A price analysis and management model for adriatic Small Pelagic fish (anchovies and pilchards)

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Jel classification: C22, Q11, Q22

Abstract

This study focuses on the price formation mechanisms and was conceived due to the crucial nature of the Adriatic small pelagic fish market. It covers several aspects of the market, although those specifically connected with supply and demand were the primary focus. The issue of price formation mechanism is unique in the fish and seafood production sector as fishing companies, unlike many other industrial sectors, cannot plan production. Fishing boats head out to sea without any certainty that the market will absorb the entire catch and that the price obtained will be profitable. This implies that, in practice, variable costs are not easily adjustable as they are paid in advance. In more general terms, this leads to a degree of asymmetry in the management of fishing companies.

The daily price series and associated volumes for the year 2009 were analyzed for anchovies (Engraulis Encrasicolus) and pilchards (Sardina Pilchardus) in the main Adriatic fishing areas. The analysis shows that a uniform approach to managing the average price of small pelagic fish for the entire Adriatic Sea would not be effective, as this would negatively impact local niche markets. Specifically, the average annual prices for anchovies (Engraulis Encrasicolus) vary greatly at the different markets and there is little competition within the various fish and seafood markets. The study also focused on determining "no-fishing days" to control the supply of product on the markets, incorporating economic/income data from companies operating in the Adriatic small pelagic fish sector.

Keywords: price, seafood markets, small pelagic fish, no-fishing days.

Résumé

Dans cette étude, nous allons parcourir les mécanismes de formation des prix dans le marché des petits pélagiques de la mer Adriatique vu l'importance stratégique de ce secteur. L'attention sera focalisée sur les différents aspects du marché, en mettant l'accent sur les éléments liés spécifiquement à la demande et à l'offre. Le mécanisme de formation des prix des produits de la mer est tout à fait unique étant donné que les entreprises de pêche, contrairement à plusieurs autres secteurs industriels, ne peuvent pas programmer leur production. Les bateaux sortent en mer sans avoir aucune certitude sur la capacité d'absorption des captures totales par le marché et la rentabilité du prix. Cela signifie qu'en pratique, on ne peut pas intervenir facilement sur les coûts variables puisque ceux-ci sont payés en avance, En général, cela cause une certaine asymétrie dans la gestion des entreprises de pêche.

La série des prix journaliers et des volumes associés en l'an 2009 sera analysée pour les anchois (*Engraulis Encrasicolus*) et les pilchards (*Sardina Pilchardus*) dans les principales zones de pêche adriatiques. Une approche uniforme à la gestion du prix moyen des petits pélagiques pour l'ensemble de la mer Adriatique ne serait pas efficace parce que cela aurait des effets négatifs sur les marchés de niche locaux. En particulier, les prix annules moyens des anchois (*Engraulis Encrasicolus*) varient considérablement sur les différents marchés et la concurrence reste limitée. Il serait aussi utile d'adopter des "journées sans pêche" pour vérifier l'offre de produit sur les marchés, en prenant en compte les données économiques/revenu fournies par les entreprises qui œuvrent dans le secteur des petits pélagiques de la mer Adriatique.

Mots-clés: prix, marchés des produits de la mer, petits pélagiques, journées sans pêche.

1. Introduction

The objective of this paper is to define a small pelagic fish price management model for the most important Adriatic fishing areas, and to plan fishing activities and catch volumes, thereby optimizing the profitability for fishing companies.

This working hypothesis is inspired by both EC Regulation 104/2000 and the state of the *Engraulis Encrasicolus* and *Sardina Pilchardus* biomass, which can be considered critical. Evidence of the latter is provided by data from the Laboratory of Marine Biology and Fisheries of Fano (University of Bologna).

The biomass indices indicate a negative trend and the lowest absolute values of the decade. In 2010, a modest recovery took place, but the indicators essentially remained at the lower end of the scale. With respect to 2011, the Italian Ministry of Agricultural, Food and Forestry Policies doubled the mandatory fishing ban period, and also established fishing quotas for an additional 8 weeks total (3 days a week). It can therefore be inferred that the state of crisis in terms of biomass still exists.

Greater control of fluctuations in producer prices leads to more efficient management of catches and an increase in the product's value in marketing channels (which are currently obliged to absorb volumes of small pelagic fish that at times exceed demand).

In fact, if prudent management of resources can ensure that the price is both accessible for consumers and profitable for producers, price can be viewed as a tool for increasing the commercial value of the product. An accessible price becomes even more attractive during a period of economic crisis and decreased consumption, as is the current case.

Until now, management of small pelagic fish resources and the small pelagic fish market has been based primarily on biological principles; the impact on the profitability of the sector has been held to be of secondary importance. This analysis is therefore innovative in the sense that it gives equal weight to both biological and economic objectives.

