AN ADAPTIVE MANAGEMENT PLAN FOR THE ITALIAN FISHERIES

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ABSTRACT

The excessive exploitation of fishery resources is generally recognized by resource managers in many European fisheries. This produces a degradation of aquatic resources, and significant social and economic waste. The development of appropriate management plans for European fisheries is considered as a priority by the European Commission. In accordance with Reg. (CE) 1967, Art.19 (Mediterranean Rule), an adaptive multi-annual management plan for the Italian fisheries has been proposed for implementation in the period 2008-2013. As Mediterranean fisheries are multi-species and multi-fleet in nature, neither management plans based on single stocks nor Harvest Control Rules can be generally applied. As a consequence, a multi-fleet and multi-species bio-economic model has been developed and used to simulate the effects of a number of potential management measures based on input and efficiency restrictions. Simulations outcomes are evaluated using a set of biological and socio-economic indicators. During the period covered by the management plan, predicted values will be compared with the real outcomes for each of these indicators, and the management measures adapted to the updated scenarios. This paper describes the structure of the adaptive management plan and shows the results of an application of the bio-economic model to the demersal fisheries in the South and Central Tyrrhenian Sea (FAO Geographical Sub Area (GSA) 10).

Keywords: management, bio-economic modelling, indicators, multi-species, multi-gear.

1. INTRODUCTION

The current Common Fishery policy contemplates a longer-term perspective on fisheries management by introducing management plans, either based on Regulation (CE) 2371/02 and Regulation (CE) 1967/06. In line with the CFP long term and multi-annual objectives in 2008 the Italian management authority has proposed for implementation twelve “national management plans”. In each of the seven homogeneous areas (FAO - Geographical Sub Area – GSA), there have been drawn adaptive management plans by fleet segments and fisheries. Each plan is characterised by measures meant to recovery the main target species in the area through an effort management approach and by social and economic accompanying measures, required to support fishermen in the transitional period.

The legal framework for the implementation of the Italian management plans refer to the Regulation (EC) 1967/06, with reference to the provisions of Article 19 relating to national management plans for fisheries conducted by trawl nets, boat seines, shore seines, surrounding nets and dredges. In compliance with the approach presented in the Operational Programme approved by the European Commission in execution of the European Fisheries Fund (EFF), the EFF may contribute to the financing of aid measures for the temporary cessation of fishing activities for fishers and the owners of fishing vessels, during the period 2007 to 2013[1]. Moreover, to satisfy the requirements of procedural aspects of the implementation of permanent

[1] Article 24, paragraph 1, section v) of the EFF Base Regulations (public aid for temporary cessation of fishing activities).

cessation measures, each Management Plan is also associated with an adjustment plan and decommissioning plans[2].

This paper aims to describe the structure of the adaptive management plans designed for the Italian fisheries. The management plans have been defined by following a procedure taking into account biological, economic and social objectives. Each plan includes a set of management tools mainly based on input control and technical restrictions. The effects of the implementation of these measures on a selected group of indicators have been estimated by using a bio-economic simulation approach. Different scenarios have been simulated to compare the effects of each of the main management measures included in the plans and the effects of a combined implementation of all measures.

The structure of the adaptive management plans is described in the next section, while an explanation of the simulation model with a focus on the economic sub-model is reported in section 3. The management plan for the demersal fisheries in the South and Central Tyrrhenian Sea (GSA 10) and the results obtained by scenarios simulations in that area are discussed in section 4. Finally, some considerations are reported.

2. STRUCTURE OF THE ADAPTIVE MANAGEMENT PLANS

In 2007, the Ministry for Food, Agriculture and Forestry (MIPAAF) decided to implement management plans for the Italian fisheries. The plans have been drawn by IREPA (Institute for Economic Research in Fishery and Aquaculture), CNR Ancona, CNR Mazara del Vallo and COISPA. The contribution given by research institutes focusing on different aspects of fisheries science made possible to take into account biological and socio-economic implications of fisheries management in the plan.

The management plans defined for Italian fisheries are generally associated to the geographical sub-areas (GSAs), as defined by FAO for management purposes (FAO, 2001), or areas merging adjacent GSAs. In each area, management plans have been defined by fleet segment (mainly, demersal or pelagic). The fleet operating in a specific area has been divided in two fleet segments, each competing for the same species: trawlers and “other systems” for demersal fisheries, and pelagic and “other systems” for pelagic fisheries.

The management plans have been drawn for the period 2008-2013 following the iterative procedure below:

1. definition of objectives and quantification of targets;
2. definition of potential management tools;
3. evaluation of the biological and socio-economic impacts of potential management measures;
4. definition of the management measures to be adopted;
5. implementation of the management measures;
6. monitoring and evaluation of results.

The last step represents probably the most important as monitoring the implementation and the effects of the management plans can show the need for the management measures to be updated. In this sense, the management plan is adaptive. Whereas bio-economic models can evaluate the potential effects of the management measures, the uncertainty included in their predictions suggests the inclusion of a monitoring process and, eventually, a redefinition of the measures.

[2] Articles 21 and 22 of the EFF relating to adaptation of the Community fishing fleet concerns public aid for owners of fishing vessels and fishers affected by fishing effort adjustment plans.

Definition of objectives and quantification of targets

The management plans have been designed by a multidisciplinary approach taking into account a biological, economic and social prospective. According to this approach, three general objectives have been defined:

- preserving the renewal capacity of commercial stocks,
- improving the economic conditions of those involved in fishing activities,
- increasing fishermen income.

