.65221	0.200732
V36	-1.00901	0.253828	**V36**	-0.87644	0.10681	**V37**	0.432185	0.190888	**V37**	0.367404	0.090272
V37	0.883375	0.479408	**V37**	-1.08662	0.163505	**V38**	-1.30583	0.451428	**V38**	-1.48019	0.45012
V38	-0.4438	0.287838	**V38**	-0.96987	0.194651	**V39**	-0.36338	0.16132	**V39**	0.374934	0.053216
V39	-0.10611	0.32021	**V39**	-0.10118	0.060236	**V40**	-0.42712	0.338995	**V40**	0.016997	0.078006
V40	1.974262	0.690944	**V40**	-0.36105	0.12698	**V41**	0.173879	0.089092	**V41**	0.243784	0.066676

V41	-1.26363	0.309503	**V41**	-0.52115	0.09557	**V42**	0.04269	0.090539	**V42**	-0.23448	0.116968
V42	-0.90458	0.291828	**V42**	0.351783	0.066227	**V43**	0.361887	0.124511	**V43**	0.484915	0.08274
V43	-2.7202	0.838032	**V43**	0.067142	0.080763	**V44**	-0.06015	0.090269	**V44**	-0.21198	0.056369
V44	0.81884	0.266984	**V44**	-1.19288	0.156826	**V45**	0.506124	0.082124	**V45**	-0.23052	0.077212
V45	1.283742	0.391207	**V45**	-0.79459	0.110147	**V46**	1.364734	0.243078	**V46**	-0.40477	0.111945
V46	1.150448	0.33133	**V46**	0.408219	0.127796	**V47**	-0.6741	0.131163	**V47**	0.298384	0.180544
V47	-1.52084	0.514779	**V47**	0.385046	0.050145	**V48**	-0.14342	0.336233	**V48**	-0.54432	0.157807
V48	0.191889	0.223444	**V48**	-0.42987	0.095859	**V49**	-0.6581	0.116565	**V49**	0.375693	0.081053
V49	0.313734	0.292015	**V49**	0.510747	0.040686	**V50**	0.589116	0.115741	**V50**	0.17624	0.057958
V50	-0.07072	0.322083	**V50**	-0.15359	0.167179	**V51**	0.156958	0.091861	**V51**	0.26064	0.042262
V51	-1.32612	0.376605	**V51**	-0.74128	0.152895	**V52**	-0.04862	0.154847	**V52**	0.022633	0.051913
V52	-1.55954	0.605217	**V52**	0.722786	0.124867	**V53**	-0.08196	0.14251	**V53**	0.243894	0.040478
V53	-0.58731	0.50655	**V53**	-0.87398	0.205263	**V54**	0.358909	0.300416	**V54**	-0.08103	0.047011
V54	-1.52738	0.291525	**V54**	-2.80394	0.569351	**V55**	-1.39273	0.180166	**V55**	-1.68363	0.089302
V55	0.500171	0.263424	**V55**	-0.62457	0.061589	**V56**	0.463065	0.115124	**V56**	-0.22361	0.243097
V56	-0.84514	0.827344	**V56**	-0.28573	0.086037	**V57**	-0.17141	0.100042	**V57**	-0.12671	0.036937
V57	-1.53567	0.5912	**V57**	-0.03266	0.105458						
V58	-1.502	0.437754	**V58**	0.28164	0.238921						
V59	-0.61745	0.121944	**V59**	-0.02293	0.042288						
V60	-0.86962	0.2279	**V60**	-0.34729	0.056072						
V61	-1.13361	0.297701	**V61**	0.499199	0.139124						
V62	-0.66242	0.242553	**V62**	-0.61919	0.189209						
			V63	0.398914	0.16461						
			V64	-0.98317	0.192357						
			V65	0.025723	0.295391						
			V66	0.243105	0.264051						
			V67	-0.82149	0.092149						
			V68	0.492983	0.061807						
			V69	-0.65974	0.053395						
			V70	-0.82806	0.176281						
			V71	-0.66735	0.12825						
			V72	-0.87664	0.031849						
			V73	0.475948	0.031869						
			V74	-1.02825	0.223554						
			V75	-1.00291	0.119712						
			V76	0.579746	0.088904						