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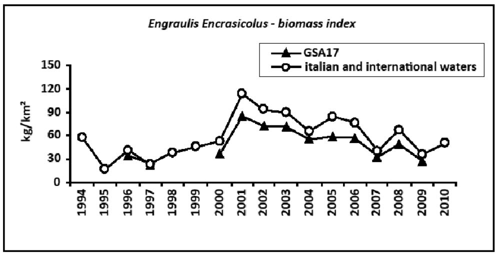

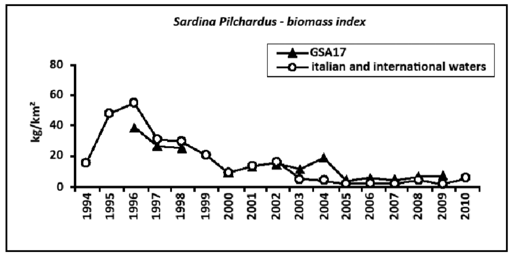

figures of interest. Nevertheless, volumes of fish from Molfetta are represented in the analysis since fishermen from this area unload their catch in other ports, particularly Martinsicuro and Ancona. This is not the case for Trieste, but the volumes involved are marginal. It should also be noted that Chioggia, Pila, Porto Garibaldi, and Ancona are the four largest fishing areas and are therefore important subjects of investigation. Of course, the contribution of the remaining five areas (Rimini and Martinsicuro in particular) was considered.

The daily price series and associated volumes were collected (taking into account whenever possible production that was not exchanged on the official market but was later sold off through other channels) for *Engraulis Encrasicolus* and *Sardina Pilchardus* in the ports of interest for the year 2009. The results of a preliminary analysis of these data are provided in the tables 1 and 2.

The results clearly demonstrate that managing the average price for the entire Adriatic Sea does not make sense and would not be effective, as it would negatively impact local niche markets. Take for example *Engraulis Encrasicolus:*

2. Empirical evidence relating to the Adriatic small pelagic fish markets

With respect to the structure and nature of the data, it should be noted that anchovy (*Engraulis Encrasicolus*) is certainly the most important of the local small pelagic fish species, both in terms of catch volumes and revenues. However, there are a total of 11 species of small pelagic fish that could be analyzed. While this does not imply that all species should be considered, as many are of marginal importance economically, selecting a single species (however important) to represent the entire market would be an oversimplification. As such, pilchard (*Sardina Pilchardus*) is included in the study along with anchovy, given its economic importance.

There are ten Adriatic small pelagic fish markets that are large enough to be considered for analysis: Trieste, Chioggia, Pila, Goro, Porto Garibaldi, Cesenatico, Rimini, Ancona, Martinsicuro, and Molfetta. Trieste and Molfetta were immediately excluded from the study due to insufficient data, as these markets have no structured system in place for daily recording of the

1. Average annual prices vary significantly in different markets, ranging from € 0.66 in Goro to € 1.70 in Martinsicuro.
2. There are several markets that, based on the principles of economic theory, do not really qualify as markets due to a lack of competition. Specifically, there are markets where the price is essentially stable – the modest standard deviations demonstrate an equally modest briskness of trading, which does not vary depending on the period of the year. The data shows that there is competition in Chioggia, Ancona and Martinsicuro, weak competition in Rimini, and lack of competition in Pila, Goro, Porto Garibaldi and Cesenatico.
3. The opinion of the producer organization is that any additional measures to limit the fishing of small pelagic fish should be done on a weekly basis, with Fridays being proposed as the most suitable day for banning fishing [Overview of Fishing in Veneto (2011)]. However, the data shows that banning fishing on Fridays would be inopportune from an economic perspective, since (with the exception of Goro and Porto Garibaldi) Fridays are not the day of the week with the lowest average price. The day with the lowest average price is Tuesday in Chioggia and Ancona, Thursday in Pila,

Table 1 - *Regional and temporal properties of the price of* Engraulis Encrasicolus.

	ENGRAULIS ENCRASICOLUS								
	Price								
	Adriatic	Chioggia	Pila	Goro	Porto Garibaldi	Cesenatico	Rimini	Ancona	Martinsicuro
Annual average	1.01	1.06	0.85	0.66	0.80	0.71	0.96	1.52	1.70
Days market open	293	225	182	191	211	200	265	209	207
January, February, December	1.10	1.27	0.90	0.70	0.84	0.71	0.99	1.85	2.13
March, April, May	1.01	1.06	0.84	0.63	0.78	0.70	0.97	1.57	1.92
June, July	0.90	0.91	0.84	0.61	0.76	0.71	0.94	1.15	1.24
(August), September, October, November	0.99	1.00	0.83	0.68	0.80	0.71	0.93	1.37	1.73
Monday	1.04	1.11	0.86	0.67	0.81	0.70	0.94	1.77	2.03
Tuesday	0.96	0.99	0.85	0.67	0.80	0.71	0.98	1.28	1.64
Wednesday	0.99	1.10	0.85	0.66	0.79	0.71	0.96	1.39	1.56
Thursday	1.03	1.03	0.84	0.66	0.79	0.71	0.95	1.60	1.84
Friday	0.99	1.05	0.86	0.64	0.79	0.71	0.98	1.51	1.57
After at least 2 days of closure	1.04	1.18	0.86	0.67	0.82	0.71	0.95	1.84	1.94
All other cases	1.00	1.01	0.85	0.65	0.79	0.71	0.96	1.39	1.60
	Standard Deviation								
	Adriatic	Chioggia	Pila	Goro	Porto Garibaldi	Cesenatico	Rimini	Ancona	Martinsicuro
Annual value	0.54	0.49	0.07	0.06	0.14	0.16	0.33	0.83	1.08
January, February, December	0.55	0.67	0.07	0.05	0.25	0.20	0.44	0.74	1.17
March, April, May	0.30	0.38	0.05	0.05	0.06	0.12	0.18	0.78	1.21
June, July	0.24	0.23	0.05	0.04	0.05	0.14	0.23	0.79	0.71
(August), September, October,	0.74	0.39	0.09	0.05	0.06	0.16	0.37	0.91	0.94
Monday	0.50	0.70	0.09	0.06	0.06	0.11	0.15	0.76	0.95
Tuesday	0.62	0.33	0.03	0.05	0.25	0.13	0.14	0.81	1.03
Wednesday	0.61	0.50	0.08	0.06	0.16	0.08	0.42	0.76	0.86
Thursday	0.43	0.44	0.06	0.06	0.06	0.17	0.14	0.86	0.99
Friday	0.41	0.38	0.09	0.06	0.06	0.25	0.28	0.79	1.37
After at least 2 days of closure	0.61	0.74	0.10	0.05	0.07	0.12	0.17	0.81	1.09
All other cases	0.52	0.36	0.05	0.06	0.16	0.17	0.35	0.83	1.07

