ADRIAMED
SCIENTIFIC COOPERATION TO SUPPORT RESPONSIBLE FISHERIES IN THE ADRIATIC SEA

Comparability of two different methods for the stock assessment of hake (*Merluccius merluccius* L.) in the Mediterranean Geographical Sub-Area 18 (Southern Adriatic Sea)

Paper presented at the GFCM-SAC Sub Committee on Stock Assessment
(Antalya, Turkey, 13-16 October 2008)

GCP/RER/010/ITA/OP-30 Rome (Italy), October 2008

Comparability of two different methods for the stock assessment of hake (*Merluccius merluccius* L.) in the Mediterranean Geographical Sub-Area 18 (Southern Adriatic Sea)*

Abstract

The hake (*Merluccius merluccius*) is one of the main commercial and heavily exploited species of the demersal fishery of the coastal countries in the Adriatic Sea. This paper aims to the test the comparability among two different methods for the assessment of the hake stock, specifically in the Adriatic Geographical SubAreas (GSAs) n° 18. Data from 1996-2006 trawl surveys carried out in the GSA n° 18 (MEDITS) were analysed by using both Empirical Indicators and SURBA method. The paper highlights the comparability of the results obtained with the application of the two methods.

1. Background

The hake (*Merluccius merluccius*) is one of the main commercial and heavily exploited species of the demersal fishery of the coastal countries in the Adriatic Sea. In recent years the General Fisheries Commission for the Mediterranean is promoting joint stock assessment exercises; during the 10th GFCM Scientific Advisory Committee (SAC) meeting a specific request to carry out joint stock assessment of hake (*Merluccius merluccius*) and associated species in each Geographical SubAreas (GSAs, or a group of GSAs, as adequate), using both commercial catches and trawl survey was formulated. The request was discussed and included into the FAO AdriaMed Project work plan for 2008 during the 9th AdriaMed Coordination Committee (December 2007, AdriaMed, 2008) where the Adriatic experts recognized the importance to take advantage of the great amount of data collected so far in the Adriatic Sea on *Merluccius merluccius* and associated species.

In this context during the AdriaMed Working Group on Demersal Fisheries Resources (June 2008, Kotor, Montenegro) the Adriatic experts discussed on the utilization of trawl surveys versus commercial catches data to perform this exercise keeping in mind the results of the meeting of the Scientific, Technical and Economic Committee for Fisheries (STECF) Subgroup on the Mediterranean (SGMED-08-01**,** Brussels 10 - 14 March 2008) during which a review of the main stock assessment methods was made highlighting the pros and cons for each method. A possible approach focusing on *Merluccius merluccius* was proposed taking into consideration only survey data by age-class and year using a model which can only be used to estimate relative rather than absolute population numbers (Survey Based Assessment, SURBA). The importance of having scientifically sound, comprehensible and suitable tools available for describing the actual status of the resources to support the fishery management process was concurred by the Working Group that agreed to apply this method on the selected species in the Adriatic Sea GSAs. Furthermore, the utilization of bio-economic indicators for the assessment was also suggested as a possible

* This paper should be cited as follows: Ungaro, N., Joksmimovic, A., Kapidani, R., Ceriola, L. and Milone, N. 2008. Comparability of two different methods for the stock assessment of hake (*Merluccius merluccius* L.) in the Mediterranean Geographical Sub-Area 18 (Southern Adriatic Sea). Paper presented at the GFCM-SAC Sub Committee on Stock Assessment (Antalya, Turkey, 13-16 October 2008). GCP/RER/010/ITA/OP-30. *AdriaMed Occasional Papers,* 30: 13 pp.

alternative method to be compared with the classic analytical methods. On the basis of the existing data, a collective working session was organised to test the feasibility of this exercise, at GSA 18 level.

2. Introduction

The mediterranean hake is one of the most important demersal species in the GSA n° 18 (Southern Adriatic Sea), due to the relative abundance and economic value (Jukic et al., 2001; Ungaro et al., 1993; 2002; 2003). The fishery of the hake in the southern Adriatic Sea is carried out mainly by trawlers (Vrgoc et al., 2004) but fixed nets and mostly bottom long lines are used also (Ungaro and Marano, 1996; De Zio et al., 1998; Vrgoc et al., 2004).
Due to the impact on fishery activities in the basin, the hake was considered one of the main shared stocks in the GSA n° 18 and to require appropriate assessment and management rules by means of effective cooperation among the Countries (AdriaMed, 2000).
The assessment of the resource in the basin has been approached in the past using the analysis of trawl surveys time-series (Marano et al., 1998; Ungaro et al., 1998), Analytical Models (Ungaro and Marano, 1996), Surplus Production models (Osmani et al., 2002) and Empirical Indicators (Ungaro et al., 2006; Ceriola et al., 2008). All the used methods highlighted a situation of growth overfishing altough the resource not experienced a major crisis for a long time (Ungaro et al., 2003).

In recent times the “state” of the hake stock in the basin was approached using the Traffic Lights method (Caddy, 2002; Caddy et al., 2005) exploiting a panel of Empirical Indicators (Ceriola et al., 2008). The use of empirical indicators can be useful to assess the impacts of fishing both at ecological and at socio-economic level (Fulton et al., 2005). Moreover, the indicators can describe in a simple way the complexity of the impacts and management processes to a non-specialist audience (Jennings, 2005). The STECF-SGMED of the European Commission considered the empirical indicators as potential useful and appriopriate, especially for the current situations of data shortage in the Mediterranean (STECF-SGMED, 2008).

Together with the empirical indicators, the STECF-SGMED proposed others stock assessment methods (STECF-SGMED, 2008) and among others the SURBA (Survey Based Assessment). SURBA is a VPA based model that assumes the fishery mortality is separable into an age (s) and a year effect (f) (Needle, 2003; Beare, 2005). The method has been proved to be a useful technique for investigating the dynamic of the fishery independently of the commercial catch and CPUE data (ICES, 2002), and it runs processing trawl surveys data (i.e. standardized abundance indices, proportion of mature individuals, etc.).

The main purpose of the present paper is to investigate the comparability of the scientific results obtained applying Empirical indicators and SURBA method for the stock assessment of the hake in the Adriatic GSA n. 18.