Specific targets have been defined for each objective and a set of indicators has been selected to monitor the status of the variables associated to the targets. The definition of specific limit and target reference values by GSA and type of fishery is based on the recommendations proposed by scientific organisations, like FAO-GFCM (General Fishery Commission for Mediterranean) and STECF-SGMED (Sub-group on Mediterranean Sea).

Given the targets, the status of marine resources has been evaluated by using both empirical approaches (historical GRUND[3] and MEDITS[4] data series of abundance indexes) and approaches based on population dynamic models (Spedicato et al., 1995, 1998, 2003a,b, 2006). The stock assessment for a number of demersal and pelagic species indicates that resources under exploitation in the Italian waters are generally in an impoverished condition. The main indicators showing the precarious conditions of fishing stocks are:

- the exploitation rate (E), generally estimated over 0.5;
- the total mortality rate, showing rising trends for almost all commercial species.

The plans aimed to achieve an improvement in the spawning stock biomass (SSB) by reducing the exploitation rate (E) from the present level to a target reference point of 0.35, or, as a second-best target, to a level of 0.5 (limit reference point). Four different indicators have been associated to the biological targets: the total mortality rate (Z), the fishing mortality rate (F), the exploitation rate (E) and a sustainability indicator, the reproductive potential, given by the ratio between the exploited and the unexploited spawning stock biomass (ESSB/USSB).

Given the biological constraints defined above, generic targets are defined from an economic and social point of view. Improving the profitability of fishing activities is monitored by the indicators “gross profit per vessel” and “added value per man employed”, while developing employment opportunities in fisheries is monitored by “number of people employed” and “cost of employment per worker”.

A synthetic description of objectives, specific targets and indicators is reported in Table 1.

Table 1 - Targets and biological, economic and social indicators

Targets	Specific targets	Indicators
Biological: preserving the renewal capacity of commercial stocks	Reducing fishing to within levels compatible with safe levels for stocks, identified by Biological Limit Reference Points, and exploitation aiming at sustainability in the medium-long term, identified by Biological Target Reference Points	1. Total instantaneous mortality rate (**Z**), 2. Instantaneous fishing mortality rate (**F**), 3. Exploitation rate (**E**), 4. Reproductive potential (**ESSB/USSB**).

[3] Bottom trawl survey on the "Evaluation of demersal resources in the Italian coasts” Italian Ministry of Agricultural Policy project

[4] EU project: International bottom trawl survey in the Mediterranean.

Economic: improvement of the economic conditions of those involved in fishing activities	Improving the income-generating capacity of fishing activities	1. Gross profit per vessel 2. Added value per man employed.
Social: Increasing fishermen income and safeguard employment levels	Given the biological targets, development of employment opportunities in related activities	1. Number of people employed, 2. Cost of employment per worker.

Definition of potential management tools

As Mediterranean fisheries are multi-species and multi-fleet, neither management plans based on single stocks nor Harvest Control Rules (HCR) can be generally applied. HRC are generally applied in mono-species fisheries or where the main target species represents most of the landings. Mediterranean fisheries are multi-species in nature with more then 50 commercial species generally landed by trawling activities. For this reason, it is commonly recognized that output driven measures, like TAC or other quotas regimes, are not applicable in this area.

A large number of measures and tools considered within the national management plans are already in force in the Italian management system. They are mainly based on input control (limitation of fishing licenses, time and area closures, etc.) and technical limitations (mesh size restrictions). The adaptive management plans described in this paper establish a more rationale and monitored implementation for some of these tools based on biological and socio-economic targets evaluated at GSAs' level. In this section the main management tools taken into account for the Italian fishery management system will be described.

Management tools generally considered for Italian fisheries can listed as follows:

- Permanent withdrawal;
- Temporary withdrawal of fishing activity;
- Mesh size restrictions;
- Technical withdrawal of the fishing activity on Saturday and Sunday;
- Minimum landing size for some target species;
- Fishing permits
- Areas where the use of towed nets is prohibited;
- Areas in which fishing is prohibited.

Permanent withdrawal. In the last years a limit on the issue of new license has been imposed by the administration in order to comply with the capacity reduction planned first, under the European Multi-annual Guidance Programs (MAGPs), in force in the period 1983-2002 and then under the EC Reg. 1438/2003, establishing the new entry-exit regime. To comply with the capacity objectives, the national Administration sets that for those segments where overcapacity has been assessed no new licence can be issued and transferability of the existing licence on another vessel can only be authorized in case the other vessel has at least the same tonnage and power of the old one.

Temporary withdrawal of fishing activity has been applied continuatively since 1988 and applies both to trawlers and to mid-water pelagic nets as its main aim is the safeguard of the juveniles of demersal species. In particular, the seasonal withdrawal is intended to safeguard demersal species during their recruitment seasons. Considering the multi-specificity of the Italian fishery, these periods vary from species to species and the period provided each year by the seasonal withdrawal represents a compromise, based on scientific advice, for the main species caught by trawlers and mid-water pelagic nets. This measure is applied in

different periods and, depending on the areas of the Italian coastline, it is compulsory (for the Adriatic fleet) or facultative (for the Tyrrhenian fleet).

Mesh size restrictions. Since the beginning of 2007, the main reference of the minimum mesh size and of the other technical measures is the EC Reg. no 1967/2006 which amends the EC Reg. no. 2847/93, abrogates the EC Reg. 1626/1994 and establishes new management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea. As far as the net used by trawlers, the above regulation establishes a set of technical rules (even if a derogation is in place until 2010) that can be summarized in a minimum mesh size:

- until 31.12.2007: 40 mm;
- since 1.7.2008 the mesh size can be 40 mm squared or 50 mm rhomboidal.

