SCIENTIFIC COOPERATION TO SUPPORT RESPONSIBLE FISHERIES IN THE ADRIATIC SEA

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Applicability and performance of some biological and economic indicators for the Adriatic Sea trawl fisheries in the western GFCM GSA 18

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Abstract

This paper analyses the state of trawl fisheries in the Southern Adriatic Sea (FAO Geographical Sub Area 18) from a biological, economic and social point of view. The analysis was performed using a set of forty-six indicators, twenty-one of which belong to the category of biological (population and community) indicators to be obtained from fishery-independent data and the remaining twenty-five are of socio-economic nature and of fishery-dependent origin. Biological indicators and relative estimators were classified for the single species (population level: *Eledone cirrhosa*, *Eledone moschata*, *Illex coindetti*, *Merluccius merluccius*, *Mullus barbatus*, *Nephrops norvegicus*, *Parapenaeus longirostris*, *Raja clavata*, and *Zeus faber*) as well as for the multispecies approach (community level). Economic indicators include six indicators on economic performance, eight on productivity, four on costs and prices, and one general indicator summarising economic sustainability. From the social point of view, five indicators plus one general indicator summarising social sustainability are defined. Particular attention was devoted to the selection and analysis of sustainability indicators. The standard distinction among biological, economic, and social sustainability has been held in this paper. Trends of these indicators were analysed using the so-called Traffic light system. Reference values were set according to their percentile value in the following series: > 66th percentile, 66th-33rd, and < 33rd percentile. Based on each specific indicator, the three standard colours, green, yellow, and red, were assigned to the three areas defined by the reference values at 33rd and 66th percentiles. The analysis was performed by using data available from the MEDITS surveys project and from IREPA monitoring system in the basin concerned. The period under consideration goes from 1996 to 2003. The inclusive discussion of the results from both fishery-independent and fishery-dependent data analysis underlines some common features. In fact, an apparent and progressive deterioration seems to affect the trawl fishery system in the GSA 18 during the investigated period, according mainly to the variation in catch composition (increasing of r-strategist species and decreasing of k-strategist ones) and to the trajectories of some socio-economic indicators.

Keywords: Demersal fisheries; Indicators; stock assessment; Fishery management; Models; Adriatic Sea; Mediterranean Sea

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1. Introduction

The use of progress indicators is a common rule to measure the present state of every earth system (Eldredge, 2002). Indicators represent a valid tool to support the decision making process in fishery management also, as it is widely discussed and treated into many scientific and technical documents, as well as in many fora (FAO, 1999b; MOFI/ALMVRV/SEAFDEC/FAO, 2001; Raakjær et al., 2001; United Nations, 2001).

An indicator has been defined as: "*a variable, pointer, or index related to a criterion. Its fluctuation reveals variations in key elements of sustainability in the ecosystem, the fishery resource or the sector and social and economic well-being. The position and trend of an indicator in relation to reference points indicate the present state and dynamics of the system. Indicators provide a bridge between objectives and actions*" (FAO, 1999a).

Indicators are useful to draw an accurate picture of fisheries from a biological, economic and social point of view. Moreover, an evaluation of the state of fisheries through time can be obtained by comparing indicators to appropriate reference points. As reported in (Caddy & Mahon, 1995), these values should be associated with either a critical or an optimal state, where the former identifies a limit which is necessary to avoid (LRPs, limit reference points) and the latter a target to be attained by the system (TRPs, target reference points). Nevertheless, LRPs and TRPs are not identifiable for many indicators, or the data needed for estimation are not available in many fisheries.

An attempt to define a general list of indicators and reference points in fishery was made by FAO in the Technical Guidelines for Responsible Fisheries (FAO, 1999b). Among the reference points proposed, only in a few cases TRPs were defined in accordance to general concepts in fishery sustainable literature, such as MSY (Maximum Sustainable Yield) and MEY (Maximum Economic Yield), while most of them were defined by the indicators historical level. However, the use of historical levels represents a very suitable method for highlighting the presence of trend and evaluating the state of fisheries through time.

Nowadays, the necessity to identify, select and test some biological and economic indicators (and their associated reference values) is considered relevant for the fishery management and it is becoming a priority for many fisheries (Bonzon, 2000; Christensen, 2000; Garcia & Staples, 2000; OECD, 2000; Halliday et al., 2001; Le Gallic, 2002; Des Clers and Nauen, 2002; Laë et al., 2004; Laloë, 2004; Raakjaier et al., 2006; Ungaro et al., in press).

The General Fisheries Commission for the Mediterranean (GFCM) acknowledged the need to further fine-tune the list of performance indicators and related criteria to approach the fishery resource assessment (FAO-GFCM, 2005a). The same Institutional Body indicated as a priority for fishery research the assessment of shared stocks and the identification of biological indicators, establishing reference points and testing them on selected fisheries or Operational Unit (OU) (FAO-GFCM, 2005b).

Moreover, in sub-regional contexts where shared stocks occur, as is the case for the Adriatic Sea (Mediterranean), the use of internationally concurred indicators and reference values assumes critical importance to support cooperative management by the countries concerned (AdriaMed, 2005a).

The main target of the scientists and managers involved in the task is the identification of the a set of indicators in coherence with some of the following well established criteria and desirable properties (FAO Fishery Resources Division, 1999b; MOFI/ALMVRV/SEAFDEC/FAO, 2001; Segnestam, 2002; Hall and Mainprize, 2004; Raakjaier et al., 2006; Rice and Rochet, 2005; Ceriola et al., 2006a; Ungaro et al., in press):

- Scientific validity in the sense they should be indicative of the objective they intend to reflect;
- Easy compilation and processing procedures;
- Reliable performance with respect to interactions between fishery, environment and resources;
- Applicability to different scenarios and capability to show response to management measures;
- Feasibility and cost-effectiveness in terms of data collection requirement;
- Comprehensibility and acceptability for all stakeholders;
- Easy integration and comparison to each other and with indicators from other sources.

Of course, most of the proposed indicators can fit some of the above mentioned desirable properties while they can give weak or misleading responses to the others assumptions (Rochet & Trenkel, 2003; Piet & Jennings, 2005). Moreover, the use of the fishery indicators' panel isn't well developed in the Mediterranean (Bonzon, 2000) where it is only related to the biological and ecological features (Bellail et al., 2003; Ragonese et al, 2005).

Results obtained from the analysis of indicators and reference points need to be represented in a clear and easily understandable way according to the criteria and desiderable properties listed above. The so called "Traffic Light" (TL) method (Caddy, 1998; Caddy, 2002) is a potentially powerful tool for developing, displaying and integrating technical information for management planning. This method has been used by Caddy (1998) to define a management system based on the precautionary approach for those fisheries characterized by scarcely available data (Caddy, 1998; Caddy, 2002).
The system of red, yellow and green colour displays time series in such a way that synchronous transitions in indicator values over a wide range of characteristics can be appreciated visually, and helps to identify likely relationships between variables. Moreover the TL methodology categorizes the indicators of the state of the resource, providing a single framework that summarise all the results, and makes them easy to understand by managers and stakeholders in relation to fishery management decisions (Caddy et al., 2005; Ceriola et al., 2006).
On the basis of the indication of the GFCM SAC and following the need to define new tools to support fisheries management and decision making process, these issues were widely discussed during the AdriaMed Working Group meeting on the Identification of Biological and Economical Indicators for Adriatic Sea Demersal Fisheries held in Fano, Italy, 2005. One of the tasks of the AdriaMed Working Group focused on the establishment of a first suite of simple indicators and their respective statistical estimators based on fishery-dependent and independent data to be applied in the Operational Units identified in the Adriatic Sea GSA 17 and 18. As follow up to the meeting, a methodology comprising both, the use of indicators and the Traffic Light methodology was approached in the framework of the AdriaMed Project, and applied by the Adriatic experts to the trawl fishery in the Southern Adriatic Sea.