3. Materials and Methods

3.1 Survey data collection

The basic data come out by eleven bottom trawl surveys carried out in the GSA 18 in the framework of the EU programme MEDITS (Mediterranean International Trawl Survey) (Bertrand et al., 2002). The related TA, TB and TC output files have been used. The surveys covered the 83% of the potential trawlable bottoms from 10 m to 800 m depths in the Southern Adriatic, excluding the Montenigrin waters only, and the sampling stations were located according to a depth-stratified random design (for further details on survey sampling protocols see Bertrand et al., 2002).
The surveys analysed in this paper were performed every year during the spring–summer season in the time period 1996-2006. All the data and pre-elaborated results needed for further analysis were obtained by using the FAO Software "ATrIS" provided by the FAO-AdriaMed Project (Gramolini et al., 2005).

3.2 Empirical Indicators

The following indicators - and relative statistical estimators - (Ungaro et al., 2006; Ceriola et al., 2008) were calculated by the software ATrIS according to the data avalaibility and quality for the surveys 1996-2006:

- Biomass index (arithmetic mean, geometric mean, 75th percentile);
- Abundance index (arithmetic mean, geometric mean, 75th percentile);
- Recruitment index (arithmetic mean, geometric mean, 75th percentile);
- Spawner index (arithmetic mean, geometric mean, 75th percentile);
- Body weight (mean);
- Body length (arithmetic mean, median, 75th percentile);
- Mean body length excluding recruits (arithmetic mean);
- Mean body length of the spawners (arithmetic mean).

Raw biomass and abundance data, as well as the other collected biological parameters, have been standardised to the bottom surface unit (km^{-2}) by using the swept-area method (Sparre and Venema, 1998). The recruitment index was calculated after the identification of the threshold size to separate the recruits from the other fraction of the sampled stock. The recruits threshold size for each survey was estimated as the mean length of the 1st component of the poly-modal pooled length frequency distribution (LFD) plus 1 standard deviation (Fiorentino et al., 2003). The spawner index was calculated considering the size of 292 mm TL as the $Lm_{50\%}$ for the female hake stock in the GSA n° 18; the chosen maturity length for the hake corresponds to the mean value from the "Adriatic" bibliography on the subject (Vrgoc et al., 2004).

The panel of indicators and relative estimators was displayed using the "Traffic Light" system (TL) (Koeller, 2002; Caddy, 2002). According to the Traffic Light approach a judgment codified by a specific colour was assigned to every year in the time series of each indicator: positive = green, intermediate/neutral = yellow, negative = red. For each indicator, the boundary values to assign judgement/colour were set according to the percentile values (33rd and 66th, respectively) in the time series (Halliday et al., 2001; Ceriola et al., 2007). The green colour was assigned to years with value >66th percentile of the time series; the yellow colour was assigned to years with value included between the 66th and 33rd percentile of time series; the red colour was assigned to year with value <33rd percentile (Ceriola et al., 2008).

Moreover, the relationships among indicators time-series were investigated by means of the correlation matrix and the visualization of the main indicative trends.

3.3 Survey Based Assessment Model (SURBA)

The survey based model was applied to the same data set exploited for the the estimation of empirical indicators (MEDITS surveys from 1996 to 2006).The software SURBA 2.10 was used to run the model. The same model requires the survey data by age-class and year, basically standardized abundance indices, mean weight, proportion of mature individuals, natural mortality and catchability. The ouputs of the model are the mean-standardised survey abundance indices by age and year, the mean stock weights-at-age, the mean estimated trend in F, the temporal trend in estimated F by age group, the temporal trend in relative SSB and the fitted temporal trend in model parameters (F, SSB, Recruitment) (Needle, 2003). The software also includes a deterministic forecasting capability.

The length data from surveys were transformed in age data by means of a von Bertallanfy growth equation, as the SURBA model needs indices by age-class. A “slow growth” function was chosen for the hake of the GSA n° 18: $L\infty = 94.04$ cm; $K = 0.11$; $t_0 = -0.63$ (parameters provided by N. Ungaro). Five age class were identified for the data processing (age 0, 1, 2, 3, 4^+). Proportion of mature individuals by age-class was calculated considering as “mature” the individuals staged 3 and 4 according to the maturity scales provided by MEDITS protocols (Bertrand et al., 2002). The vector of natural mortality was used as the input for the model, ranging from 0.6 (age 0) to 0.2 (age 4^+). Moreover, the catchability value was fixed as 1 for all age-classes.
The chosen parameters has been valued as suitable for the hake stock in the southern Adriatic altough the SURBA estimates are not particularly sensitive to the estimation settings used (Needle, 2003).

4. Results

4.1 Empirical Indicators

The results from the calculation of empirical indicators and the Traffic Light display are reported in the Table 1 and Figure 1. The displayed colours distribution highlights a “bad” or “intemediate” situation of the hake stock in the period from 1998 to 2004 after “good” 1996 and 1997 years. During the 2005 and 2006 most of the indicators are in the “good” area. It is very interesting the picture describing an apparent relationship among relative low level of recruitment in the years 1997, 1998, 1999, and the decrease of spawners indicators and body length indicators in the following years (respectively in the triennium 2000-2002 and 2003-2005).
The correlation matrix of the indicators’ time trends is reported in Figure 2. According to the correlation coefficient values, the strongest positive relationships are between the recruitment indicators and total abundance indicators. High significant positive correlation was also found between spawners indicators and total biomass indicators. Moreover, recruitment indicators negatively affect the body length indicators and, of course, the mean body weight.
In Figure 3 and 4 the graphs related to the time-series with the highest positive and negative correlation coefficient respectively are reported.

Tab. 1 – GSA 18: 33rd and 66th percentile values for the chosen indicators (time period 1996-2006).