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

Table 2 - *Regional and temporal properties of the price of* Sardina Pilchardus.

SARDINA PILCHARDUS – Price	Adriatic	Chioggia	Pila	Goro	Porto Garibaldi	Cesenatico	Rimini	Ancona	Martinsicuro
Annual average	0.92	1.22	0.53	1.03	0.83	0.69	0.63	0.85	1.01
Days market open	276	222	87	36	131	153	252	208	125
January, February, December	1.00	1.66	0.49	0.88	0.78	1.03	0.92	0.79	1.06
March, April, May	1.10	1.20	0.85	1.60	0.95	0.89	0.77	1.23	1.51
June, July	0.92	1.21	0.94	1.03	0.94	0.70	0.60	0.97	0.70
(August), September, October, November	0.81	1.11	0.52	0.54	0.76	0.57	0.54	0.72	0.97
Monday	1.05	1.37	0.53	0.83	0.85	0.78	0.65	1.06	0.91
Tuesday	0.89	1.13	0.56	1.20	0.84	0.72	0.67	0.85	1.25
Wednesday	0.91	1.27	0.49	0.99	0.87	0.68	0.62	0.83	1.14
Thursday	0.84	1.14	0.55	1.35	0.80	0.69	0.57	0.75	0.83
Friday	0.90	1.10	0.44	0.67	0.80	0.48	0.62	0.90	0.66
After at least 2 days of closure	1.02	1.39	0.53	1.08	0.85	0.72	0.66	0.86	0.90
All other cases	0.88	1.15	0.53	0.93	0.83	0.67	0.62	0.84	1.11

Standard Deviation	Adriatic	Chioggia	Pila	Goro	Porto Garibaldi	Cesenatico	Rimini	Ancona	Martinsicuro
Annual value	0.46	0.68	0.23	0.65	0.47	0.75	0.37	0.47	0.71
January, February, December	0.47	0.71	0.24	0.32	0.44	1.04	0.38	0.36	0.68
March, April, May	0.40	0.63	0.20	0.61	0.78	0.77	0.31	0.40	0.59
June, July	0.30	0.49	0.25	0.56	0.25	0.24	0.34	0.45	0.56
(August), September, October, November	0.54	0.36	0.13	0.24	0.23	0.41	0.31	0.44	0.76
Monday	0.41	0.62	0.24	0.79	0.39	0.74	0.16	0.43	0.52
Tuesday	0.59	0.72	0.19	0.50	0.27	0.59	0.36	0.44	0.92
Wednesday	0.53	0.68	0.24	0.56	0.74	0.68	0.46	0.45	0.79
Thursday	0.37	0.75	0.18	0.69	0.36	0.80	0.33	0.47	0.58
Friday	0.32	0.53	0.50	0.23	0.21	0.93	0.35	0.50	0.36
After at least 2 days of closure	0.51	0.70	0.23	0.71	0.65	0.83	0.30	0.49	0.70
All other cases	0.44	0.66	0.23	0.52	0.26	0.67	0.39	0.46	0.73

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

Monday in Cesenatico and Rimini, and Wednesday in Martinsicuro.

4. It is therefore apparent that a non-uniform "leopard spot" strategy for daily fishing bans should at least be considered. In fact, a higher average price is attained when trading takes place after a fishing halt of at least two days. It should be noted that the ports that have the widest spread between the two prices are those with the greatest competition: Chioggia, Ancona and Martinsicuro.

3. Definition and computation of the model

The literature offers numerous studies that evaluate the commercial and production dynamics of fishing. However, none have the same objectives or depth as the present study, which features:

1. variables considered on a daily rather than annual, monthly or weekly basis;
2. areas subdivided into individual fishing areas rather than regions or provinces;
3. analysis of price formation mechanisms rather than mere price, with the aim of developing hypotheses for regulating the volume of supply.

When surveying the literature, it was necessary to concentrate on bio-economic and economic modelling, as these focus (or should focus) specifically on price [Bjorndal and Conrad (1987), Sparre and Willmann (1993), Conrad and Clark (1994), Danielsson *et al.* (1997), Mardle *et al.* (2000), Eide *et al.* (2003), Garza *et al.* (2003), SEC (2006), Tjeerd-Boom *et al.* (2008), Frost *et al.* (2009)].

It should be stressed that the objective of the analysis goes beyond the simple price dynamics, going so far as to outline management strategies available to the public decision-maker. These strategies take into consideration both the economic requirements (value of the volume traded in the markets) and the tools that are normally used to limit fishing efforts (trips out to sea and catches).