Accordingly the analysis of the state of demersal fisheries in the GFCM GSA 18 (FAO-GFCM, 2001) from a biological, economic and social point of view is undertaken in the present study using data coming from the MEDITS (Mediterranean Trawl Surveys) project and from IREPA (Institute of Economic Research in Fishery and Aquaculture) monitoring system through the collaboration between AdriaMed and IREPA.
A period of eight years, from 1996 to 2003, has been analysed by using both biological (population and community) indicators from fishery-independent data and socio-economic nature ones (fishery-dependent data). The socio-economic aspects have been analysed using two types of indicators: indicators to evaluate the state of the fisheries and indicators to measure fisheries sustainability. For the first group, historical levels of the indicators have been used as reference values, while for the second group ad hoc LRPs have been identified. Finally, the results were reported by using the "traffic light" representation (Caddy, 1998; Caddy, 2002).
Hence, the chosen approach is intended to provide a comprehensive understanding of the evolutionary state of fishery in the Southern Adriatic Sea, widening the classical biological approach by using also a number of socio-economic indicators to evaluate the actual condition of the fisheries and to measure fisheries sustainability.

2. Material and Methods

2.1. Investigated area

The Adriatic Sea may be considered as a semi-enclosed basin within the Mediterranean Sea. It is characterised by an extended continental shelf in the Northern and Central part while the continental slope is mostly found in the Southern part. Mostly of the wide shelf and the upper slope are characterised by soft bottoms (sandy-muddy sediments), which cover a large area moving away from the coast. These features have made the Adriatic particularly suitable for trawl fishery, both bottom and beam trawling for demersal species, mid-water pair trawl for small pelagic fish and dredgers for clams.

Two Geographical Sub Areas (GSA) have been defined in the Adriatic Sea for management purposes, GSA 17 (North and Central Adriatic) and GSA 18 (Southern Adriatic) (FAO-GFCM, 2001). This study covers the Italian fishing zone within the GSA 18 (Figure 1), and it is focused on the Italian bottom trawl fleet operating there.

2.2 Trawl fishery and Operational units in the GSA 18.

In 2003, 415 bottom trawl Italian vessels were active in this area, with a gross tonnage of 12,622 GRT and an engine power of 81,965 kW, representing a quota of 22% of the total demersal fleet of Puglia in terms of number and 62% in terms of GRT. In the same year, 15,537 t of fish, around 45% of total demersal landings, for a value of 77.47 MEuros were produced by this fleet segment (IREPA, 2003). The same active fleet in the GSA 18 can be subdivided in three partitions according to the concept of Operational Units, this last established in order to facilitate the fishery assessment and management in a view of a sustainable development (AdriaMed, 2004).

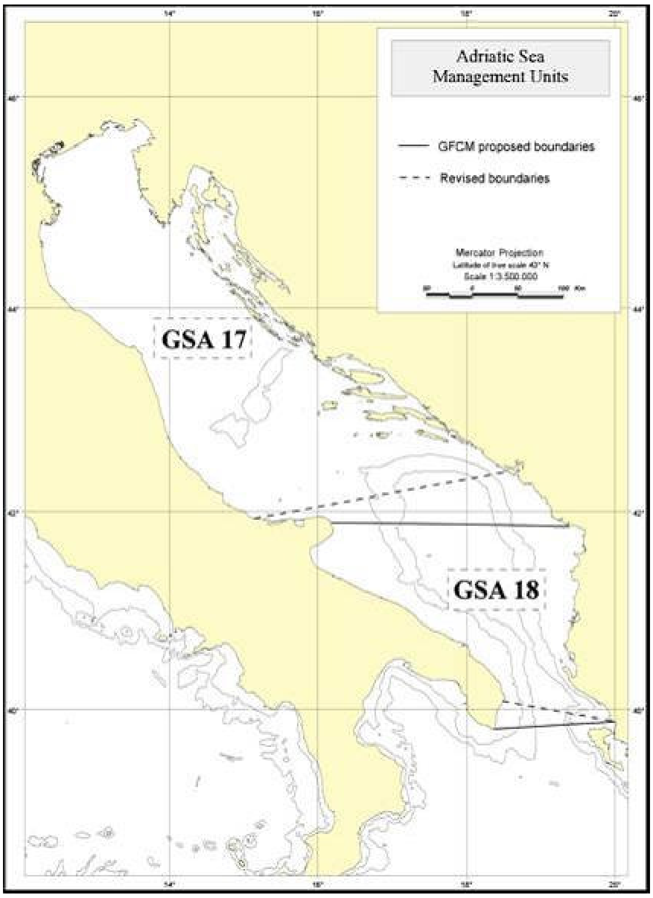

Figure 1. GFCM Geographical Sub Area 17 (North and Central Adriatic) and 18 (Southern Adriatic Sea).

2.3 Data sources

The biological fishery-independent data came from the MEDITS surveys carried out in the GSA 18 from 1996 to 2003. The trawl surveys were carried out during the spring-summer season in the framework of the Medits Programme, according to a specified protocol (Bertrand et al., 2002).

The socio-economic data came from the IREPA (Institute for Economic Research on Fisheries and Aquaculture) monitoring system for the years from 1996 to 2003. The IREPA monitoring system for economic data on the Italian fishery sector is based on three main modules: fishing effort and activities, landings and prices by species, and economic data. All the data within these modules are collected through a National Monitoring System based on a unique sample. A number of vessels are monitored each week and elementary data are later expanded to the universe (the whole Italian fleet) using statistical sampling procedures (for more details, see IREPA, 2001; IREPA, 2002).

2.4 The chosen indicators, data elaboration and results presentation.

With regard to the fishery-independent data (species populations and communities) the twenty-one indicators have been chosen according to the data availability and their intrinsic features (including the supposed reaction to the fishery exploitation)) and according to the list of indicators identified by the Adriatic experts during the AdriaMed Working Groups on Shared Demersal Resources meetings (AdriaMed, 2004, 2005). The indicator values were calculated using statistical estimators such as arithmetic and geometric mean, median, and 75th percentile, according to the results of a testing procedure carried out by AdriaMed (2005b) and Ungaro et al. (in press). The estimator values per each indicator were estimated according to the "indicators estimate guidelines" discussed and shared by the Adriatic experts (AdriaMed, 2004). The indicators list, with respective estimators and main characteristics, are described in tables 1 and 2.

Table 1: Biological (population) indicators on the state of fisheries and description.