	TOTAL BIOMASS INDEX		
	*total biomass arithmetic mean (kg*km^{-1})*	*total biomass geometric mean (log kg*km^{-1})*	*total biomass 75° percentile (kg*km^{-1})*
33rd percentile value	18.46	2.39	27.24
66th percentile value	27.36	2.68	38.47
	TOTAL ABUNDANCE INDEX		
	*total abundance arithmetic mean (n*km^{-1})*	*total abundance geometric mean (log n*km^{-1})*	*total abundance 75° percentile (n*km^{-1})*
33rd percentile value	450.06	4.86	586.83
66th percentile value	651.37	5.21	748.93
	RECRUITMENT ABUNDANCE INDEX		
	*recruits abundance arithmetic mean (n*km^{-1})*	*recruits abundance geometric mean (log n*km^{-1})*	*recruits abundance 75° percentile (n*km^{-1})*
33rd percentile value	210.28	3.32	222.16
66th percentile value	352.52	3.68	392.33
	SPAWNER ABUNDANCE INDEX		
	*spawners abundance arithmetic mean (n*km^{-1})*	*spawners abundance geometric mean (log n*km^{-1})*	*spawners abundance 75° percentile (n*km^{-1})*
33rd percentile value	12.11	1.34	22.19
66th percentile value	20.60	1.61	29.27
	BODY WEIGHT	**BODY LENGTH**	
	mean value (g)	*mean body length excluding the recruits (mm)*	*mean body length of the spawners (mm)*
33rd percentile value	35.16	198.73	358.07
66th percentile value	46.08	204.51	379.74
	BODY LENGTH		
	body length arithmetic mean (mm)	*body length 75° percentile (mm)*	*body length median (mm)*
33rd percentile value	142.64	179.09	114.74
66th percentile value	154.21	194.18	128.13

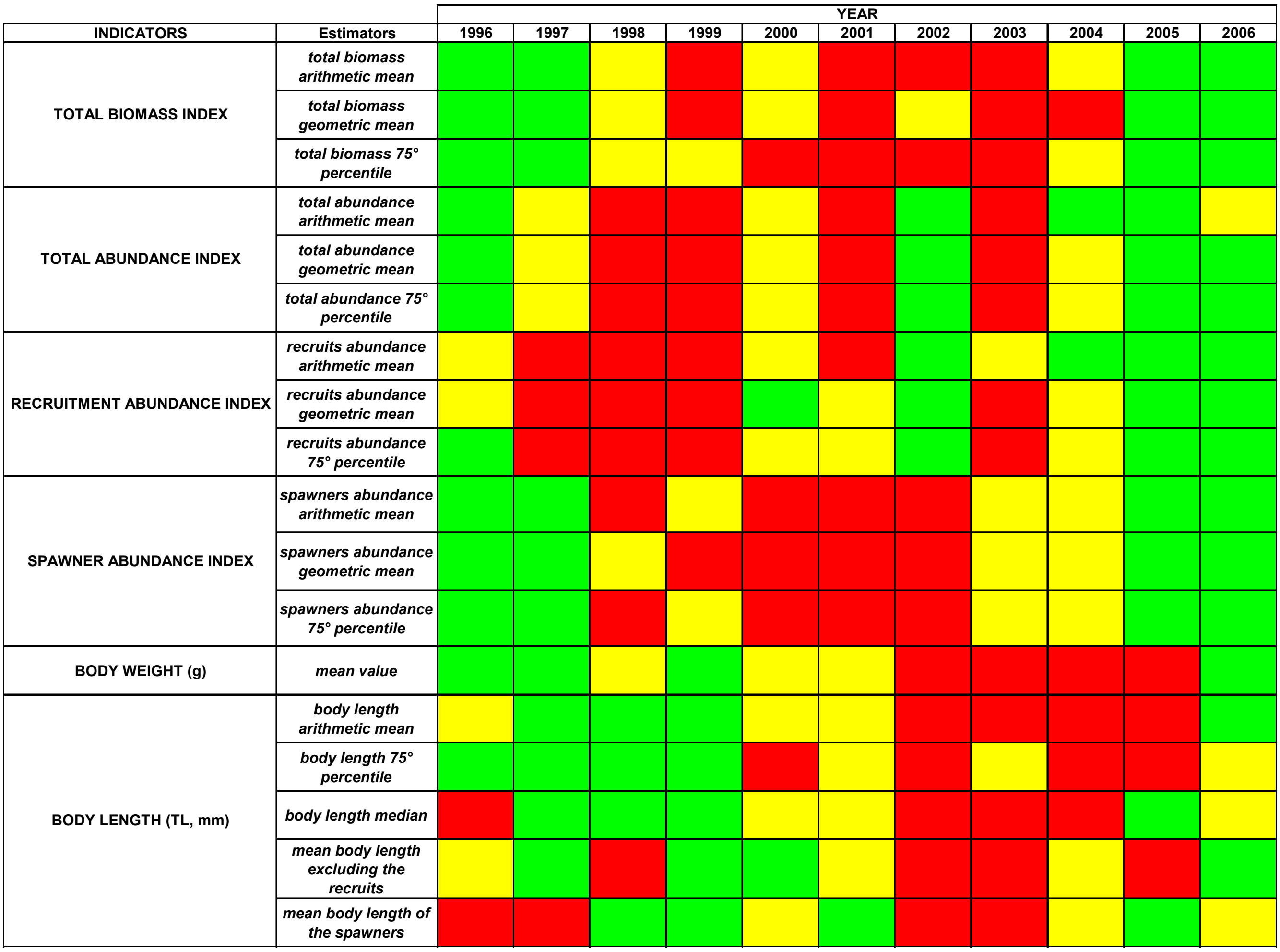

Figure 1. GSA 18: Traffic Light display for the hake stock in the time period 1996-2006.