When the various small pelagic fish markets (which are primarily wholesale markets) are considered simultaneously, the predominant characteristic that emerges is the interaction effect among markets. In fact, major buyers (large-scale distribution companies and other retailers) communicate with intermediaries located throughout the Adriatic in order to buy where the price is most advantageous. In practice, simultaneity may be a fundamental, central and deciding aspect of the price formation mechanism in the Adriatic basin. The analysis model must therefore meet two different requirements – it must incorporate the determining variables that govern price (as well as their importance and effect) and maximize the interaction effects.

The standard deviation of the price and the effect of volume on price were used to determine the markets for which it would be more useful (at least a priori) to develop a price. This method suggests that the most appropriate markets to study are the following[1]:

Table 3 - *Markets of interest.*

Species	Markets
Engraulis Encrasicolus	Chioggia, Ancona, Martinsicuro
Sardina Pilchardus	Chioggia, Cesenatico, Ancona, Martinsicuro

The rationale of these choices is based on the hypothesis that when prices are close to their average value, and their elasticity tends toward zero, the markets are probably less competitive.

Based on tests performed on basic data, and taking into consideration ideas from the literature [Clark (1985), Conrad (1995), Arnason (2000), Knowler (2002), Bjorndal *et al.* (2004), Plagànyi (2007), Biscaro (2010)], the study considered the the following variables affecting price in each market a priori:

Tables 4 - *List of predictors.*

the volume supplied daily in the market of interest
the volume supplied daily in other markets
the volume that was not sold (excess supply)
the previous price in the market of interest
the price in other markets
dummy for the first calendar effect: the days immediately preceding the Easter and Christmas holidays
dummy for the second calendar effect: the days immediately preceding fishing bans
dummy for the third calendar effect: the days when there was no market on the previous day, and two or more consecutive days prior
dummy for the days the market is open
dummy for the fourth calendar effect: the different days of the week
dummy for the fifth calendar effect: the different months of the year

[1] With respect to the representative markets for *Sardina Pilchardus*, it should be noted that the exclusion of Goro is due to its marginal economic importance (only 36 trading days and an average daily volume of 122 kg). In contrast, Ancona was included due to its economic importance, despite price fluctuations.

Having selected the relevant markets and the variables that are most likely to affect prices, there are various types of analysis models that can be run. The three that are of most interest are a simultaneous equation model, a neural model and an autoregressive integrated moving average model.

The first type, the simultaneous equation model, is the well-known three-stage least squares regression model; it was computed using Eviews 7.1. The second type, the neural model, is a multilayer perceptron model (two hidden layers, tangent-sigmoid hidden function, tangent-sigmoid-identity output function, batch-minibatch training method, gradient descent and scaled conjugated gradient optimization method); it was computed with Pasw Statistics 18. The third type, the autoregressive integrated moving average model, also takes into consideration some predictors and is therefore an ARIMAX model; it was computed with Pasw Statistics 18.

The computation of these three different types of models generated different results. Bearing in mind that the most important criterion is accuracy (minimum error) in simulating the market price, the best model proved to be the ARIMAX model. There are additional reasons for dismissing the simultaneous equation model and the neural model. In both models, it is difficult to deal with outliers[2], while in the neural model there is the additional complexity of assigning an easily interpretable economic significance to the various stages of estimation.

The computed structure of the ARIMAX model is as follows

$$\left(1-\sum_{i=1}^{p}\varphi_i L^i\right)(1-L)^d P_t = \left(1+\sum_{i=1}^{q}\theta_i L^i\right)\varepsilon_t + \sum_{i=1}^{b}\sum_{j=1}^{k}\beta_i L^i X_{j,t}$$

where P is the price, X are the predictors, p is the maximum order of the autoregressive component, d is the maximum order of integration, q is the maximum order of the moving average components, L is the lag operator, and ⍰ is the error term.

Before discussing the primary results of the ARIMAX model, attention should be brought to the legend of variables and symbols. The following legend is an example that refers to the market in Ancona[3]:

Table 5 - *Legend of variables and symbols used in the model.*

Markets:	Chioggia Pila Goro Porto Garibaldi Cesenatico Rimini Ancona Martinsicuro	CH PI GO PG CE RI AN MA
	price	ANp
	price on the previous day	ANp1
	volume	ANq
	volume for the previous day	ANq1
	excess supply	ANe
	dummy that takes a value of 1 if there was no market on the previous day, 0 otherwise	ANg1
	dummy that takes a value of 1 if there was no market on the preceding 2 or more consecutive days, 0 otherwise	ANg2
	dummy that takes a value of 1 if the market is open, 0 otherwise[1]	ANothers
dummies that take a value of	1 for Monday, 0 otherwise 1 for Tuesday, 0 otherwise 1 for Wednesday, 0 otherwise 1 for Thursday, 0 otherwise 1 for Friday, 0 otherwise	Dmo Dtu Dwe Dth Dfr
	dummy that takes a value of 1 the week preceding the fishing ban	Dfb

The model allows the area of influence of the markets to be identified. With regard to *Engraulis Encrasicolus*, Chioggia and Ancona markets show a large area of influence, whereas that of Martinsicuro market is more limited. With regard to *Sardina Pilchardus*, the markets generally have a very limited area of influence (Martinsicuro is an exception in this case as well).

As is apparent, the regions associated with each of the markets studied are highly heterogeneous, both in terms of composition and size. This, of course, adds an additional layer of complexity to any market intervention by public decision-makers.