Indicator	*Description*	*Variable*	*Estimator*	*Application level*	*Expected effect of fishing*	*Main advantages*	*Main disadvantages*
Frequency of occurrence (%)	The indicator measure the occurrence of a species within the catch, as the frequency of positive hauls over the total number of the hauls carried out during the survey.	%	percentage values	Population of a single species	Negative correlation. A decrease of the indicator value according to an increasing exploitation level is expected. The variance associated to the biomass estimates may increase in response to a decrease of occurrence. Due to this effect, an increase of the variance of the biomass estimates can be related to an increase of the exploitation level (Blanchard & Boucher, 2001).	Easily measurable	The performance of the indicator is strictly related to the sampling scheme. The best performance is provided for species with a homogeneous distribution.
Biomass Index	Biomass of a species per unit area	Kg Km^{-2}	Geometric mean, percentile	Population of a single species	Negative correlation. A decrease of the biomass index according to an increasing exploitation level is expected (Heesen & Daan, 1996; Rijnsdorp et al., 1996; Jennings et al., 1999).	Easily measurable	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator
Abundance Index	Number of individuals of a species per unit area	number of individuals Km^{-2}	Geometric mean, percentile	Population of a single species	Negative correlation. A decrease of the biomass index according to an increasing exploitation level is expected (Heesen & Daan, 1996; Rijnsdorp et al., 1996; Jennings et al., 1999).	Easily measurable	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator; the indicator describes population as a whole, thus an increase of the juveniles (strong recruitment) may mask the decrease in the other fractions of the population (medium age-adult individuals).
Recruitment Index	Number of recruits to the fishery gear per unit area. To estimate the indicator value a preliminary definition of the threshold size for the recruits' fraction is needed.	number of recruits Km^{-2}	Geometric mean, percentile	Population of a single species	Negative correlation. A decrease of the recruitment strength according to an increase of the exploitation level is expected.	The indicator allows to define the effective level of the recruitment to the fishery gear.	The response information may depend on the criterion adopted to identify the recruits; in many cases the environmental condition may positively affect the recruitment (e.g. promoting enhanced juvenile survival) even in an overexploited population.
Spawner density index	Number of potential spawner per unit area. To estimate the indicator value a preliminary definition of the threshold size to identify the spawners' fraction of the population is needed. The size of the smaller mature female recorded in the area, or the length at 50% of mature ($L_{50\%}$ may be considered two potential criteria.	number of spawners Km^{-2}	Geometric mean, percentile	Population of a single species	Negative correlation. By targeting mostly the older and larger individuals (the spawners) in a population, fishing can produce a decrease of the indicator. The estimate of the indicator is generally 20-30% smaller for an exploited population than for a virgin (unexploited) population; a lower number of spawners may negatively affect the recruitment process (Rochet & Trenkel, 2003).	The indicator allows to define the effective strength of the potential spawner fraction in a population.	The response information may depend on the criterion adopted to identify the potential spawners; in some cases the $L_{50\%}$ is not easy to estimate, and may depend from many factors (e.g. the adopted maturity scale, the size interval considered, and the sampling period).
Mean body weight	Individual mean body weight. The indicator is estimated by using the biomass and abundance data.	Kg; g.	Total sample weight total sample number ratio.	Population of a single species	Negative correlation. By removing mostly the older and larger individuals fishing can produce a decrease of the population mean body weight (Rochet & Trenkel, 2003).	The indicator value is easily measurable when the abundance and biomass estimates are available.	The indicator is strictly related to the recruitment fluctuations (negative correlation): it can increase (or decrease) according to a weak (or a strong) recruitment, even in an unexploited population; it would be appropriate to consider individuals larger than a minimum size only.
Mean body length	Mean length of the population. In some cases the exclusion of the recruits' fraction of the population from the computation of the Lmean may be useful.	cm; mm	Arithmetic mean; median	Population of a single species	Negative correlation. By removing mostly the older and larger individuals, fishing can produce a decrease of the Lmean (Haedrich & Barnes, 1997; Babcock et al., 1999).	The indicator allows to appreciate visually the individual mean size of the population.	The indicator is strictly related to the recruitment fluctuations (negative correlation): it can increase (or decrease) according to a weak (or a strong) recruitment, even in an unexploited population; it would be appropriate to consider individuals larger than a minimum size only. The use of the "median" instead of the "arithmetic mean" as statistical estimator is more appropriate in the case of very skewed length frequency distributions.
Mean body length excluding the recruits	Mean length of the population excluding the recruits' fraction.	cm; mm	Arithmetic mean; median	Population of a single species	Negative correlation. By removing mostly the older and larger individuals, fishing can produce a decrease of the Lmean (Haedrich & Barnes, 1997; Babcock et al., 1999).	The indicator allows to appreciate visually the individual mean size of the "larger sized" fraction of population.	The use of the "median" instead of the "arithmetic mean" as statistical estimator is more appropriate in the case of very skewed length frequency distributions.
Ratio between mean length and length at first maturity	Ratio between mean length and length at first maturity	Value	Lmean / Lmat ratio	Population of a single species	Negative correlation. A decrease of the indicator according to an increased exploitation level is expected. The reaction of Lmean to the fishing pressure is supposed to be faster than the reaction of the Lmat. In most species the Lmat variation requires some appropriate and not immediate biological and physiological adaptations (O.N.U., 2001).	The indicator value is easily measurable when the mean Lmean and the Lmat are available.	The estimate may be affected by the uncertainty in the Lmean and Lmat computation (see previous comments).

Table 2: Ecological (community) indicators on the state of fisheries and description.