Technical withdrawal. Notwithstanding the provisions of the national collective employment contract in respect of weekly rest periods for all maritime activities, fishing using trawls and or mid-water pair trawls will be prohibited on Saturdays, Sundays and public holidays. During the eight weeks following the temporary withdrawal of fishing activity, units having suspended their activity will not fish on Fridays. No catching up on any inactive days caused by adverse sea and weather conditions will be permitted, except under emergency and calamity conditions.

Minimum landing sizes. The legislative reference is made to current European regulations (Reg. EC no. 1967/2006) and national regulations (Law no. 963 of the 14 July 1965 and subsequent amendments, decree no. 1639 by the President of the Republic of the 2 October 1968 and subsequent amendments).

Fishing permits. Pursuant to the provisions of Reg. (EC) no. 1967/2006, Article 19, paragraph 6 and in accordance with Reg. (EC) no. 1627/94 the national government will issue a specific fishing permit in favour of each vessel equipped for trawling in the area covered by the Plan, indicating the technical measures in force, the areas in which fishing is prohibited and the permitted gear for the area. In order to encourage the process of administrative simplification, fishing permits issued with regard to the principle of relative stability of fishing habits will identify individual boats within an authorised fishing group. Fishing permits will not replace fishing licences.

Areas where the use of towed nets is prohibited. The use of towed gear is prohibited within a distance of 3 nautical miles from the coast or within the 50 m depth contour where this depth is reached at a shorter distance from the coast.

Areas in which fishing is prohibited include Marine Protected Areas (MPAs) and fishing protected areas. Italian MPAs are generally divided into 3 different zones according to their different environmental features (A, B and C), where the fishing restrictions are gradually less restrictive. As far as the fishing protected areas, they respond to the need to protect juveniles concentration of some species in specific areas. In these zones the fishing activity is completely banned.

Depending upon the financial resources available and the directives which might emerge at local level, the plan foresees also the possibility to activate socio-economic measures to compensate for the smaller income generated as a result of the introduction of these measures.

Evaluations of the biological and socio-economic impacts of potential management measure

A set of input control and technical measures has been evaluated by a multi-fleet and multi-species bio-economic model. The model, consisting of a biological and an economic component, has been used to simulate biological, economic and social effects of a number of potential management measures for the period 2008-2013.

The biological impacts of these measures have been simulated using the predictive ALADYM model (Age-Length Based Dynamic Model)[5]. Using traditional population dynamic equations, the model is able to predict the impact that any change in pressure factors (e.g. fishing and total mortality), management measures (e.g. mesh size variations, fishing effort restrictions) or biological variables (e.g. recruitment level) has on the biomass of the most relevant species in terms of landings and revenues. From an economic viewpoint, the ALADYM model works like a production function which output is represented by the level of landings by species.

The level of landings predicted by ALADYM represents an input to the economic model for the evaluation of socio-economic impacts that management measures can have on the fisheries under analysis. To assess the variations in a set of economic and social indicators deriving from the implementation of the measures proposed in the management plans, a simplified version of the BIRDMOD model (Accadia and Spagnolo, 2006) compatible with the biological model has been developed. The main assumptions adopted in the economic model can be resumed as follows:

- Prices by target species and fleet segment are assumed to be a function of landings through flexibility coefficients;
- Variable costs by fleet segment are assumed to be a linear function of days at sea and revenues;
- Fixed costs are assumed to be a linear function of GT.

Definition of the management measure to be adopted

The Italian adaptive management plans consist of 12 plans, one for each GSA concerned and specified fisheries: 8 for bottom trawl fishery and "other" fishing systems targeting demersal fisheries, and 4 for purse-seine fisheries targeting small pelagic species. Table 2 and Table 3 show the measures simulated for the demersal and the pelagic fisheries respectively. The bio-economic model have simulated the following four scenarios:

Scenario 1. Permanent withdrawal has been scheduled in two different periods: a first period during the years 2008/2010 and a second period during the years 2011/2013. The envisaged change in capacity has been subdivided into equal parts for each period. For each capacity levels have been calculated on the basis of the biological simulations. Permanent withdrawal varies from a minimum of 5% in GT in GSA 11 to a maximum of 27% in GSA 17 (Table 2) for demersal fisheries. For pelagic fisheries on the basis of the available financial resources, it was established an homogenous implementation for all GSAs equal to a reduction of 3% in GT. (Table 3).

Scenario 2. Temporary withdrawal, in which for demersal fisheries a shutdown of 45 consecutive days was diversified by area and stock (Table 2). It was also assumed that the temporary suspension would be followed in the next two months by a further reduction in activity of four days per month (post-shutdown period). For pelagic fisheries the temporary withdrawal was assumed to be 15% less the average number of days in 2006 (Table 3).

Scenario 3. Change in mesh size, an increase in the stretched mesh in the cod-end was introduced with effect from 2010 and the measure was implemented having regard to a mesh with an opening of 50 mm which will presumably preferred to the alternative option (nets with a 40 mm square mesh).

[5] ALADYM was developed as part of the European FISBOAT project (Fisheries Independent Survey Based Operational Assessment Tools). Details of its methodology and use can be found on the following website: http://www.ifremer.fr/drvecohal/fisboat/.

Scenario 4. Combination of measures or mixed scenario, in which the complementary and synergistic action of the individual measures mentioned hitherto, applied simultaneously, was envisaged.