	INDICATOR	total biomass index			total abundance index			recruitment abundance index			spawner abundance index			body weight	body length				
INDICATOR		total biomass arithmetic mean	total biomass geometric mean	total biomass 75° percentile	total abundance arithmetic mean	total abundance geometric mean	total abundance 75° percentile	recruits abundance arithmetic mean	recruits abundance geometric mean	recruits abundance 75° percentile	spawners abundance arithmetic mean	spawners abundance geometric mean	spawners abundance 75° percentile	mean value	body length arithmetic mean	body length 75° percentile	body length median	mean body length excluding the recruits	mean body length of the spawners
total biomass index	*total biomass arithmetic mean*	1.00	0.98	0.96	0.80	0.84	0.80	0.68	0.55	0.70	0.81	0.76	0.77	0.06	0.09	-0.05	0.22	-0.01	0.08
	total biomass geometric mean		1.00	0.97	0.75	0.84	0.76	0.63	0.56	0.66	0.79	0.73	0.78	0.10	0.12	-0.03	0.23	0.03	0.14
	total biomass 75° percentile			1.00	0.62	0.71	0.63	0.48	0.37	0.52	0.82	0.82	0.84	0.26	0.26	0.14	0.32	0.13	0.11
total abundance index	*total abundance arithmetic mean*				1.00	0.94	0.98	0.98	0.85	0.96	0.43	0.28	0.28	-0.51	-0.41	-0.57	-0.10	-0.47	0.12
	total abundance geometric mean					1.00	0.92	0.89	0.83	0.88	0.54	0.36	0.42	-0.42	-0.36	-0.50	-0.11	-0.43	0.08
	total abundance 75° percentile						1.00	0.96	0.85	**0.99**	0.41	0.27	0.30	-0.41	-0.31	-0.49	-0.02	-0.39	0.29
recruitment abundance index	*recruits abundance arithmetic mean*							1.00	0.90	0.97	0.30	0.12	0.13	-0.60	-0.50	**-0.69**	-0.18	-0.49	0.14
	recruits abundance geometric mean								1.00	0.81	0.16	-0.03	0.04	-0.56	-0.52	**-0.69**	-0.31	-0.37	0.17
	recruits abundance 75° percentile									1.00	0.28	0.12	0.17	-0.50	-0.39	-0.56	-0.10	-0.43	0.31
spawner abundance index	*spawners abundance arithmetic mean*										1.00	0.95	0.94	0.30	0.29	0.20	0.24	0.25	-0.28
	spawners abundance geometric mean											1.00	0.95	0.48	0.45	0.41	0.36	0.38	-0.21
	spawners abundance 75° percentile												1.00	0.49	0.43	0.41	0.28	0.38	-0.07
body weight	*mean value*													1.00	0.96	0.91	0.69	0.88	0.15
body length	*body length arithmetic mean*														1.00	0.85	0.85	0.83	0.22
	body length 75° percentile															1.00	0.54	0.72	0.11
	body length median																1.00	0.50	0.34
	mean body length excluding the recruits																	1.00	0.04
	mean body length of the spawners																		1.00

x	**positive correlation *(r* value*)***
x	**negative correlation (*r* value)**
	high significant positive correlation (2a = 0.001)
	significant positive correlation (2a = 0.05)
	high significant negative correlation (2a = 0.001)
	significant negative correlation (2a = 0.05)
	Correlation between estimators of the same indicator (not considered)

Figure 2. GSA 18: Correlation matrix of of the hake indicators' time trends.

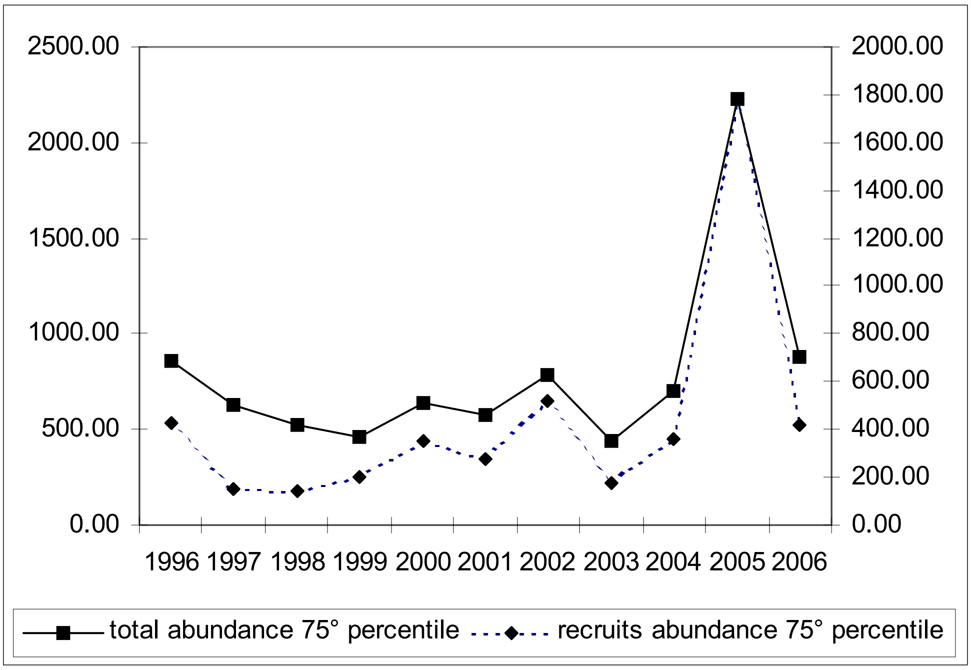

Figure 3. GSA 18: Time trends of the two indicators with the highest correlation coefficient (positive).

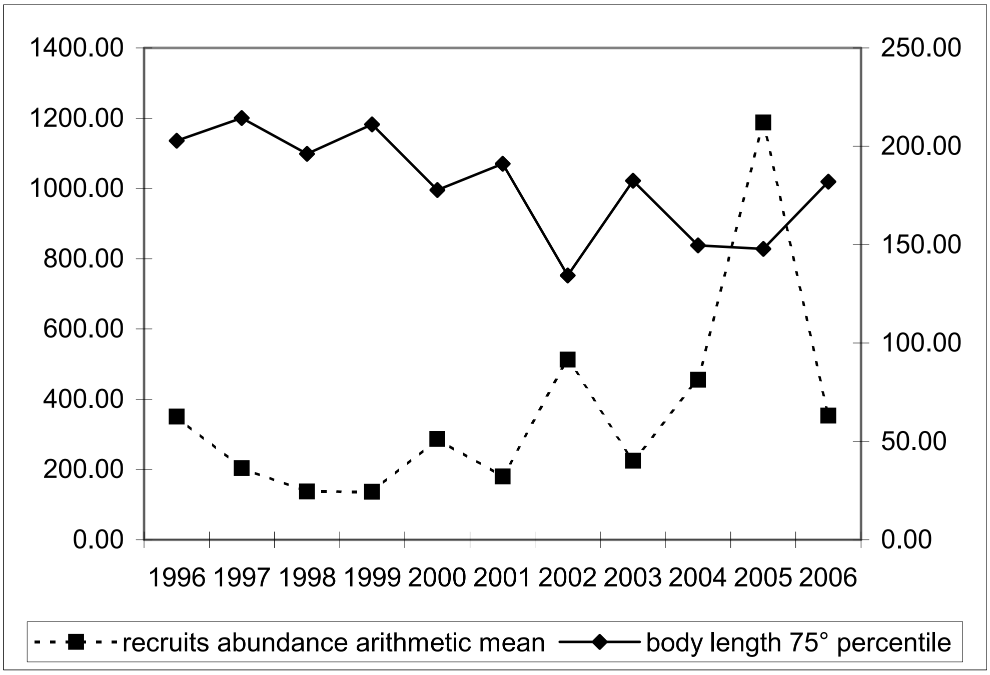

Figure 4. GSA 18: Time trends of the two indicators with the highest correlation coefficient (negative).