The methodology proposed takes also into consideration the importance of calendar effects, specifically:

Finally it is worth highlighting a fundamental aspect of the model – its reliability as a forecasting tool. It can be assumed that the model has good out-sample predictive power. Excluding the days with outliers, the in-sample and out-sample estimation errors are as follows:

4. Simulation of a new strategy

After selecting the best ARIMAX model, a procedure for simulating the economic impact of regulating the volume of supply of small pelagic fish was devised. The procedure involves the following:

1. Determination of the unit production cost (an essential step).

2. Determination of the type of unit production cost that is most appropriate for use in market interventions (to regulate the volume of supply) by public decision-makers. A priori, the ideal parameter would be the total unit production cost. However, fixed costs must also be considered. These may vary greatly from company to company, depending on the age and size of the boats (major factors in depreciation), the company's debt level (financial burdens),

[2] The computing of the ARIMAX model with Pasw Statistics 18 allows the detection and neutralization of all types of outliers (additive, level shift, innovational, transient, seasonal additive, local trend, additive patch).

[3] The dummies absent from this legend are not statistically significant for any market (the first and the fifth calendar effects).

[4] This dummy is not among those considered a priori (table 4); it was added during the estimation process. It is not a calendar effect. It aims to capture the typical characteristics of the market that are not explicitly represented by other variables [such as the quality of the fish].

The primary results of the model are shown in the following tables:

Number of Predictors		Stationary R-squared		Ljung-Box Q (18) Statistics	DF	Sig.
14		0.914		29.334	18	0.044442
Variables			Estimate	SE	t	Sig.
CHg1	Numerator	Lag 0	0.409496	0.104486	3.919137	0.000120
PIg1	Numerator	Lag 0	0.769935	0.129541	5.943559	0.000000
PGg1	Numerator	Lag 0	0.504626	0.112964	4.467121	0.000013
CEg1	Numerator	Lag 0	-0.249449	0.070809	-3.522818	0.000522
PGg2	Numerator	Lag 0	-0.923906	0.136098	-6.788522	0.000000
Dwe	Numerator	Lag 0	0.204972	0.042589	4.812815	0.000003
Dth	Numerator	Lag 0	0.226315	0.043835	5.162880	0.000001
Dfr	Numerator	Lag 0	0.244604	0.041892	5.838972	0.000000
Lag 1						
PIq	Numerator	Lag 0	0.000009	0.000001	8.391849	0.000000
GOq	Numerator	Lag 0	-0.000010	0.000005	-2.145262	0.033064
PGq	Numerator	Lag 0	0.000010	0.000002	6.090885	0.000000
Lag 7						
CEq	Numerator	Lag 0	0.000011	0.000002	4.987660	0.000001
MAq	Numerator	Lag 0	-0.000018	0.000004	-4.274463	0.000029
		Lag 2	0.000021	0.000004	4.993221	0.000001
	Denominator	Lag 2	-0.933163	0.071097	-13.125197	0.000000
CEp	Numerator	Lag 0	0.439734	0.057031	7.710427	0.000000

ANCONA - *Engraulis Encrasicolus*

Number of Predictors		Stationary R-squared		Ljung-Box Q (18) Statistics	DF	Sig.
8		0.800		19.677	17	0.291109
Variables			Estimate	SE	t	Sig.
ANp	Constant		-0.209909	0.090860	-2.310242	0.021793
	MA	Lag 7	-0.413636	0.060288	-6.860995	0.000000
ANg1	Numerator	Lag 0	0.658342	0.159138	4.136936	0.000050
MAg2	Numerator	Lag 0	0.640985	0.144947	4.422192	0.000015
CHq	Numerator	Lag 0	0.000012	0.000005	2.640397	0.008869
Lag 6						
GOq	Numerator	Lag 0	0.000034	0.000008	4.240969	0.000033
ANq	Numerator	Lag 0	-0.000030	0.000003	-8.633723	0.000000
		Lag 1	-0.000032	0.000003	-9.152924	0.000000
	Denominator	Lag 1	0.409165	0.094195	4.343786	0.000021
Lag 1						
MAq	Numerator	Lag 0	0.000030	0.000011	2.674132	0.008049
Lag 2						
RIe	Numerator	Lag 0	-0.000153	0.000067	-2.282324	0.023417
ANp1	Numerator	Lag 0	0.681660	0.044181	15.428743	0.000000

and the total payroll, based on the contract minimum (depends on the number of crew and their positions, which in turn depend on the type and size of the boat, and the seniority of the crew). This suggests that the cost parameter that should be used by the public decision-maker or the producers' organization is the unit variable cost, since this is (potentially) much more uniform among the companies involved. If the cost parameter is changed from the total cost to the variable cost, the impact of the market regulation should be measured based on the contribution margin (profit – variable costs) rather than the net profit (profit – costs). In other words, the market intervention would be assessed in relation to its ability to allow for companies to finance fixed costs.

3. Given the price, it is evident that a uniform cost parameter is essential as this also ensures that the market intervention has a uniform impact on the companies, thereby averting any discriminatory effects (avoiding any unfair advantages caused by the different cost structures of the various companies).