Indicator	*Description*	*Variable*	*Estimator*	*Application level*	*Expected effect of fishing*	*Main advantages*	*Main disadvantages*
Total biomass index	Total biomass within the community.	Kg Km^{-2}	Geometric mean, percentile	Community	Negative correlation. A decrease of the total biomass index according to an increasing exploitation level is expected (Duplisea et al., 1997; Blanchard & Boucher, 2001; Rochet & Trenkel, 2003).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator.
Total abundance index	Total abundance within the community.	number of individuals Km^{-2}	Geometric mean, percentile	Community	Negative correlation. A decrease of the total abundance index according to an increasing exploitation level is expected (Duplisea et al., 1997; Blanchard & Boucher, 2001; Rochet & Trenkel, 2003).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium and long time series; the response information may depend on the adopted statistical estimator; the indicator describes the populations as a whole, thus an increase of the juveniles (strong recruitment) may mask the the decrease in the other fractions of the population (medium age-adult individuals).
Total biomass index excluding pelagic species	Total biomass within the community.	Kg Km^{-2}	Geometric mean, percentile	Community	Negative correlation. A decrease of the total biomass index according to an increasing exploitation level is expected (Duplisea et al., 1997; Blanchard & Boucher, 2001; Rochet & Trenkel, 2003).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator.
Total abundance index excluding pelagic species	Total abundance within the community.	number of individuals Km^{-2}	Geometric mean, percentile	Community	Negative correlation. A decrease of the total abundance index according to an increasing exploitation level is expected (Duplisea et al., 1997; Blanchard & Boucher, 2001; Rochet & Trenkel, 2003).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium and long time series; the response information may depend on the adopted statistical estimator; the indicator describes the populations as a whole, thus an increase of the juveniles (strong recruitment) may mask the the decrease in the other fractions of the population (medium age-adult individuals).
Biomass of the main target species	Biomass of the main target species per unit area	Kg Km^{-2}	Geometric mean, percentile	Community	Negative correlation. A decrease of the indicator along with an increasing exploitation level is expected (O.N.U., 2001).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator.
Cephalopods biomass index	Biomass of cephalopods per unit area	Kg Km^{-2}	Geometric mean, percentile	Community	Positive correlation. Considering the short life-span, the high adaptability, and the trophic level of cephalopods, an increase of the indicator in a highly harvested area is expected (Caddy & Garibaldi, 2000; Mannini et al., 2004).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator.
Small pelagics biomass index	Biomass of small pelagics per unit area	Kg Km^{-2}	Geometric mean, percentile	Community	Positive correlation. Considering the short life-span, the ecologic strategy, and the trophic level of small pelagics, an increase of the indicator in a highly harvested area is expected (Caddy & Garibaldi, 2000).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator. It is widely reported that the abundance of small pelagic species is mostly affected by the environmental conditions fluctuation (de Leiva Moreno et al., 2000).
Elasmobranch biomass index	Biomass of elasmobranchs per unit area	Kg Km^{-2}	Geometric mean, percentile	Community	Negative correlation. Considering the long life-span, the ecologic strategy, and the high trophic level of elasmobranchs, a decrease of the indicator in a highly harvested area is expected within a medium-long period of time (Holden, 1974; Walker & Hislop, 1998).	The indicator value is easily measurable when the data of all the populations are available.	The best performance is provided for medium- and long-time series; the response information may depend on the adopted statistical estimator.
BOI index (Bottom-dwelling fish/overall ratio index)	The indicator describes the ratio between the biomass of the strictly benthic (bottom-dwelling) fin-fishes, and the total biomass in the area. The bottom-dwelling species are identified according to their morphologic characteristics. The biomass of the auxiliary species (sporadic species) for a specific fishing activity may be excluded from the computation of the total biomass.	BOI Index	Bottom-dwelling fish/overall ratio index.	Community	Negative correlation. In some areas the decrease in biomass of the bottom dwelling fish, with respect to the overall biomass, has been related to an increased exploitation level (Gristina et al., 2004).	The indicator can describe some shifts in the fraction of the community exploited by the fishing activity.	The best performance is provided in a short- rather than in a medium- or long- time series. The indicator may not provide reliable results in areas that have been highly harvested for several years.
Ecological indices	Biodiversity Indices	Indices values	Margalef index Shannon index Pielou index	Community	Negative correlation. A decrease of the ecological indices, according to an increase of the exploitation level is expected (Jennings & Kaiser, 1998; Gislason et al. 2000; Raakjaier et al., 2006).	The indicator allows to detect the "biodiversity level" within a community.	The indices are not always easily measurable. In some cases it is not possible to find out/detect all the species within a community. The indices values should be compared if coming from the same habitats and sampling scheme (e.g. sampling density and hauls allocation).

Both biological indicators and their relative estimators were classified for the single species (*Eledone cirrhosa*, *Illex coindetti*, *Merluccius merluccius*, *Mullus barbatus*, *Nephrops norvegicus*, *Parapenaeus longirostris*, and *Zeus faber*) as well as for the multispecies approach (considering both the total number of caught species and a set of thirty four commercially relevant species in the Adriatic Sea, see at the table 3). The single species have been chosen considering both the relative importance for the fishery exploitation and the differences in the life cycles and resilience (Vrgoč et al., 2004).

The estimator values per each indicator were estimated according to the "indicators estimate guidelines" discussed and shared by researchers from all the Adriatic countries within the framework of the AdriaMed project (AdriaMed, 2005b). The whole procedure was previously tested on the basis of biological data by Ceriola et al. (2006a) and Ungaro et al. (in

press). More in details, the abundance, biomass and size data from trawl surveys to be used to calculate indicators' values were standardised by using the swept-area method (Sparre and Venema, 1998) in order to obtain the relative indices (kg km-^{2}; n° km-^{2}). The arithmetic mean and the geometric mean of the indices were weighted by sampled bathymetric stratum area in order to reduce the variance (Cochran, 1977 in Souplet, 1995).
The recruitment index was estimated according to the procedure reported by Fiorentino et al. (2003a). The individuals belonging to the 1st component of the poly-modal pooled length frequency distribution (LFD) by species and survey were considered as recruits. Moreover, the estimated threshold sizes for the recruits (the mean length of the 1st component of LFD plus l standard deviation) have been used to separate the other fraction of the sampled stock in order to calculate the "Mean body length excluding the recruits".
With regard the community indicator "Abundance of commercial species", the index values were estimated including the most important shared fisheries resources in the Adriatic as agreed by the Adriatic experts (AdriaMed, 2005) as listed below (Table 3):

Table 3: List of the commercial and shared demersal resources of the Adriatic Sea considered for the indicators estimation.

Adriatic demersal commercial species and shared stocks		
Eledone cirrhosa	*Mustelus mustelus*	*Scyliorhynus canicula*
Eledone moschata	*Nephrops norvegicus*	*Sepia officinalis*
Illex coindetii	*Octopus vulgaris*	*Solea vulgaris*
Lepidorhombus spp.	*Pagellus acarne*	*Spicara spp.*
Loligo vulgaris	*Pagellus bogaraveo*	*Squalus acanthias*
Lophius budegassa	*Pagellus erythrinus*	*Squilla mantis*
Lophius piscatorius	*Parapeneus longirostris*	*Trigla lucerna*
Merlangius merlangus	*Pecten jacobaeus*	*Trigloporus lastoviza*
Merluccius merluccius	*Platichthys flesus italicus*	*Trisopterus minutus capelanus*
Micromesistius potassou	*Psetta maxima*	*Zeus faber*
Mullus barbatus	*Raja clavata*	
Mullus surmuletus	*Scophthalmus rhombus*	

Finally, the BOI, bottom-dwelling fish/overall fish biomass ratio index was calculated according to Fiorentino et al., 2003), while diversity indices were estimated according to Magurran (1991).

With regard to the fishery-dependent data the analysis has been performed by using a set of 25 socio-economic indicators. A distinction has been held between indicators evaluating the state of the fisheries and indicators measuring fisheries sustainability. The selection of indicators was based on data available from the IREPA monitoring system for Italian GSAs defined by GFCM (FAO-GFCM, 2001).

Table 4 displays the list of the economic indicators on the status of fisheries and their description. They include six indicators on economic performance, eight on productivity and four related to the market (costs and prices). As for the evaluation of economic performance, traditional indicators based on the return on the capital invested and indicators related to the quota of revenues directed to production factors have been used. A number of indicators has been used in the evaluation of productivity as well. They can be divided into two groups, physical and economic productivity indicators, where the former are expressed in terms of landings and the latter in terms of revenues. The last four economic indicators, related to market variables, are to measure the evolution of landings prices and of the most relevant costs in demersal fisheries, specifically maintenance and fuel costs.

Table 4: Economic fishery indicators and their description.