4.1 Survey Based Assessment

The results from the application of the SURBA model mainly consist of trends of abundance index by year-class and by age, as well as the trend of mean stock weight-at-age, the fitted temporal trend, the temporal trend of F , the trend of relative SSB an the trend of recruiment. The mentioned trends are reported in the Figures 5, 6, 7,8, 9, 10 and 11.

Summarizing, the main results are: the consistency of the year-class “0” strongly decreased from 1997 to 1999 and after increased; the mean weight of the stock at the age “4+” highlighted an apparent decreasing trend in the whole period; the fitted temporal trend was decreasing from 1997 to 2004 and increased in the last two years (tha same for the trend of F); the relative SSB experienced a crisis between 2000 and 2002; the relative recruitment highlighted a strong peak during the 2005.

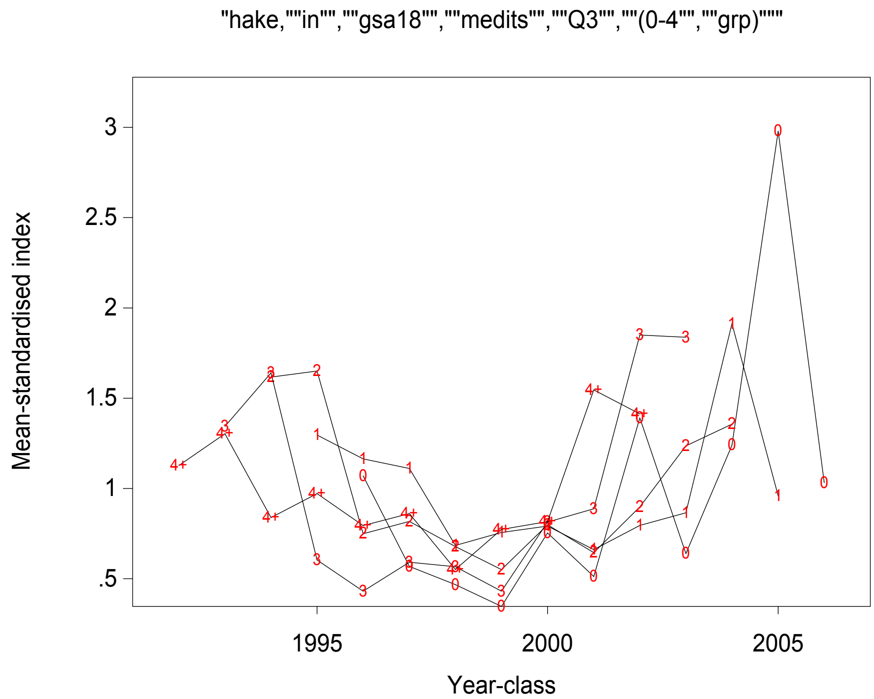

Figure 5. The hake stock in the GSA 18: mean-standardised survey abundance indices by age and year-class.

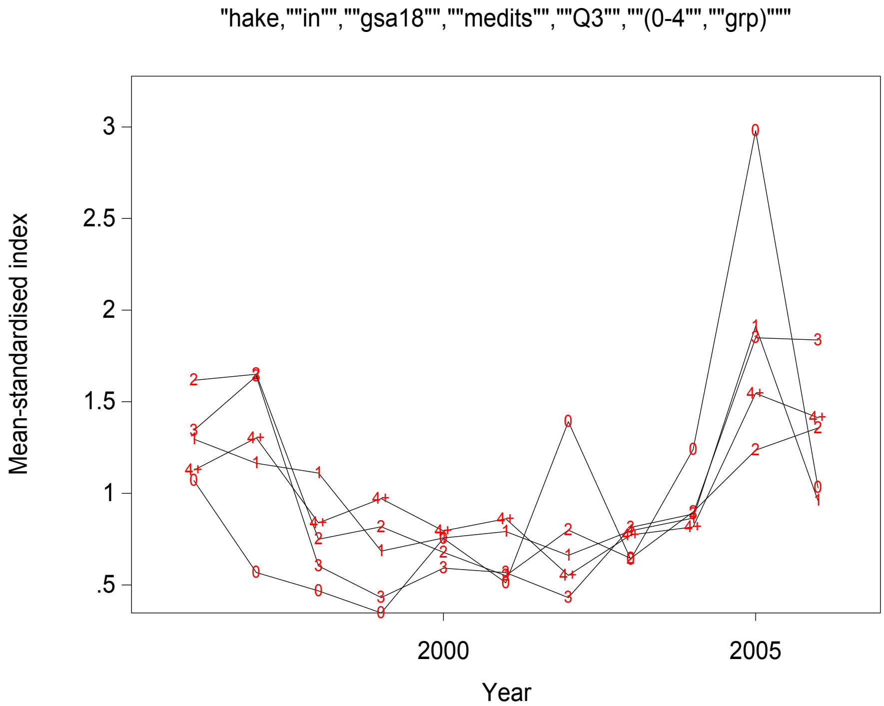

Figure 6. The hake stock in the GSA 18: mean-standardised survey abundance indices by age and year.