Thus, a possible strategy for regulating the volume of supply can be summarized as follows:

1. The establishment of an appropriate reduction in the volume of the supply, attained by decreasing the permitted number of fishing days (taking into consideration the average daily catches of the *Engraulis Encrasicolus/Sardina Pilchardus* boats). This paper is proposing an innovative approach to determining the fishing ban days, specifically a non-uniform "leopard spot" strategy. This would entail banning fishing on the days that historically had an excess supply, followed by those that generated lower profits. The selection of days must take into consideration all of the Adriatic markets to avoid potential moral hazard problems[5].
2. The effect of the decreased supply will be an increase in price. The volume sold would be lower, so total profits could potentially decrease. However, the reduced number of fishing days would lead to an analogous reduction in the total variable costs. The contribution margin could therefore be higher or lower than it would be in the absence of any regulation of the volume of supply.
3. The contribution margin will be used to assess the effects of regulating the supply. If the contribution margin is lower, the intervention should not be viewed as a failure since reducing the number of fishing days has positive effects on the reproduction of fish and seafood resources (and ensures future profits).

A concrete example is offered by the simulation of such a strategy in Chioggia *Engraulis Encrasicolus* market. Specifically, it is interesting to compare the "leopard spot" strategy with the "traditional" strategies:

[5] Some fishermen may catch fish in areas that are not banned, and sell the fish in the markets of banned areas.

MARTINSICURO - *Engraulis Encrasicolus*

Number of Predictors			Stationary R-squared	Ljung-Box Q (18) Statistics	DF	Sig.
3			0,881	12.757	16	0.690418
Variables			Estimate	SE	t	Sig.
MAp	MA	Lag 1	-0.294292	0.049038	-6.001324	0.000000
		Lag 7	-0.476483	0.047050	-10.127165	0.000000
MAq	Numerator	Lag 0	-0.000104	0.000011	-9.138421	0.000000
MAp1	Numerator	Lag 0	0.109824	0.038601	2.845106	0.004846
MAothers	Numerator	Lag 0	2.098475	0.107147	19.584952	0.000000

CHIOGGIA - *Sardina Pilchardus*

Number of Predictors			Stationary R-squared	Ljung-Box Q (18) Statistics	DF	Sig.
6			0.913	16.969	18	0.525209
Variables			Estimate	SE	t	Sig.
CHg2	Numerator	Lag 0	0.809949	0.064712	12.516222	0.000000
Dwe	Numerator	Lag 0	0.181756	0.061221	2.968831	0.003304
Dth	Numerator	Lag 0	0.282732	0.059132	4.781409	0.000003
CHq	Numerator	Lag 0	-0.000028	0.000006	-4.911866	0.000002
ANp	Numerator	Lag 0	0.144698	0.037377	3.871343	0.000141
CHp1	Numerator	Lag 0	0.784281	0.024809	31.612706	0.000000

CESENATICO - *Sardina Pilchardus*

Number of Predictors			Stationary R-squared	Ljung-Box Q (18) Statistics	DF	Sig.
4			0.986	25.089	17	0.092734
Variables			Estimate	SE	t	Sig.
CEp	MA	Lag 14	-0.103577	0.019755	-5.243141	0.000000
Lag 2						
PGq	Numerator	Lag 0	-0.000017	0.000006	-2.857492	0.004713
CEq	Numerator	Lag 0	-0.000012	0.000004	-3.406491	0.000793
CEothers	Numerator	Lag 0	0.391997	0.028206	13.897870	0.000000
CEp1	Numerator	Lag 0	0.562169	0.019765	28.442913	0.000000

ANCONA - *Sardina Pilchardus*

Number of Predictors			Stationary R-squared	Ljung-Box Q (18) Statistics	DF	Sig.
4			0.890	19.506	17	0.300284
Variables			Estimate	SE	t	Sig.
ANp	MA	Lag 1	0.361712	0.062483	5.788953	0.000000
ANg2	Numerator	Lag 0	0.566105	0.083210	6.803307	0.000000
Dwe	Numerator	Lag 0	0.278451	0.062618	4.446826	0.000014
ANq	Numerator	Lag 0	-0.000058	0.000007	-8.203565	0.000000
	Denominator	Lag 1	-0.893005	0.101603	-8.789146	0.000000
		Lag 2	-0.356385	0.102345	-3.482190	0.000595
ANp1	Numerator	Lag 0	0.851029	0.028833	29.515409	0.000000
		Lag 1	0.893089	0.094635	9.437175	0.000000
		Lag 2	-0.708453	0.080477	-8.803153	0.000000
	Denominator	Lag 1	1.087008	0.085615	12.696515	0.000000
		Lag 2	-0.818220	0.065716	-12.450941	0.000000

1. the strategy proposed by the fishing companies of banning fishing on Fridays;
2. the strategy proposed in the national planning documents GSA17 and GSA18 of having a uniform reduction (every day of the year) of fishing efforts.

A simulation using the data for Chioggia from 2009 (excluding 13 days that had abnormal prices) results in the following economic changes:

Although there is a decrease in the contribution margin, the amount lost by employing the "leopard spot" strategy would only have a modest impact on the individual companies as the above figure is the combined annual total for all of the companies. Furthermore, it could be viewed as an "acceptable price to pay" to increase the reproduction of the biomass. The simulations of the three proposals unequivocally demonstrate the superiority of the "leopard spot" strategy for reducing supply, as it has the least economic impact on operators.