With reference to the decommissioning plan, the aforementioned tables illustrate capacity levels as calculated for the management plans and the planned reductions in GT during the implementation period. In the economic model such reductions have been calibrated with the planned reductions in fishing effort deriving from the application of the temporary withdrawal of fishing activity and mesh size restrictions in order to obtain a combined effect in the mixed scenario.

Whereas, for some pelagic fisheries, model simulations indicated a need for stronger reductions in fishing effort to achieve the biological target reference points, given the insufficient availability of financial resources, it was established an homogenous reduction of 3% in GT and 15% in fishing days. However, these measures should make possible to achieve the biological limit reference points.

Table 2 – Management plans (demersal fisheries)

DEMERSAL FISHERIES		**Decommissioning plan**				**Temporary withdrawal**	**Variation in selectivity of gears**
GSA	**MANAGEMENT PLAN**	**Fishing system**	**Current GT (Fleet 31/12/06)**	**%GT change**	**GT change**	**Days**	**Net size**
9	Trawling and other systems Ligurian Sea, Northern and Central Tyrrhenian Sea GSA9	Trawling	13188	8	1056	45	50 mm
		Other systems	3842	5	192.1		
10	Trawling and other systems Central-Southern Tyrrhenian Sea GSA10	Trawling	4872	23	1121	45	50 mm
		Other systems	3855	10	386		
11	Trawling and other systems Sardinia GSA11	Trawling	9511	8	761	45	50 mm
		Other systems	3814	5	191		
16	Trawling Sicilian Strait GSA16	Trawling > 18m overall length	25959	25	6490	45	50 mm
17	Trawling and other systems Central and Northern Adriatic GSA17	Trawling	35523	8	2842	45	50 mm
		Other systems	12414	5	621		
18	Trawling and other systems Southern Adriatic Sea GSA18	Trawling	14446	27	3944	45	50 mm
		Other systems	2374	10	237		
19	Trawling and other systems Ionian Calabria and Ionian Puglia GSA19	Trawling	4127	22	908	45	50 mm
		Other systems	2106	10	211		
9, 10,16	Trawling and other systems Sicily	Trawling <18m overall length	13108	25	3277	45	50 mm
		Other systems	11857	10	1186		

Table 3 – Management plans (pelagic fisheries)

PELAGIC FISHERIES			Decommissioning plan		Temporary withdrawal	
GSA	**MANAGEMENT PLAN**	**Fishing system**	**Current GT (Fleet 31/12/06)**	**% GT change**	**GT change**	**Days**
9, 10,16	Pelagic trawling and seine fishing Sicily	Pelagic trawling and seine fishing	3676	3	110	20 (-15%)
10	Pelagic trawling and seine fishing Central-Southern Tyrrhenian Sea GSA10	Pelagic trawling and seine fishing	1433	3	43	9 (-15%)
17, 18	Pelagic trawling and seine fishing Adriatic Sea GSA17, 18	Pelagic trawling and seine fishing	16155	3	428	22(-15%)
9	Pelagic trawling and seine fishing Ligurian Sea, Northern and Central Tyrrhenian Sea GSA9	Pelagic trawling and seine fishing	1756	3	53	14 (-15%)

Implementation

A preliminary step for the implementation of a management plan is its submission to the European Commission. In accordance with Regulation (EC) n.1967/2006, given the information included in the plan and scientific advice provided by other sources, the Commission evaluates the management plan and verifies if this is suitable to ensure a high level of protection of resources and the environment. Based on this evaluation, the Member State (MS) can be required to amend the plan or specific management measures can be suggested by the EC.

When a management plan is considered acceptable by EC, the MS can proceed with its implementation by issuing a specific ministerial decree.

The Italian management plans were submitted to the Commission in October 2008.

Monitoring

The monitoring system will be used in order to control the timing of the plans and improve the design and the future implementation of plans. This represents a necessary step in order to ensure transparency and accountability to the programming process.

During the period covered by the plans, predicted values will be compared with the real biological and socio-economic indicators on the basis of the databases sourced by the National Programme[6] for fishery data collection. Any delays in implementing the programme and/or failure to pursue the biological objectives will

[6] COUNCIL REGULATION (EC) No. 199/2008 of 25 February 2008 concerning the establishment of a Community framework for the collection, management and use of data in the fisheries sector and support for scientific advice regarding the Common Fisheries Policy.
COUNCIL REGULATION (EC) No. 1543/2000 of 29 June 2000 establishing a Community framework for the collection and management of the data needed to conduct the Common Fisheries Policy.
COMMISSION REGULATION (EC) No. 1639/2001 of 27 July 2001 establishing the minimum and extended Community Programmes for the collection of data in the fisheries sector and laying down detailed rules for the application of Council Regulation (EC) No. 1543/2000.

constitute grounds for a re-examination by the management authority. In particular, the results of the scientific monitoring work will be communicated to the management authority in order to investigate the reasons of gaps and engage in any reprogramming of target values.

The change in fishing capacity will be monitored from the fleet register and individual units will be removed from the register. The consolidated procedures underlying implementation of the permanent withdrawal measure, only allowed to vessels engaged in fishing during the two preceding years, foresees the certification by the port authority, Temporary withdrawal of fishing activity will be monitored through the delivery of logs to the corresponding port authorities. In this case the number of days of effective withdrawal will constitute the indicator for monitoring the measure and its corresponding impact on resources will be the subject to a scientific report at the end of each temporary withdrawal period.

With reference to the state of biological resources, the effects of the measures adopted will be evaluated by estimating abundance indexes for the total population, reproducers and recruits, total mortality rates (Z), fishing mortality rates (F), exploitation rates (E) and the ratio between the exploited and unexploited biomass of reproducers (ESSB/USSB). These values will be related to suitable biological reference points in order to evaluate the effectiveness of the management measures in returning fishing activities to conditions of greater sustainability.