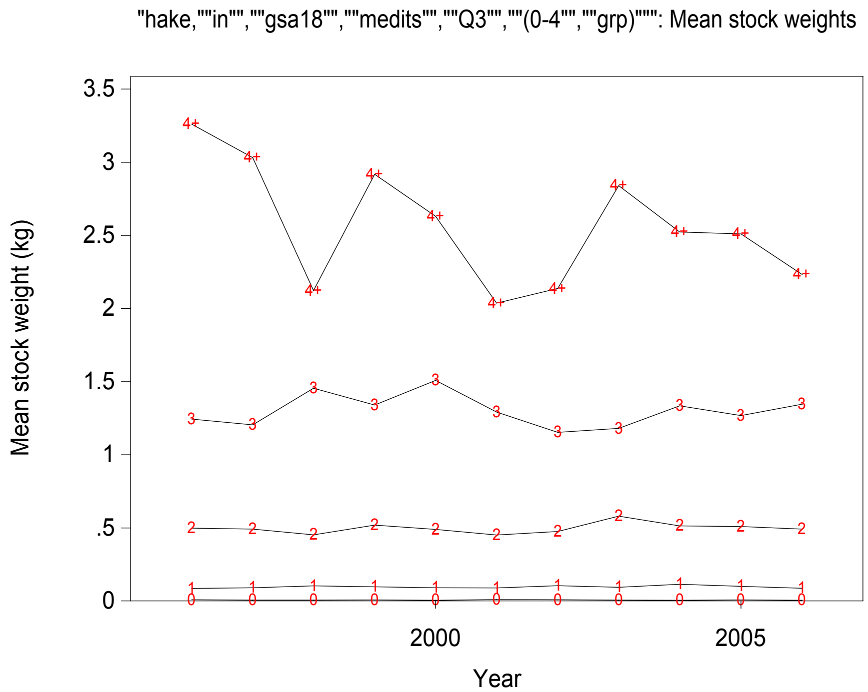

Figure 7. The hake stock in the GSA 18: mean stock weights-at-age.

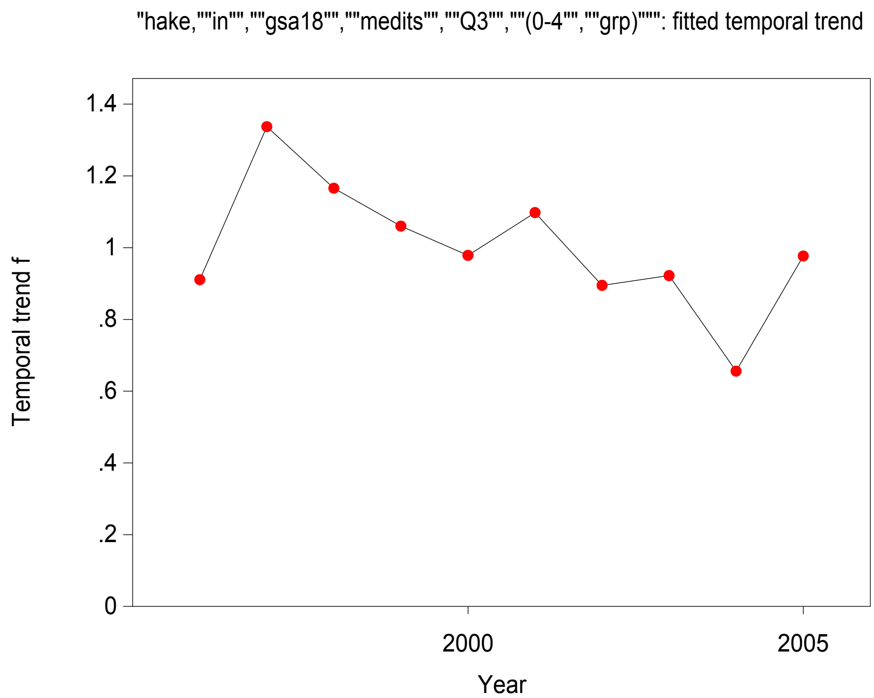

Figure 8. The hake stock in the GSA 18: fitted temporal trend.

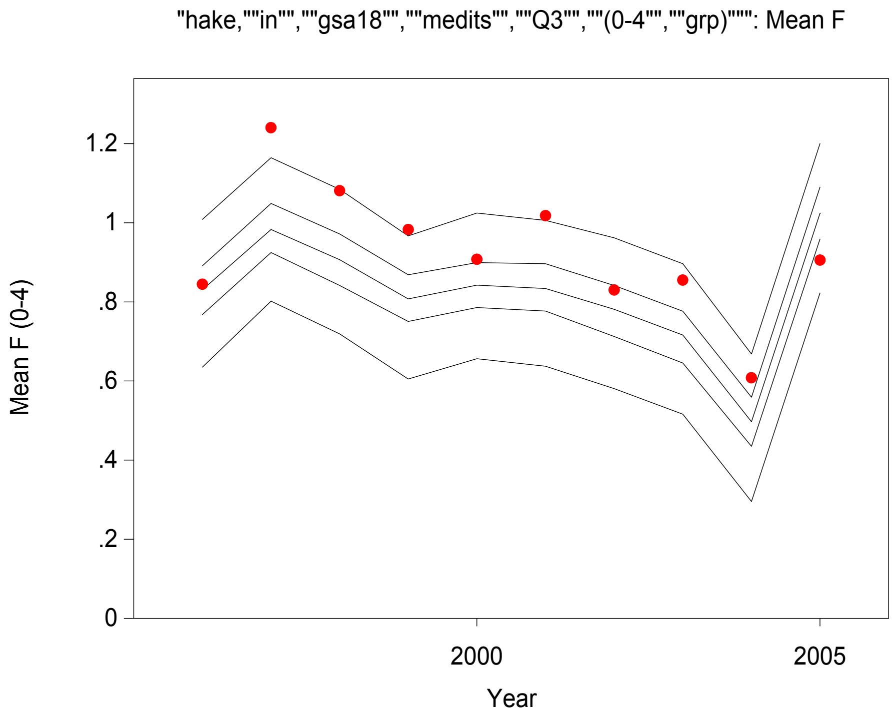

Figure 9. The hake stock in the GSA 18: estimated F (0-4).