INDICATOR	**DESCRIPTION**
Added Value/Revenue	percentage of revenues which is directed to salary, profit, opportunity cost and depreciation.
Gross Operative Margin/Revenue	percentage of revenues which is directed to profit, opportunity cost and depreciation.
ROS (Return on Sale)	percentage of revenues which is directed to profit and opportunity cost.
ROI (Return on Investment) (%)	percent ratio of net profit plus the opportunity cost in relation with the investment.
Revenue/Invested Capital (%)	percent ratio of revenues in relation with the investment.
Net Profit per vessel (000 €) *	average net profit of each vessel.
Landings per vessel (ton)	average production of each vessel in terms of weight of landings.
Landings per GRT (ton)	average production in terms of weight of landings for each capacity unit (GRT) of the vessels.
Landings per day (ton)	average production in terms of weight of landings for each day at sea.
CPUE (kg)	average production of each effort (GRT*days/N.vessels) unit in terms of weight of landings.
Revenue per vessel (000 €) *	average production of each vessel in terms of market value.
Revenue per GRT (000 €) *	average production in terms of market value for each capacity unit (GRT) of the vessels.
Revenue per day (000 €) *	average production in terms of market value for each day at sea.
RPUE (€) *	average production of each effort (GRT*days/N.vessels) unit in terms of market value.
Average price (€/kg)	average market price of landings.
Fuel cost per vessel (000 €) *	average fuel cost of each vessel.
Fuel cost per day (000 €) *	average fuel cost for each day at sea of a vessel.
Maintenance cost per vessel (000 €) *	average maintenance cost of each vessel.

* Deflated by Italian consumer price index for the entire community.

From a social point of view, five indicators have been defined. As listed in Table 5, two indicators on labour productivity, an indicator on the ratio between human and physical capital, an indicator on the number of people employed and one on their average salary have been used for the analysis.

Table 5. Social fishery indicators and their description.

INDICATOR	DESCRIPTION
Landings per crew (ton)	average production in terms of weight of landings for each man employed.
Revenue per crew (€) *	average production in terms of market value for each man employed.
Crew/GRT	ratio between man employed and GRT employed.
Employed persons (num)	number of people employed in fishing activities.
Salary per crew (000 €) **	average salary obtained by each man employed.

* Deflated by Italian consumer price index for the entire community.
** Deflated by Italian consumer price index for workers and employees.

As for the evaluation of fisheries sustainability, two specific indicators have been defined from an economic and social point of view. The approach followed in this paper is based on the consideration that natural, economic and human resources are involved in fisheries contemporarily, and fisheries sustainability is possible only if the availability of all the components is ensured in the long term.

From an economic point of view, this means safeguarding the ability of the sector to attract investments by protecting its profitability. Therefore, the level of economic sustainability can be measured by comparing the profitability of investments in fishery to those in other sectors. In this paper, the traditional indicator for profitability, represented by the return on capital invested (ROI), is compared to the average rate of the Italian Treasury securities with a long term maturity (Buoni del Tesoro Pluriennali (BTP)). The indicator of economic sustainability (ESI) is then obtained as a difference between the two rates of profitability. When the value of ROI is lower than or very close to the BTP rate (the value of ESI is negative or very close to zero), investments in public bonds are preferable to investments in fishery and the status of the fisheries under investigation cannot be considered as economically sustainable.

The approach described above can only be partially applied for measuring social sustainability. The availability of human resources in fishery cannot be treated as that of other economic resources, and comparing the labour remuneration in the fishery sector to those of other economic sectors would result in a mistake. The labour market in Italian fisheries is characterized by an excess of supply, especially due to immigration from Mediterranean developing countries. Moreover, the level of flexibility of labour market is not comparable to that existing in capital market. People employed in fisheries are generally not able to move to other sectors and should work even for low wages and poor safety conditions.

In such a context, the role of trade unions and safety laws assume a particular importance, and the minimum salary level, when defined in the trade unions agreements, can be considered as the minimum level at which an economic sector is socially sustainable. Therefore, the difference between the average salary per man employed and the minimum salary stipulated by the Italian laws (Contratto Collettivo Nazionale di Lavoro (CCNL)) can be used as an indicator of social sustainability (SSI). A value close to zero for the SSI highlights the presence of a status of social unsustainability for the fisheries under investigation.

In order to effectively interpret the information obtained from the indicators, some reference values are generally applied. In this paper, historical data are analysed through a traffic light representation (Caddy, 1998). According to the TL system, a judgment codified by a specific colour was assigned to each value of a given indicator in the time series (Caddy, 1998; Caddy, 2002). By adopting the standard three colours TL approach - where green, yellow and red colours are associated respectively to reference values which need to be defined.

These values are generally associated with either a difficult or an optimal (or sub-optimal) situation. The former (LRPs, limit reference points) identifies a limit which is necessary to avoid, while the latter (TRPs, target reference points) represents a target to be attained by the system (Caddy & Mahon, 1995; Caddy, 1998).

The LRPs or TRPs related to the bio-ecological and socio-economic fishery indicators chosen and used in this paper are not easily identifiable. Their estimation generally requires the use of specific tools and data, which are not available for the investigated fisheries. Nevertheless, very simple and immediate reference points and/or limits can be calculated by considering the indicator historical levels (as suggested in FAO, 1999b). Thus, we decided to set the reference boundaries for the bio-ecological and socio-economic indicators according to their percentile value (33-66%) in the available time series (1996-2003). The same methodology was used in other paper (DFO, 2002; Caddy et al., 2005) although it isn't free from some undesiderable effects (Caddy et al., 2005).
More in details indicators' values have been classified as reported below:

- Yearly value > $66t^{h}$ percentile in time series = 'safe values', green colour assigned;
- Yearly value included between 66^{th} and 33^{rd} percentile in time series = 'intermediate values', yellow colour assigned;
- Yearly value < 33^{rd} percentile in time series = 'dangerous values', red colour assigned.

However, in the case of indicators supposing to react positively to a negative impact for the fishery sector (both biological and socio-economic resources) green and red colorations were interchanged. This is true for the bio-ecological indicators "Cephalopods Abundance", "Small Pelagics Abundance" and for the socio-economic "Cost Indicators".

For the sustainability indicators ESI and SSI, LRPs have been associated respectively to the average rate of the Italian BTP and the minimum salary foreseen by the Italian CCNL for fishery sector. As ESI and SSI are calculated by subtracting the LRPs from the indicators, the related reference values, used to separate the red from the yellow area within the traffic light representation, are set to zero. For the same indicators a second reference value, useful to define the boundary between the yellow and the green area, is associated to the mean value of the indicator historical series.

3. Results

The analysis has been performed on a period of 8 years from 1996 to 2003. The bio-ecological indicators' tables (Tables 6, 7, 8, 9, 10, 11, 12, 13) highlight the obtained results according to the previously mentioned "Traffic lights" method. The main indications from the tables are summarized as follows.