3. THE SIMULATION MODEL

As reported above, the simulation model consists of two stand-alone sub-models. However, they are connected by the level of landings predicted by the biological model for each of the main target species. The estimated landings represent an output of the biological model and an input to the economic one. In this section, the economic model is described, while a detailed description of the ALADYM model can be found in Lembo et al., 2007.

The economic model is a dynamic simulation model which assesses the impacts on socio-economic indicators deriving from the implementation of the measures proposed in the management plans. The bio-economic model is able to simulate a number of different scenarios consisting in specific management measures or combinations of management measures.

The main equations in the model relate to the dynamics of prices and costs. Each equation has been tested on the basis of available historical series of data in order to check that the functional relationships are correctly specified. Each parameter and variables starting value has been calculated as an average in the period 2004-2006, which represents the reference baseline.

Estimate of production and fishing effort

For each scenario, the ALADYM model estimates catches for each of the main target species. Assuming that the landings of these species represent a constant percentage of corresponding catches (assuming a constant percentage of discards into the sea), landings are simulated on the basis of the percentage changes in catches deriving from the simulations performed by the biological model.

For the generic species j, annual landings at time t, $S_{j,t}$, are obtained by applying the percentage change in catches since time $t\text{-}1$, $C_{j,t-1}$, to time t, $C_{j,t}$, to the landings observed or estimated at time $t\text{-}1$, $S_{j,t-1}$:

$$S_{j,t} = S_{j,t-1} * \left(\frac{C_{j,t}}{C_{j,t-1}} \right). \qquad (3.1)$$

Equation 3.1 estimates total landings by the entire fleet for each of the main target species. However, from an economic point of view it is essential to know the production by fleet segment. To this end, a specific procedure has been defined to estimate the quota of landings which is to be attributed to trawling (pelagic trawling and seine fishing) and "other systems" in demersal (pelagic) fisheries. Both the production levels by fleet segment estimated in the years preceding the simulation period and the effects the planned management measures might have on the fishing effort of the two fleet segments have been taken into consideration in this procedure.

Where one of the two fleet segments have on average produced more than 99% of total landings for a specific species in the past, all landings are attributed to that fleet segment. On the other hand, where the contribution of both segments of the fleet is not negligible, a subdivision has been made assuming that the ratio between landings per unit of effort (CPUE) for the two segments of the fleet is constant over time.

Total production for a particular species *j* is given by the sum of the production relating to the two segments of the fleet, $S'_{j,t}$ and $S''_{j,t}$.

$$S_{j,t} = S'_{j,t} + S''_{j,t}. \tag{3.2}$$

Multiplying and dividing the first term on the right-hand side of equation 3.2 by the level of effort for the first fleet, and assuming that the ratio between the CPUE for the two segments of the fleet is constant and equal to λ:

$$S_{j,t} = \frac{S'_{j,t}}{E'_t} E'_t + S''_{j,t}, \tag{3.3}$$

$$\lambda = CPUE'/CPUE'' = \frac{S'_{j,t}}{E'_t} \Big/ \frac{S''_{j,t}}{E''_t}, \tag{3.4}$$

equation 3.2 can be rewritten as follows:

$$S_{j,t} = \lambda \frac{S''_{j,t}}{E''_t} E'_t + S''_{j,t}. \tag{3.5}$$

From equation 3.7, the production for the second segment of the fleet can be expressed in terms of the fishing effort of the two fleet segments, the total production and the ratio between the CPUEs of the first and the second fleet segment:

$$S''_{j,t} = \frac{E''_t}{E''_t + \lambda E'_t} S_{j,t} \tag{3.6}$$

The production for the first fleet segment can then be calculated as a difference:

$$S'_{j,t} = S_{j,t} - S''_{j,t} \tag{3.7}$$

Equation 3.6 is used to vary the quotas of total estimated landings between the two segments of the fleet given the changes in fishing effort due to the implementation of the management measures. Fishing effort is calculated as the product of gross tonnage (GT) and the average number of days at sea per boat (gg_t/N_t), both permanent and temporary withdrawal of fishing activity are taken into account in the subdivision of total production:

$$E_t = \frac{gg_t}{N_t} GT_t \tag{3.8}$$

Price dynamics

Prices are estimated by species and fleet segment as a function of landings. The functional relationship between prices and landings for each species and fleet segment has been defined using a flexibility coefficient representing the percentage change in prices due to a one percent change in landings[7]. The price-quantity relationship has been specified by various formulae in the literature (Huang, 2005). On the basis of the regressions operated on the data collected for the Italian fisheries, the following functional form has been adopted:

$$P_{j,t} = P_{j,0}\left(\frac{S_{j,t}}{S_{j,0}}\right)^{\varepsilon}, \qquad (3.9)$$

where ε represents the flexibility coefficient for a given species and a given fleet segment. In equation 3.9 the annual price $P_{j,t}$ of species j is a function of the mean annual relative price $P_{j,0}$, the estimated landings for the year t, $S_{j,t}$, and the mean annual landings in the period 2004-2006, $S_{j,0}$.

Sector studies (Nielsen, 2000) confirm that the flexibility coefficient is normally between -0.1 and -0.4. These investigations assume that the flexibility coefficient is around -0.2 on average, which means that given a 1% fall in the production of a given species, it is assumed an increase in price of 0.2%. For the Italian management plans, flexibility coefficients have been estimated for each of the main target species. The results are reported in Table 4.