A few clarifications should be made regarding the methodology:

1. The amount of the reduction in the volume of supply should be as close as possible in the three cases, to ensure comparability.
2. The public decision-maker must make decisions for the entire Adriatic rather than individual markets (for obvious reasons of fairness and to avoid opportunistic behaviour on the part of the companies involved).
3. The "fishing ban on Fridays" strategy was used as a reference to determine the reduction in volume for each market and for the Adriatic. The total reduction for all of the Adriatic markets is 10.66%, but it is clear that implementation of this strategy implies that each market will have a different reduction in supply.
4. The "uniform reduction" strategy must therefore be based on this same percentage, applying the decrease to each day the market is open (without adding any fishing ban days).
5. This same percentage of reduction in supply (10.66%) was also applied to the "leopard spot" strategy. This was

MARTINSICURO - *Sardina Pilchardus*

Number of Predictors			Stationary R-squared	Ljung-Box Q (18) Statistics	DF	Sig.
7			0.810	18.673	18	0.412186
Variables			Estimate	SE	t	Sig.
PGg2	Numerator	Lag 0	0.419190	0.083408	5.025781	0.000001
MAg2	Numerator	Lag 0	1.049273	0.069018	15.202975	0.000000
Dfb	Numerator	Lag 0	-0.443409	0.170965	-2.593564	0.010164
ANq	Numerator	Lag 0	0.000034	0.000007	5.121390	0.000001
	Denominator	Lag 1	0.579395	0.088219	6.567702	0.000000
		Lag 2	-0.647159	0.094858	-6.822387	0.000000
Lag 8						
MAq	Numerator	Lag 0	0.000665	0.000112	5.918279	0.000000
Lag 7						
PGp	Numerator	Lag 0	-0.174481	0.041324	-4.222228	0.000036
Lag 1						
RIp	Numerator	Lag 0	0.201495	0.040776	4.941465	0.000002
		Lag 1	0.102872	0.043022	2.391115	0.017676
	Denominator	Lag 1	0.739717	0.070688	10.464565	0.000000
		Lag 2	-0.772659	0.076371	-10.117217	0.000000

Table 6 - *Area of influence by species and markets.*

SPECIES	MARKETS	AREA OF INFLUENCE
Engraulis Encrasicolus	Chioggia	Pila, Goro, Porto Garibaldi, Cesenatico, Martinsicuro
Engraulis Encrasicolus	Ancona	Chioggia, Goro, Rimini, Martinsicuro
Engraulis Encrasicolus	Martinsicuro	-
Sardina Pilchardus	Chioggia	Ancona
Sardina Pilchardus	Cesenatico	Porto Garibaldi
Sardina Pilchardus	Ancona	-
Sardina Pilchardus	Martinsicuro	Porto Garibaldi, Rimini, Ancona

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

Table 7 - *Calendar effects by species and market.*

SPECIES	MARKETS	AREA OF INFLUENCE
Engraulis Encrasicolus	Chioggia	Pila, Goro, Porto Garibaldi, Cesenatico, Martinsicuro
Engraulis Encrasicolus	Ancona	Chioggia, Goro, Rimini, Martinsicuro
Engraulis Encrasicolus	Martinsicuro	-
Sardina Pilchardus	Chioggia	Ancona
Sardina Pilchardus	Cesenatico	Porto Garibaldi
Sardina Pilchardus	Ancona	-
Sardina Pilchardus	Martinsicuro	Porto Garibaldi, Rimini, Ancona

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

achieved by first subtracting from the volume on days that had excess supply, and then subtracting from days that were less profitable. In actuality it was necessary to approximate, as the volume of supply needed to be reduced by the target amount. Furthermore, it is clear that decisions for both methodologies (elimination of excess supply days and less profitable days) must be made on an Adriatic-wide basis rather than for individual markets, so as to prevent opportunistic behaviour on the part of operators. It is therefore possible that a day identified as "less profitable" on an Adriatic-wide basis is not necessarily "less profitable" for every single market.

Based on the above issues, it is inevitable that the volume of supply removed from the markets with each of these three strategies is similar, but not identical. In addition to addressing these important methodological aspects, it is also necessary to assess the applicability of the new strategy. Clearly this study involves a simulation, not a forecast, since the no-fishing days were selected based on data from the year 2009. When applying this strategy to future time periods, however, public decision-makers or producers' organizations must determine a priori the most appropriate no-fishing days. A specific forecasting model is therefore needed to determine suitable dates. The creation of such a model, however, goes beyond the scope of the present analysis.

5. Conclusions

The analysis and simulations of the model outlined here bring to light some important characteristics of markets, which need to be considered when planning regulatory interventions in the sector. EU legislation authorizes producer organizations to manage the number of fishing days, taking into consideration not only biological factors but also economic aspects and earnings.

The Adriatic small pelagic fish price analysis and management model is most effective when it is part of a comprehensive strategy to manage production and marketing.

The results obtained with the ARIMAX model show that, in addition to the obvious impact of local factors, price formation is influenced by two effects:

1. the interaction effect: the predictors of price refer to the general Adriatic context[6];
2. the effect of simultaneity: the most important predictors are relevant over the same time horizons[7].

[6] Seven markets were analyzed: three for *Engraulis Encrasicolus* and four for *Sardina Pilchardus*. Non-local predictors, belonging to other markets, are statistically significant in five of these markets.

[7] In the seven markets considered, the analysis identified a total of 46 statistically significant predictors; only five of these are temporally misaligned with the dependent variable.