<u>Population</u>:
- *Eledone cirrhosa*. The indicators are fluctuating among the dangerous, safe and intermediate values. No trend highlighted.
- *Illex coindetii*. Increase of biomass and abundance in the last years, mostly due to the strength of recruitment.
- *Merluccius merluccius*. Most of indicators highlight warning situations for the last surveyed years.
- *Mullus barbatus*. The panel of indicators shows different pictures according to the years periods. The first period (1996-1998) is in the "dangerous values", the second (1999-2001) was in the "safe values" zone, the third (2002-2003) was in the "intermediate values".
- *Nephrops norvegicus*. Decrease of resource in the last two investigated years.
- *Parapenaeus longirostris*. Clear trend from "dangerous values" zone to "safe values" zone in the investigate time period.
- *Zeus faber*. Most of indicators highlight warning situations for the last surveyed years especially for the length based indicators.

<u>Community</u>:
- The panel of indicators don't show any appreciable trend, although the year 2003 fall in the "dangerous values"zone.

Table 6. *Eledone cirrhosa*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%								
BIOMASS INDEX (kg/km^2)	Geometric mean								
	75° percentile								
ABUNDANCE INDEX (n/km^2)	Geometric mean								
	75° percentile								
RECRUITMENT INDEX (n/km^2)	Geometric mean								
	75° percentile								
SPAWNER INDEX (n/km^2)	Geometric mean								
	75° percentile								
MEAN BODY WEIGHT (g)	Ratio								
MEAN BODY LENGTH (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio								

Table 7. *Illex coindetii*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%								
BIOMASS INDEX (kg/km^2)	Geometric mean								
	75° percentile								
ABUNDANCE INDEX (n/km^2)	Geometric mean								
	75° percentile								
RECRUITMENT INDEX (n/km^2)	Geometric mean								
	75° percentile								
SPAWNER INDEX (n/km^2)	Geometric mean								
	75° percentile								
MEAN BODY WEIGHT (g)	Ratio								
MEAN BODY LENGTH (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio								

Table 8. *Merluccius merluccius*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%								
BIOMASS INDEX (kg/km^2)	Geometric mean								
	75° percentile								
ABUNDANCE INDEX (n/km^2)	Geometric mean								
	75° percentile								
RECRUITMENT INDEX (n/km^2)	Geometric mean								
	75° percentile								
SPAWNER INDEX (n/km^2)	Geometric mean								
	75° percentile								
MEAN BODY WEIGHT (g)	Ratio								
MEAN BODY LENGTH (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio								

Table 9. *Mullus barbatus*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%								
BIOMASS INDEX (kg/km^2)	Geometric mean								
	75° percentile								
ABUNDANCE INDEX (n/km^2)	Geometric mean								
	75° percentile								
RECRUITMENT INDEX (n/km^2)	Geometric mean								
	75° percentile								
SPAWNER INDEX (n/km^2)	Geometric mean								
	75° percentile								
MEAN BODY WEIGHT (g)	Ratio								
MEAN BODY LENGTH (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean								
	Median								
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio								

Table 10. *Nephrops norvegicus*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%	G	G	G	Y	R	R	Y	R
BIOMASS INDEX (kg/km^2)	Geometric mean	G	G	Y	Y	R	Y	R	R
	75° percentile	G	G	G	Y	R	Y	R	R
ABUNDANCE INDEX (n/km^2)	Geometric mean	G	G	G	Y	R	Y	R	R
	75° percentile	G	G	G	Y	Y	R	R	R
RECRUITMENT INDEX (n/km^2)	Geometric mean	G	R	R	R	Y	G	Y	Y
	75° percentile	Y							
SPAWNER INDEX (n/km^2)	Geometric mean	G	Y	G	G	Y	R	R	R
	75° percentile	G	R	Y	Y				
MEAN BODY WEIGHT (g)	Ratio	R	R	R	Y	G	Y	G	G
MEAN BODY LENGTH (mm)	Arithmetic mean	R	G	R	Y	G	R	Y	G
	Median	R	G	Y	Y	G	Y	Y	G
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean	Y	G	R	R	Y	R	G	G
	Median	Y	Y	R	R	Y	Y	G	G
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio	R	G	Y	G	G	R	Y	Y

Table 11. *Parapenaeus longirostris*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%	R	R	Y	R	Y	Y	G	G
BIOMASS INDEX (kg/km^2)	Geometric mean	Y	R	Y	R	R	G	G	G
	75° percentile	R	R	Y	R	Y	G	G	G
ABUNDANCE INDEX (n/km^2)	Geometric mean	R	R	Y	R	Y	G	G	G
	75° percentile	R	R	Y	R	G	G	G	G
RECRUITMENT INDEX (n/km^2)	Geometric mean	Y	R	R	R	Y	G	G	G
	75° percentile	R		R		Y	Y	G	G
SPAWNER INDEX (n/km^2)	Geometric mean	Y	R	Y	R	R	G	G	G
	75° percentile	Y	R	Y	R	R	G	G	G
MEAN BODY WEIGHT (g)	Ratio	R	R	G	G	Y	R	Y	G
MEAN BODY LENGTH (mm)	Arithmetic mean	R	Y	G	G	Y	R	G	R
	Median	Y	Y	G	G	Y	Y	Y	Y
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean	Y	G	G	G	R	R	Y	R
	Median	Y	G	Y	G	R	R	Y	R
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio	Y	R	G	G	R	Y	Y	Y

Table 12. *Zeus faber*: results of the traffic light method applied to the biological indicators for GSA 18 (blank cell = value not estimated because of data characteristics).

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
OCCURRENCE	%	G	R	Y	G	G	Y	R	R
ABUNDANCE (kg/km^2)	Geometric mean	G	R	Y	G	G	Y	R	R
	75° percentile								
DENSITY (n/km^2)	Geometric mean	G	R	Y	G	G	Y	R	Y
	75° percentile								
RECRUITMENT INDEX (n/km^2)	Geometric mean	R	Y	R	G	Y	R	Y	G
	75° percentile								
SPAWNER INDEX (n/km^2)	Geometric mean	Y		R	R	Y	Y		
	75° percentile								
MEAN BODY WEIGHT (g)	Ratio	G	G	G	R	Y	R	Y	R
MEAN BODY LENGTH (mm)	Arithmetic mean	G	Y	G	R	G	Y	R	R
	Median	G	G	G	R	Y	Y	R	R
MEAN BODY LENGTH EXCLUDING THE RECRUITS (mm)	Arithmetic mean	G	G	G	Y	Y	R	R	R
	Median	G	G	G	Y	Y	R	R	R
MEAN BODY LENGTH/LENGTH AT MATURITY	Ratio	G		Y	R	G	R		

Table 13. Results of the traffic light method applied to the biological community indicators for GSA 18.