Table 4 - Flexibility coefficient for the main target species

Species	Flexibility coefficients
European Hake	-0.37
Striped Mullet	-0.22
Deepwater rose shrimp	-0.20
Norway lobster	-0.44
Anchovy	-0.30
Sardine	-0.32

Estimate of revenues

Revenues by species are obtained as the product of the mean annual price and the landings for a particular species. For each fleet segment total revenues should be obtained by summing the revenues calculated for individual species. In general, given the large number of species caught in the Mediterranean, it is not possible to obtain a reliable estimate of landings for each of them. The sum of the revenues relating to the main target species represents just a fraction of total revenues. However, when this value represents a sufficiently stable percentage of total revenues over time, it can be multiplied by a constant parameter to obtain total revenues.

Assuming the biological model is able to estimate landings for n target species. Assuming also that revenues by secondary species (those not included in the biological model) represent a constant percentage (rr) of revenues by target species, total revenues RT can be estimated using the following equation:

$$RT_t = (1+rr)\sum_{j=1}^{n} P_{j,t}S_{j,t}\ . \qquad (3.10)$$

[7] In economic terms, the prices flexibility coefficient is the reciprocal of the demand elasticity coefficient which considers quantities produced as a function of prices. On the other hand, in statistical terms, in which the stochastic disturbance component is considered, this inverse relationship cannot be verified.

The parameter *rr* is calculated as an average value in the period 2004-2006.

Costs dynamics and estimate of gross profit

The costs of each fleet segment are broken down into the following four groups:

- variable costs,
- fixed costs,
- labour cost,
- depreciation and interests.

Variable costs are then classified under three headings: fuel and lubricant costs, commercial costs and other variable costs. Fuel costs *Cc* are estimated as a function of the fishing effort *E* and the fuel price *Pc*. The former, identified as *Cc* (fuel costs), and the other variable costs (*Acv*) are a function of the fishing effort, (that is, tonnage multiplied by average days):

$$Cc_t = \alpha_1 E_t Pc \,. \tag{3.11}$$

Other variable costs *Acv* are estimated as a direct function of fishing effort:

$$Acv_t = \alpha_2 E_t \,. \tag{3.12}$$

Commercial costs (*Cco*) are defined as a function of the total revenues for the fleet segment:

$$Cco_t = \alpha_3 R_t \,. \tag{3.13}$$

Variable costs (*CV*) can also be estimated in an aggregate way as follows:

$$CV_t = \alpha_1 E_t Pc + \alpha_2 E_t + \alpha_3 R_t = (\alpha_1 Pc + \alpha_2) E_t + \alpha_3 R_t \,. \tag{3.14}$$

Fixed costs are assumed to be a function of the gross tonnage *GT* and are independent from the level of the activity: considered to be independent of fishing effort:

$$CF_t = \beta TSL_t \,. \tag{3.15}$$

The labour cost *CL* has been estimated to be proportional to revenues *R*:

$$CL_t = \delta(R_t) \,. \tag{3.16}$$

Gross profit (*PL*) is obtained by subtracting labour and intermediate costs, i.e. the total of variable and fixed costs, from revenues:

$$PL_t = R_t - (CV_t + CF_t + CL_t) \,. \tag{3.17}$$

Added value is calculated as total revenues less variable costs and fixed costs. On the basis of equation 4.19, this can also be obtained from the sum of gross profit and labour cost:

$$VA_t = R_t - (CV_t + CF_t) = PL_t + CL_t \,. \tag{3.18}$$

Depreciation and interest are estimated by a simplified approach where they are supposed to be proportional to the gross tonnage *GT*:

$$AM_t + I_t = \gamma GT_t \,. \tag{3.19}$$

Thus, net profit *PN* can be obtained using the following equation:

$$PN_t = PL_t - AM_t - I_t . \quad (3.20)$$

4. THE CASE OF TRAWLING FISHERY IN GSA 10

This management plan applies to fishing vessels registered in the maritime areas of Campania and Tyrrhenian Calabria authorised for trawling or "other" fishing systems (mainly passive gear and long line) active in demersal fisheries. The main target species include European hake (*Merluccius merluccius*), striped mullet (*Mullus barbatus*), deepwater rose shrimp (*Parapenaeus longirostris*), Norway lobster (*Nephrops norvegicus*) and giant red shrimps (*Aristaeomorpha foliacea* and *Aristeus antennatus*).