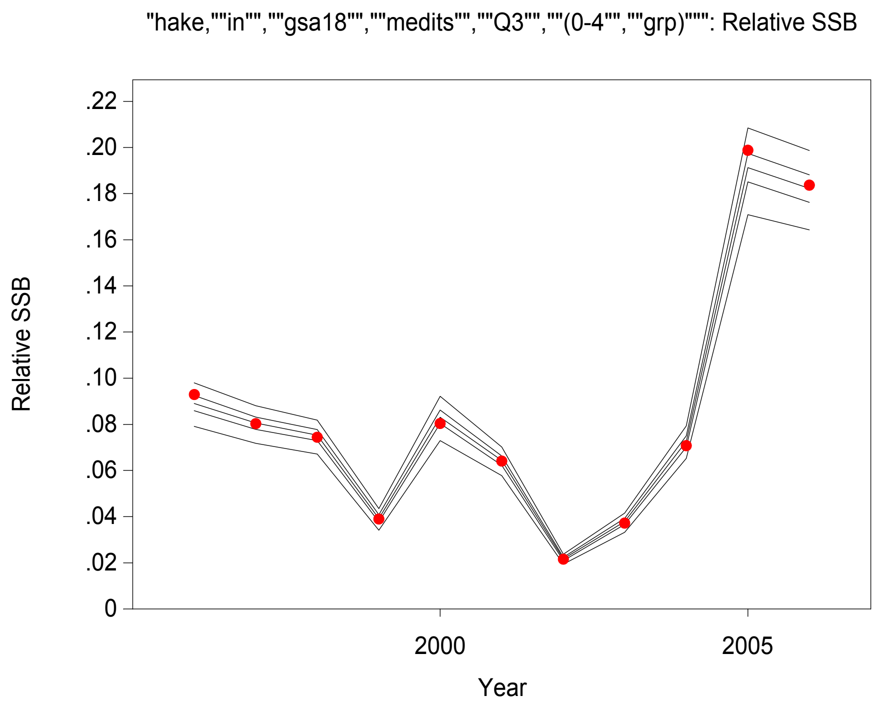

Figure 10. The hake stock in the GSA 18: estimated relative (mean-standardised) spawning stock biomass.

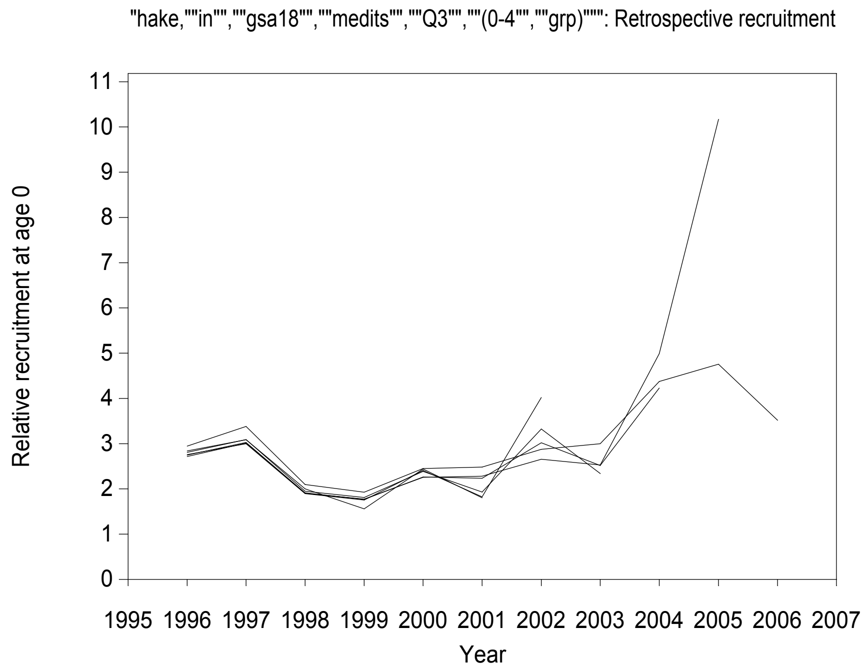

Figure 11. The hake stock in the GSA 18: estimated relative recruitment at age 0.

The mean values of the parameters in the time-period 1996-2006 are (from SURBA outputs):

- Mean F (0-4) = 0.927
- Mean relative spawning stock biomass (SSB) = 0.086
- Mean relative recruitment at age 0 = 3.074

Moreover, the model short time forecast gives a slight decrease of the yield, total stock biomass and spawning stock biomass in the next three years with respect to the last investigated year (2006).

5. Conclusion

The data-sets from 1996-2006 trawl surveys in the GSA n° 18 were analysed by means of two different methods. Most of the results obtained for the hake stock by using the empirical indicators methodology and the SURBA model are scientifically sound and comparable. In fact, both the methods highlighted similar trends in the recruitment and spawner availability (i.e. the decrease of spawners index and SSB during the triennium 2000-2002). Moreover the trend of the 75° percentile of body length (empirical indicator related to the presence of larger sizes) is very similar to the trend of mean stock weights-at-age 4^+ from SURBA outputs.
The main conclusion from the analysis of the hake stock in the Southern Adriatic is the confirmation of the strong dependence of the resource on the success of the recruitment (Ungaro and Marano, 1996; Ungaro et al., 2003) and the apparent and light decreasing trend of the larger hake specimens (older than four years).
In the end, both the used methods can be considered as suitable for the diagnosis of the state of the hake stock in the GSA n° 18. Furthermore, the estimated 33rd and 66th percentile values of the Empirical Indicators can be, respectively, comparable to limit reference value and target reference value in the time series (Halliday et al., 2001; Ceriola et al., 2007), as well as Reference Points can

be calculated using the SURBA estimates (SSB, recruitment indexes), exploring stock-recruitment relationships (STECF-SGMED, 2008).

6. References

AdriaMed. 2000. Priority Topics Related to Shared Demersal Fishery Resources of the Adriatic Sea. Report of the First Meeting of the AdriaMed Working Group on Shared Demersal Resources. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea. GCP/RER/010/ITA/TD-02: 21 pp.

Beare, 2005. Using survey data independently from commercial data in stock assessment: an example using haddock in ICES Division Via. ICES J. Mar. Sci., 62: 996-1005.

Bertrand, J.A., Gil De Sola, L., Papacostintinou, C., Relini, G., Souplet, A., 2002. The general specifications of the Medits Surveys. Sci. Mar. 66 (Suppl.1–2), 9–17.

Caddy, J.F., 2002. Limit reference points, traffic lights, and holistic approaches to fisheries management with minimal stock assessment input. Fish. Res. 56, 133–137.