INDICATOR	ESTIMATOR	1996	1997	1998	1999	2000	2001	2002	2003
TOTAL BIOMASS INDEX (kg/km^2)	Geometric mean	green	green	red	green	yellow	yellow	red	red
	75° percentile	green	green	yellow	green	yellow	red	red	red
TOTAL ABUNDANCE INDEX (n/km^2)	Geometric mean	green	green	red	green	red	yellow	red	yellow
	75° percentile	green	green	red	red	yellow	green	red	yellow
TOTAL BIOMASS INDEX excluding pelagic species (kg/km^2)	Geometric mean	green	yellow	red	green	yellow	yellow	green	red
	75° percentile	green	green	red	green	yellow	red	yellow	red
TOTAL ABUNDANCE INDEX excluding pelagic species (n/km^2)	Geometric mean	green	red	yellow	green	red	yellow	green	red
	75° percentile	green	yellow	yellow	green	yellow	red	green	red
BIOMASS INDEX OF THE MAIN TARGET SPECIES (kg/km^2)	Geometric mean	green	red	red	green	red	yellow	green	red
	75° percentile	green	red	red	green	green	yellow	yellow	red
CEPHALOPODS BIOMASS INDEX (kg/km^2)	Geometric mean	green	green	green	red	red	yellow	yellow	red
	75° percentile	yellow	green	green	red	red	red	green	yellow
SMALL PELAGICS BIOMASS INDEX (kg/km^2)	Geometric mean	red	red	yellow	yellow	green	green	green	red
	75° percentile	red	red	yellow	yellow	green	green	green	red
ELASMOBRANCHS BIOMASS INDEX (kg/km^2)	Geometric mean	red	yellow	red	green	green	green	yellow	red
	75° percentile	red	red	red	green	green	green	yellow	yellow
BOI	Ratio	red	red	yellow	green	red	green	green	yellow
ECOLOGICAL INDICES	Richness (Margaleff)	green	red	yellow	green	green	red	yellow	red
	Diversity (Shannon)	yellow	red	green	green	yellow	red	green	red
	Evenness (Pielou)	yellow	red	green	green	yellow	red	green	red

With regard to the fishery-dependant indicators the results show a negative trend in the investigated period from both an economic and social point of view (Tab. 14). Specifically, the year 2003 shows the worst performance for the demersal fisheries in that area, even though the critical status of these fisheries started in 1999 when a change in the level of almost all indicators is registered. Most of indicators highlighted a strong reduction in this period, such as productivity per vessel and per unit of GRT decreasing of around 40%. Landings per day and per unit of effort highlighted a strong reduction from 1998 to 1999 also (nearly 30%), the decreasing trend continuing until 2003.

During the years 2001 and 2002, a partial improvement in the economic condition of these fisheries was detected. It was due essentially to the increase in the average number of days at sea which passed from 170 in 2000 to 197 in 2001, and to 206 in 2002. Actually, just the indicators parameterized by vessel and by GRT show an increase, while indicators independent by changes in the activity level, like landings per day, show a stable or declining trend. Moreover, in 2003, when a reduction in the number of days at sea at 172 is registered, all the indicators of productivity show the lowest values along the period under investigation and are classified with the red colour in the traffic light table.

Table 14. – Results of the traffic light method applied to economic indicators for GSA 18.

INDICATOR	1996	1997	1998	1999	2000	2001	2002	2003
Economic sustainability (ROI - Risk_free_rate)(%)	Green	Green	Green	Yellow	Yellow	Yellow	Yellow	Yellow
•Added Value/Revenue (%)	Green	Green	Green	Yellow	Red	Yellow	Red	Red
•Gross Operative Margin/Revenue (%)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•ROS (Return on Sale) (%)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•ROI (Return on Investment) (%)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•Revenue/Invested Capital (%)	Green	Yellow	Green	Red	Red	Green	Yellow	Red
•Net Profit per vessel(000 €)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•Landings per vessel (ton)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•Landings per GRT (ton)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•Landings per day (ton)	Green	Green	Green	Yellow	Red	Yellow	Red	Red
•CPUE (kg)	Green	Green	Green	Yellow	Red	Yellow	Red	Red
•Revenue per vessel (000 €)	Green	Green	Green	Red	Red	Yellow	Yellow	Red
•Revenue per GRT (000 €)	Green	Yellow	Green	Red	Red	Green	Yellow	Red
•Revenue per day (000 €)	Green	Green	Green	Yellow	Yellow	Red	Red	Red
•RPUE(€)	Green	Green	Green	Yellow	Red	Yellow	Red	Red
•Average price (€/kg)	Red	Red	Red	Yellow	Green	Yellow	Green	Green
•Fuel cost per vessel (000 €)	Green	Green	Green	Yellow	Red	Red	Red	Yellow
•Fuel cost per day(000 €)	Green	Green	Green	Red	Red	Yellow	Red	Yellow
•Maintenance cost per vessel(000 €)	Green	Red	Red	Green	Green	Yellow	Red	Yellow

The negative trend in productivity also applies to the indicators on economic productivity, which show a similar behaviour to that of physical productivity. Increasing prices are not high enough to compensate for the reduction in physical productivity. Also for these indicators, the worst performance is registered in 2003, when the table shows a red colour for all of them.

Besides the decreasing productivity, another negative effect on the economic performance of the fisheries investigated was determined by increasing costs. An increase higher than the inflation rate was registered by the indicators on fuel costs in the last five years. As for productivity, also for fuel costs, which represent about a half of the total costs for the demersal fleet, indicators show a clear change in level from 1998 to 1999. Table 14 shows a change in the associated colour from green until 1998 to red and yellow from 1999 onwards both for fuel cost per vessel and per day. It is related to a constant increase of fuel price, which started in the spring of 1999 and is still continuing.

A change in level from 1999 is shown for the economic performance indicators as well. In detail, the quota of revenues directed to the production factors (added value on revenues), in terms of profit, salary, interest on the invested capital, and depreciation, registered a reduction of 14 percentage points, from 71% in 1998 to 57% in 1999. In the following years, further reductions in this quota have been registered with the lowest level, 47% of revenues, reached in 2003.

From a social point of view, the indicators on labour productivity show the presence of a critical period in 1999-2000, an improvement probably due to the increase in the activity level in 2001-2002 and the worst performance in 2003 (Table 15). These results, which are strongly affected by the negative trend in productivity, differ someway from those described above with respect to the productivity indicators because of the variations in the number of people employed.

The average salary per man employed was negatively affected by the negative trend in productivity as well. The related indicator shows a change in level in 1999 and, except for the year 2001, a declining trend along the period under investigation by changing the colour from green in the first three years to yellow in 1999, and to red in the last two years.

Finally, the social sustainability indicator, obtained as a difference between the average salary per man employed and the minimum salary foreseen by the Italian CCNL, shows, except for the year 2001, a declining trend from the year 1999. The lowest value is registered in 2003, when the average salary perceived by the people employed in these fisheries exceeded the minimum salary of just 4.920,00 €.

Table 15 – Results of the traffic light method applied to social indicators for GSA 18.