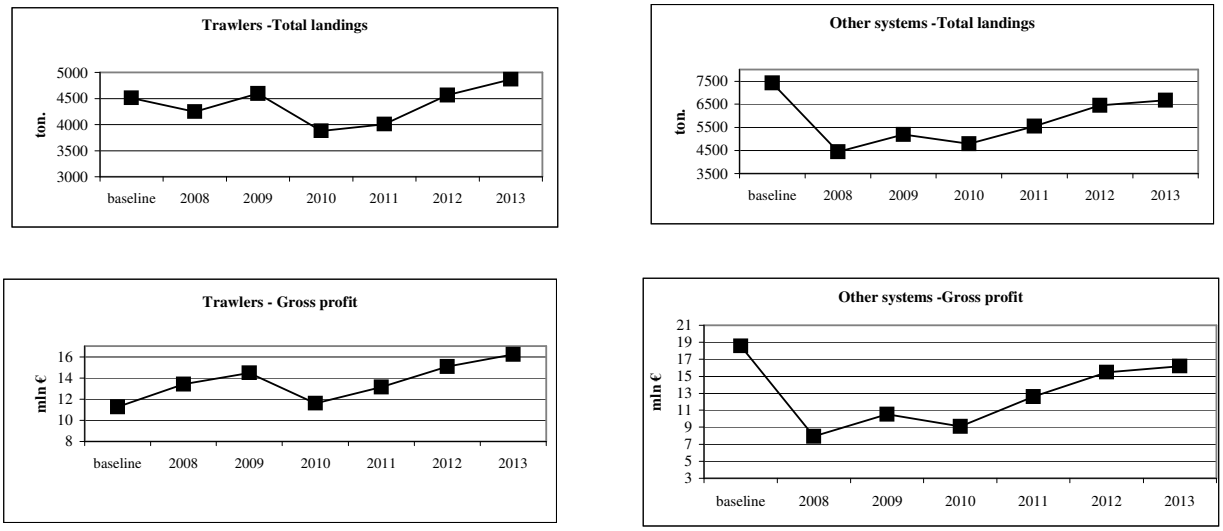
The trawling fleet consists of 171 boats having an overall tonnage of almost 5000 GT and an engine power of almost 30,000 kW for a total of 487 people employed. This represents an 11% of the number of vessels operating in the area, and a 44% of the total GT of the fleet. A significant part of the production both in weight and in value is produced by trawling vessels. In 2006 trawlers production amounted to almost 6000 metric tons (45.77 million euro in value), a third of the total landings in the area and a 41% of total revenues. More than a 60% of landings is composed by fishes, while the remaining part is equally distributed between crustaceans and molluscs. On the total production, the three main target species, European hake, striped mullet and deepwater rose shrimp represent a 33% of total landings and a 48% of total revenues.

The group of vessels belonging to the fleet defined as "other systems" consists of 1,362 units having an overall tonnage of 3,942 GT and an engine power of 46,055 kW for a total of 2,326 people employed. This fleet represents 85% of the total number of vessels operating in the area. In 2006, their production was estimated in 6,278 metric tons, equivalent to a value of 50.56 million euro. More than 90% of the vessels belonging to this fleet are small fishing boats less than 12 metres length, which use passive gears like drift nets, lines, pots and other traditional techniques.

The biological objective for the demersal species in GSA 10 was the reduction of the exploitation rate (weighted for a pool of species: hake, mullet, deepwater pink shrimp) from 0.66 (current level) to 0.35 (target reference value). Four simulation scenarios have been simulated to estimate the effects of the different management measures included in the plan. For each scenario, given the results on the biological variables estimated by the ALADYM model, the economic model was used to estimate the changes over time in total landings and other economic and social indicators (income, gross profit, remuneration of labour).

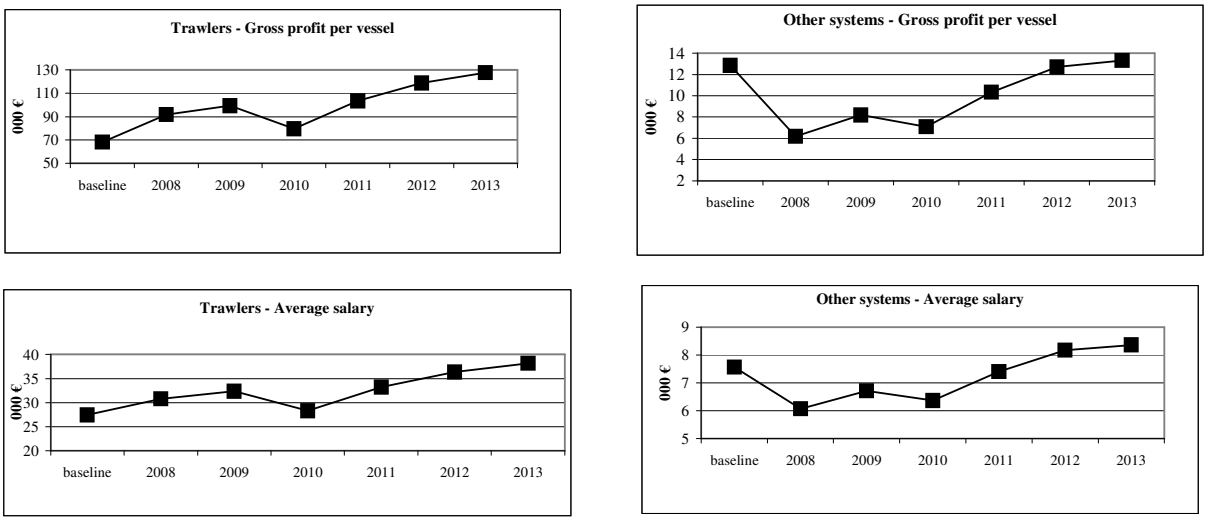
Graphs 1 and 2 show the simulation outcomes for the mixed scenario (all management measures included) compared with a baseline represented by the average values in the period 2004-2006.

Graph 1 – Demersal GSA 10 – Mixed scenario simulation outcomes



Graph 1 indicates that the implementation of the plan should produce a reduction in total landings in the period 2008-2010 for both trawlers and "other system". On the contrary, in the second period, from 2010 to 2013, landings should increase for both fleets. This increase will be particularly relevant in the last two years of the simulation period. From 2011 to 2013, an increase of more than 20% is predicted in landings for both fleets. While landings dynamic is similar for both fleets, relevant differences have been predicted for gross profit. In the first two years the gross profit of trawlers shows a significant increase of 29% compared with the baseline. An increasing trend is also predicted in the second part of the simulation period, with the exception of the year 2010 when profits fall down probably as a consequence of the implementation of the mesh size restrictions. As for "other systems", profits show a strong reduction in the period 2008-2010 compared with the baseline. However, from 2011 an increasing trend is expected also for this fleet.