Table 8 - *The precision of the model.*

SPECIES	MARKETS	simulation errors (euros/000)	
		in-sample	out-sample
Engraulis Encrasicolus	Chioggia	-25	-61
Engraulis Encrasicolus	Ancona	-43	-39
Engraulis Encrasicolus	Martinsicuro	-51	-144
Sardina Pilchardus	Chioggia	2	10
Sardina Pilchardus	Cesenatico	25	60
Sardina Pilchardus	Ancona	-26	7
Sardina Pilchardus	Martinsicuro	-86	65

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

Table 9 - CHIOGGIA - *Engraulis Encrasicolus (in Euros).*

	"FRIDAYS" STRATEGY	"UNIFORM REDUCTION" STRATEGY	"LEOPARD SPOT" STRATEGY
Δ market revenues	-592,818	-752,835	-252,136
Δ variable costs for the companies	-314,242	-239,297	-205,642
Δ contribution margin	-278,576	-513,537	-46,493

Source: Processed by the Socio-economic Observatory for Fishing and Aquaculture based on data provided by producers' organizations.

It therefore becomes crucial to adopt a strategy for the Adriatic that integrates production and marketing, while keeping in mind the reproduction needs of the biomass involved.

The overall strategy that should be adopted can be divided into 4 steps:

1. Catches should be planned based on a 3-factor Production Function, in which capital is approximated with tonnage or engine power, and work is approximated with the number of fishing days; a third key factor is represented by the biomass of small pelagic fish. The goal is to program catches logically, employing the usual measures of limiting fishing effort and taking into consideration biomass preservation.
2. A key issue in matching supply to demand in the Adriatic small pelagic fish sector is the variation of demand over very short periods of time (daily and weekly). However, the creation of a demand model would allow catch parameters (see step 1) to be established that would avoid excess supply.
3. The ARIMAX model defines the equilibrium price between the production model (step 1) and the demand model (step 2). This enables a production value to be defined that takes into consideration the fishing effort, biomass reproduction issues and consumer needs.
4. Based on the results achieved in step 3, continuous monitoring of the producers' economic and financial condition would allow the price-production cost margin to be defined, thus ensuring profitability.

It is evident that the management strategy being proposed is iterative, since profitability will affect the number of fishing companies. A change in the number of companies would necessitate re-calculation of the production function (step 1) and subsequent refinement of the entire strategy.

References

Arnason R. (2000), Endogenous optimization fisheries models, *Annals of Operations Research* 94: 219-230.

Biscaro Q. (2010), *Un modello pilota per il mercato del pesce azzurro*, Atti degli Stati Generali Clodiensi, Chioggia Venezia, 6 febbraio 2010.

Bjørndal T., Conrad J. (1987), Capital dynamics in the North Sea herring fishery, *Marine Resource Economics* 4: 63-74.

Bjørndal T., Kaitala V., Lindroos M., Munro G.R. (2000), The management of high seas fisheries, *Annals of Operations Research* 94, pp. 183-196.

Bjørndal T., Lane D.E., Weintraub A. (2004), Operational research models and the management of fisheries and aquaculture: a review, *European Journal of Operational Research* 156: 533-540.

Clark C.W. (1985), *Bioeconomic Modelling and Fisheries Management*, John Wiley and Sons, New York.

Conrad J. (1995), *Bioeconomic models of the fishery*. In: Bromley D. ed. *Handbook of Environmental Economics*, Blackwells, Oxford and Cambridge, pp. 405-432.

Conrad J.M., Clark C. (1994), *Natural Resource Economics*, Cambridge University Press, Cambridge, UK.

C.R. (2000) - Council Regulation (EC) No 104/2000 of 17 December 1999 on the common organisation of the markets in fishery and aquaculture products, *Official Journal of the ECL* 17 of 21.1.2000, pp. 22-52.

Danielsson A., Stefansson G., Baldursson F.M., Thorarinsson K. (1997), Utilization of the Icelandic cod stock in a multispecies context, *Marine Resource Economics* 12: 329-344.

Eide A., Skjold F., Olsen F., Flåten O. (2003), Harvest functions: the Norwegian bottom trawl cod fisheries, *Marine Resource Economics* 18: 81-94.

Frost H., Levring J.A., Hoff A., Thøgersen T. (2009), The EIAA model: methodology, definitions and model outline.

Garza-Gil M.D., Varela-Lafuente M., Suris-Regueiro J.C. (2003), European hake fishery bioeconomic management (southern stock) applying en effort tax, F*isheries Research* 60: 199-206.

Knowler D. (2002), A review of selected bioeconomic models with environmental influences in fisheries, *Journal of Bioeconomics* 4: 163-181.

Plagányi E. (2007), *Models for an ecosystem approach to fisheries*, Rome.

SEC (2006), Report of the Joint SGECA - SGRST sub-group meeting on bioeconomic modelling. Ispra 4-6 October 2005 and 7-9 March 2006. Commission Staff Working Paper, Brussels 2006.

Sparre P.J., Willmann R. (1993), Software for bio-economic analysis of fisheries. BEAM 4. Analytical bio-economic simulation of space-structured multi-species and multi-fleet fisheries. Volume 1: Description of model. User's manual. FAO, 3, Rome.

Veneto Region Hunting and Fishing Department (2011), Overview of Fishing in Veneto – Proceedings of the "Management Plans" seminar, Mestre (Venice), 13 April 2011.

Tjeerd-Boom J., Frost H., Sørensen L. (2008), Integrated modeling of fisheries. Development of a global view based on models and bioeconomic data, Nordic Council of Ministers, Copenhagen.