INDICATOR	1996	1997	1998	1999	2000	2001	2002	2003
Social sustainability (Salary - Minimum_salary)(000 €)								
•Employed persons GSA 17(num)								
•Landings per crew (ton)								
•Revenue per crew (000 €)								
•Crew per GRT (%)								
•Salary per crew(000 €)								

4. Discussions and conclusions

The results from the analysis of biological indicators at population level highlight the apparent decrease of some species which can be considered as “K” strategist and the partial increase of other “r” strategist populations. Thus, the actual mean trophic level in the investigated area could be assumed lower in comparison with the past years (Caddy & Garibaldi, 2000). The decrease of the “K” strategist resources is mostly due to the depletion of the adult fraction of the populations, thus suggesting a “Fishing down the food web” situation (Christensen, 2000). According to Tudela (2004) who reviewed the effect of the fishing pressure in the Mediterranean, fishing activities profoundly affects the complex structure of the ecosystem and the marine food webs over time. Pauly et al. (1998) described the existence of a global “fishing down marine food webs effect” based on the steadily decreasing trend of trophic level values of catches. Moreover when larger multi-age-group predatory fish are exploited at or above the mortality rate corresponding to the maximum sustainable yield, large reductions in the size of older cohorts is observed (Caddy and Rodhouse, 1998), as described in GSA 18 for *M. merluccius* and *Z. faber*, and in the whole Mediterranean for large pelagic species (Tserpes et al., 2001; Tudela, 2004).
Likewise a positive effect of high exploitation level on short lived species was documented in many oceanic regions and in the Adriatic Sea (Caddy and Rodhouse, 1998; Pauly et al., 1998; Balguerías et al., 2000; Vrgoć et al., 2004; Ceriola et al., 2006a, b). This for cephalopods was explained with the reduction of potential predators and with the fast turn-over within the population by Ceriola et al. (2006a). Furthermore Vrgoć et al. (2004) in a review of the current knowledge on shared demersal stocks in the Adriatic Sea, described a high resilience to fishery exploitation of the species with a short life span and a high production/biomass ratio, such as commercial important cephalopods.
Probably the increasing “r” populations, such as the deep water rose shrimp and the broadtail shortfin squid, are exploiting both the environmental changes (Sharp, 2004) and the supposed variations in the ecological links (i.e. prey-predator relationships and density-dependant interactions) (Caddy et al., 2005).

Thus, at population level the obtained results can be explained both by the impact of fishery (overexploitation of large-sized fish, and the related changes in trophic interactions) and by the environmental influence (direct effect on recruitment and growth rate).
These considerations seem to describe for the GSA 18 a situation already occurring in several highly harvested regions, with the decrease of the mean trophic level (e.g. east and west Canadian coasts, Pauly et al., 2001), species replacement (e.g. Sahara Bank, Balguerías et al., 2000) and the reduction or the decrease of the age of the top predators' stock (e.g. The Gulf of Thailand, Caddy and Rodhouse, 1998).
At community level the behavior of the multispecies indicators is less evident. The chosen biological indicators seem to give weak response to the fishery pressure. The total community biomass as well as the total community abundance can remain stable in the time period due the species substitution / vicariancy effect (Blanchard and Boucher, 2001; Jukic et al., 2001; Mannini et al., 2005). The trend of some indicators such as "Small Pelagics biomass" or "Elasmobranch biomass" can be useful, although the decrease/increase of the small pelagics resource is mostly related to the changes in the oceanographic features (de Leiva Moreno et al., 2000). The BOI index does not seem to perform well in the investigated scenario where semi-industrial fishery has been a well-developed activity for some time (Ungaro et al., in press). Moreover, the chosen indices on species diversity can provide unreliable results (Rochet e Trenkel, 2003; Piet & Jennings, 2005). However, they have been utilized in other frameworks on the same subject (Jenning e Kaiser, 1998; Gislason et al., 2000; Raakjaier et al., 2006).

The analysis performed according to the available fishery-dependant data highlighted the presence of a negative trend throughout the period under investigation both for the economic and the social indicators. The worst performance for demersal fisheries in this area is registered in 2003, when almost all indicators in the table are classified with the red colour. However, a change in the level for most of them was registered already from 1999, when a strong reduction in the days at sea was caused by the Balkan War.
In the first period of the war, the negative effects were limited to changes in the fishing activity routes because of the presence of warships. Later, the presence of explosive devices in the Adriatic Sea resulted in a period of temporary withdrawal of fishing activity to allow for their removal. This involved almost the whole demersal fleet in the Southern Adriatic Sea from the half of May to the end of August, and produced a relevant decrease of days at sea in that year. It is worth of note that during the same period most of the biological "community" indicators resulted in the "green" area (see at the table 14).
However, during the following year, when the average number of days at sea was brought back to the same level registered in 1998, indicators of productivity show a further reduction. In particular, landings per day show a clear declining trend from 1999 to 2003.
The negative trend in economic performance, which culminated in the critical year 2003, was mainly due to reduced physical productivity and increasing costs. From a cost prospective, the most relevant factor affecting the performance of the demersal fisheries is represented by the constant increase in fuel prices, which started in the spring of 1999 and is still in act. Therefore, two causes of potential economic unsustainability can be identified for the fisheries under investigation: fishing effort level and fuel cost.
Especially during the years 2000 and 2003, the economic sustainability indicator shows values very close to zero, 1.21% and 1.28% respectively. In those years, investments in

Treasury bonds were preferable to investments in fishery and the status of the fisheries under investigation could not be considered as economically sustainable.

In 1999, both profits and salary were penalized by the effects of the Balkan War and increasing prices; while, in the following years, the effects of the negative trend in productivity penalized more the remuneration of labour than profit. This determines a potential factor of unsustainability from a social point of view. In fact, the average salary per man employed declined, and so did the social sustainability indicator whose lowest value was registered in 2003. These variations are strictly correlated to increases in total costs, and more specifically to fuel cost. In 1999, however, both profits and salary were penalized by the critical condition in which the fisheries were, as results by comparing added value and gross operative margin on revenues. During the following years, in contrast to the reduction in the added value on revenues, the gross operative margin on revenues, which does not include the quota of revenues directed to salary, shows a constant behaviour. Therefore, the effects of the negative trend in productivity penalized more the remuneration of labour than the profit.
From a social point of view, the indicators on labour productivity show the presence of a critical period in 1999-2000, an improvement probably due to the increase in the activity level in 2001-2002 and the worst performance in 2003. These results, which are strongly affected by the negative trend in productivity, differ someway from those described above with respect to the productivity indicators because of the variations in the number of people employed. The positive performance highlighted in the years 2001 and 2002 is clearly related to the reduction registered for this variable in that period.

The inclusive discussion of the results from both fishery-independent and fishery-dependent data analysis underlines some common features. In fact, an apparent and progressive deterioration seems to affect the trawl fishery system in the GSA 18 during the investigated period, according mainly to the variation in catch composition (increasing of r-strategist species and decreasing of k-strategist ones) and to the trajectories of some socio-economic indicators.
Of course, the obtained results need confirmation and in this context several indicators still require further information, as well as the definition of the relative weight of each of them (Rochet & Trenkel, 2003). The same weight have to be defined on the basis of *ad hoc* Committees involving all the representative stakeholders of the fishery sector (Caddy, 1999; Raakjær et al., 2006).
Notwithstanding, this tentative preliminary global picture of the trawl fishery in the GSA 18 is now available and constitutes part of the necessary baseline knowledge to address the issue of bio-economic indicators identification. This is true at least in the Mediterranean Sea where the common studies involving the biological and socio-economic fishery aspects are lacking at the date. Thus, this paper shows how powerful and effective can be the joint use of both bio-ecological and socio-economic indicators. This kind of fishery appraisal and combination of multidisciplinary indicators should be further tested through discussion with the relevant stakeholders within a context where fishery management objectives are clearly defined.

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