Caddy, J.F., Wade, E., Surette, T., Hebert, M., Moriyasu, M., 2005. Using an empirical traffic light procedure for monitoring and forecasting in the Gulf of St. Lawrence fishery for the snow crab, Chionoecetes opilio. Fish. Res. 76, 123–145.

Ceriola L., Accadia P., Mannini P., Massa F., Milone N., Ungaro N., 2008. A bio-economic indicators suite for the appraisal of the demersal trawl fishery in the Southern Adriatic Sea (Central Mediterranean). Fisheries Research, 92 (2-3): 255-267.

Ceriola, L., Ungaro, N., Toteda, F., 2007. A "traffic" light approach for the assessment of the Broadtail shortfin squid Illex coindetii Verany, 1839 in the Southern Adriatic Sea (Central Mediterranean). Rev. Fish Biol. Fish 17(2–3), 145–157.

De Zio V., Ungaro N., Vlora A., Strippoli G., 1998. Lo stock di nasello del Basso Adriatico: struttura demografica e rendimenti di pesca della frazione catturata con palangaro di fondo. Biol. Mar. Medit., 5 (2): 128-135.

Fiorentino F., Bertrand J.A., Ferrandis E., Garofalo G., Gonzalez M., Politou C.Y., 2003. Nurseries of Hake, Greater Fork-beard, Deep Water Pink Shrimp and Broadtail Shortfin Squid in the Mediterranean using MEDITS trawl survey data. Working Group on Nursery Areas – MEDITS Program. ED/WP/FF-JAB- EF-GG-MG-CYP/3/0102/DRAFT/50p.

Fulton, E.A., Smith, A.D.M., Punt, A.E., 2005. Which ecological indicators can robustly detect effects of fishing? ICES J. Mar. Sci. 62, 540–551.

Gramolini, R., Mannini, P., Milone, N., Zeuli, V. 2005. AdriaMed Trawl Survey Information System (ATrIS): User Manual. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea. GCP/RER/010/ITA/TD17. *AdriaMed Technical Documents*, 17: 141 pp.

Halliday, R.G., Fanning, L.P., Mohn, R.K., 2001. Use of traffic light method in fishery management planning. Marine Fish Division, Science Branch, Scotia-Fundy Region, Department of Fisheries and Oceans, Bedford Institute of Oceanography, Dartmount, NS, B2Y, 4A2, Canadian Science Advisory Secretariat, Res Doc 2001/108, pp. 1–41.

ICES, 2002. Report of the working Group on the Assessment of Northern Shelf demersal Stocks. ICES CM 2003/ACFM:04.

Jennings S., 2005. Indicators to support an ecosystem approach to fisheries. Fish Fish. 6, 212–232.

Jukic-Peladic, S., Vrgoc, N., Krstulovic-Sifner, S., Piccinetti, C., Piccinetti-Manfrin, G., Marano, G., Ungaro, N., 2001. Long-term changes in demersal resources of the Adriatic Sea: comparison between trawl surveys carried out in 1948 and 1998. Fish. Res. 53, 95–104.

Koeller, P., 2002. A New Traffic Light Assessment for the Eastern Scotian Shelf Shrimp Fishery in 2001. Can. Sci. Advisory Secretariat 6, 50.

Marano G., Ungaro N., Marzano M.C., Marsan R., 1998. Le Risorse Demersali dell'Adriatico pugliese: analisi di una serie storica ('85-'95) relativa ai dati di cattura e demografia degli stock. Biol. Mar. Medit., 5 (2): 52-67.

Needle C.L., 2003. Survey based assessment with SURBA. Working document to the ICES WGMFSA, Copenhagen, 29 January to 5 February 2003.

Osmani, K., Decolli, P., Ceriola, L., Ungaro, N., 2002. Past and current status of Albanian demersal trawl fishery (Mediterranean Sea, geographical sub-area 18). In: International SAMED Symposium, Rome, FAO.

Sparre, P., Venema, S.C., 1998. Introduction to tropical fish stock assessment. Fao fish. Tec. Pap. 306/1, Rev. 2. FAO, Rome, pp. 1–407.

STECF-SGMED, 2008. Report of the SGMED-08-01 SubGroup on the Mediterranean. Part 1.

Ungaro N., Marano C.A., D'uggento A., 1998. Relazioni tra specie demersali del bacino adriatico sud-occidentale: analisi statistica di serie storiche. Biol. Mar. Medit., 5 (1): 196-202.

Ungaro N., Marano G., 1996. Considerations on the hake stock of the South-Western Adriatic Sea. FAO Fish. Rep., 533 (Suppl.): 97-100.

Ungaro N., Marano G., Ceriola L., Bertoldi G., Di Turi L., 2002. Lo sbarcato del porto peschereccio di Molfetta (Basso Adriatico): aree di pesca, catture e sforzo in un anno di osservazioni. Biol. Mar. Medit., 9(1): 290-294.

Ungaro N., Rizzi E., Marano G., 1993. Note sulla biologia e pesca di Merluccius merluccius (L.) nell'Adriatico pugliese. Biologia Marina, 1: 329-334.

Ungaro N., Vrgoc N., Mannini P., 2003. The biology and stock assessment of Merluccius merluccius (L.) in the Adriatic Sea: an historical review by geographical sub-areas. Acta Adriat., 44 (1): 9-20.

Ungaro, N., Ceriola, L., Marano, C.A., Osmani, K., Mannini, P., 2006. On the suitability of some indicators from trawl surveys data. Mediterranean geographical sub-area No. 18. In: Lembo, G. (Ed.), Selected Papers Presented at theWorkshop on Biological Reference Points, Rome, 20–21 April, 2004. Studies and Reviews, General Fisheries for the Mediterranean 83, 37–54.

Vrgoc, N., Arneri, E., Jukic-Peladic, S., Krstulovic Šifner, S., Mannini, P., Marceta, B., Osmani, K., Piccinetti, C., Ungaro, N., 2004. Review of current knowledge on shared demersal stocks of the Adriatic Sea. FAO-MiPAF Scientific Cooperation to Support Responsible Fisheries in the Adriatic Sea. GCP/RER/010/ITA/TD-12. AdriaMed Technical Documents, 12: 91 pp.