Graph 2 – Demersal GSA 10 – Mixed scenario simulations results (average values)



Graph 2 shows the simulated effects of the mixed scenario on gross profit per vessel and average salary per man employed. As labour costs are estimated as a fixed percentage of revenues, it is not surprising that the two indicators show similar dynamics. As for trawlers, the increasing trend predicted for both indicators

should produce an improvement of 87% and 39% in gross profit and salary respectively in 2013 compared with the baseline. As for "other systems", the two indicators should rise from 2011 after a reduction in the first three years of the simulation period. Compared with the baseline, increases of 3.6% and 10.5% in gross profit and salary respectively are registered for 2013.

Table 5 – Expected results in 2013 for trawlers

(% variations with baseline)				
Trawlers	Permanent withdrawal	Activity Temporary withdrawal	Mesh size restriction	**Mixed scenario**
Total landings	7.7%	7.1%	27.5%	**7.9%**
Total income	9.0%	8.7%	21.2%	**7.8%**
Gross profit	33.2%	26.3%	33.4%	**44.1%**
Trawlers	Permanent withdrawal	Activity Temporary withdrawal	Mesh size restriction	**Mixed scenario**
Landings per vessel	39.4%	6.8%	27.1%	**39.7%**
Income per vessel	41.0%	8.2%	20.7%	**39.4%**
Gross profit per vessel	72.7%	26.1%	33.1%	**86.9%**
Average salary	40.7%	8.0%	20.4%	**39.1%**

Tables 5 and 6 show the expected impacts in 2013 deriving from each of the four scenarios. The results are expressed in percent variations of the baseline values. As for the trawl system (Table 5), mesh size restriction seems to be the management measure producing the most relevant increase in total landings, total income and gross profit. However, when average values per vessels are considered, permanent withdrawal produces the best results. Given the reduction in the number of vessels foreseen in the first scenario, we can say that permanent withdrawal performs better for the vessels remaining in the fleet. Finally, results from the mixed scenario show that combining the three management measures can produce a further improvement in gross profit both for the entire fleet and by single vessel.

Table 6 – Expected results in 2013 for other systems

(% variations with baseline)				
Other systems	Permanent withdrawal	Activity Temporary withdrawal	Mesh size restriction	**Mixed scenario**
Total landings	-37.6%	-31.7%	-28.1%	**-10.0%**
Total income	-26.9%	-22.7%	-19.7%	**-7.2%**
Gross profit	-49.0%	-50.6%	-45.1%	**-12.7%**
Other systems	Permanent withdrawal	Activity Temporary withdrawal	Mesh size restriction	**Mixed scenario**
Landings per vessel	-25.9%	-27.1%	-23.2%	**6.9%**
Income per vessel	-13.3%	-17.4%	-14.2%	**10.1%**
Gross profit per vessel	-39.5%	-47.2%	-41.3%	**3.6%**
Average salary	-12.9%	-17.1%	-13.9%	**10.5%**

Simulations performed for the vessels belonging to the non-trawling fleet show reductions in all indicators independently o the management measure adopted. However, the combined use of different measures seems to mitigate the negative effects on the economic variables. The implementation of the mixed scenario would result in a decrease of 10% and 7.2% in total landings and total income respectively, while the total gross

profit would decrease by 12.7%. The positive effects of the combination of different management measures is even more evident when average values per vessels are considered. In this case, mixed scenario would produce an increase in all indicators.

5. FINAL CONSIDERATIONS

Italian adaptive management plans represent an important step towards a more effective management approach in accordance with the guidelines expressed at Community level. They are the result of a long process of research and analysis based on the use of bio-economic models specifically structured for the Mediterranean Sea. In the light of a shift from "Stock" to Fishery/Area plans (Lindebo, 2009), the socio-economic objectives are examined within biological constraints.

One of the main achievements of the management plans for the Italian fisheries is represented by the attempt to shift the management unit from "Stock" to "Fishery-Area". As Mediterranean fisheries are generally multi-species, an exploitation index estimated as a weighted sum of the exploitation rates for a pool of species has been used to define biological target and limit reference points. Given the biological objectives, different management scenarios have been simulated to find the optimal combination of management measures satisfying the biological constraints at the minimum cost in both economic and social terms. To this end, a specific bio-economic simulation model has been used.

Whereas bio-economic models are widely used to simulate the effects of potential management measures, a level of uncertainty is always included in their estimations. For this reason, it is particularly important to check that the model output has an 'error' within reasonable bounds. The bio-economic model used for the Italian management plans represents necessarily a simplification of the real world. However, some arrangements can be made to improve the model reliability. In particular:

- the biological and the economic sub-models should be further integrated to make possible that the biological component, which actually produces outputs to the economic one, could also receive inputs from the economic component;
- the number of species used to simulate landings dynamic should be increased from the actual three main species to a set of species covering at least a 50% of total landings and revenues for each of the fleets included in the plan;
- the number of management measures simulated by the bio-economic model should be enlarged from the actual three main measures, permanent withdrawal, temporary withdrawal of fishing activity and mesh size restrictions, to all measures included in the plans.

Furthermore, an evaluation of the model predictive capacity will be possible by the implementation of the management plans and the development of the monitoring process. Comparing the model outputs to the real outcomes collected year by year in the period 2008-2013 will allow to highlight errors in both the model structure and parameter estimates. When the model outputs will diverge substantially from the estimates from other sources, adjustments will be required. This process will give confidence to model performance, and lead to the improvement of the predictive capacity of the model.

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