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Methods for Assessing Mediterranean Fisheries

by

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Summary

Existing methods, their data needs (appropriate quality, coverage and mainly their availability) and expected outputs (effort-based control system in the context of the Precautionary Approach as management objective) are revised to find the most suitable method for establishing a harmonised assessment methodology in the Mediterranean. Considering the lack of reliable data bases, the Length Cohort Analysis (LCA) proves to be the best, if not the only existing method adapted to the current characteristics of the region. Furthermore, the software called VIT[1], especially applied to analyse Mediterranean fisheries, is identified as the most suitable software to assess and provide advice for the management of Mediterranean fisheries.

1. Rationale

The GFCM, in its Twenty-Sixth Session, held in Lacco Ameno, Ischia, Italy, from 10 to 13 September 2001, asked to its Scientific Advisory Committee (SAC) to review **existing stocks/fisheries assessment methods** highlighting data needs, expected outputs and pros and cons and their suitability to Mediterranean stocks and fisheries. On the results of this review the SAC will have to define, at their Fifth Session to be held next June 2002, a set of the most appropriate assessment methods which should result in the establishment of a harmonised assessment methodology, agreed by scientists of member countries.

One of the FAO COPEMED Project objectives is to offer support to the works of the General Fisheries Commission for the Mediterranean (GFCM) and of it Scientific Advisory Committee (SAC) to allow the formulation of recommendations and the definition of scientific criteria for a better management of the exploited resources in the Mediterranean. In this context

[1] **The program VIT** (**Lleonart, J., and Salat, J.** 1997. VIT: Software for fishery analysis,. User's manual. FAO Computerised Information Series. Fisheries, 11: 107 pp.) is designed for the analysis of marine populations, exploited by one or several gears, based on single species' catch data (structured by age or size). The main assumption underlying the model is that of steady state, because the program works with pseudo-cohorts and it is therefore not suitable for historical data series. The program uses the catch data and ancillary parameters for rebuilding the population of the species and the mortality vectors affecting it by means of Virtual Population Analysis (VPA). Once the virtual population has been rebuilt, an analysis of the fishery can be carried out with the aid of several tools: Comprehensive VPA results, Yield-per-Recruit analysis based on the fishing mortality vector, analysis of sensitivity to parameter values and transition analysis. The latter permits non-equilibrium analysis of how a shift in exploitation regime is reflected in the fisheries. All these tools can be applied to specific studies of competition among fishing gears. The program can be used to carry out the numerical analysis, the edition of data and parameters, to obtain an age-structured data file from a size-structured data file and to visualise results. The results can also be exported to other Windows applications to refine specific details of the analysis or for the final presentation of the results. http://www.ua.es/copemed/en/index.htm

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2. Background

2.1. Stock assessment methods and their use in the Mediterranean

There are currently three dominant approaches to fisheries stock assessment:

1. Simple models of biomass dynamics (often called surplus production models or global models) that rely only on catch and some index of abundance.
2. Analytical models: Analysis of length frequency data of catches (often called Length Cohort Analysis – LCA).
3. Analytical models: Analysis of catch-at-age data (often called Virtual Population Analysis – VPA).

There is an abundant literature on these methods and many manuals have been published to describe them and to facilitate their use. Among them the Manual of Fish Stock Assessment (Cadima, 2002), recently published by FAO is recommended to find out more about these methods. The possibilities of applying these different population dynamics methodologies to the Mediterranean are also discussed by Lleonart (1993).

Since remote antiquity, the Mediterranean has been the object of observations and descriptions in which maritime activities and fishing occupy a paramount place. The very rich Mediterranean fauna and the highly multispecific nature of catches certainly favoured the fact that the **first works were mainly oriented towards attempts exhaustive descriptions of the vital cycles and biological parameters of a given species** (Demiere,1979, Quesada, 1991)[2].

Umberto D'Ancona's observations on Mediterranean fisheries and variations in fish populations as a result of changing fishing patterns after the first World War allowed Lotka and Volterra to establish the mathematical foundations of population dynamics in the 1920s. However, the transition from marine biology *sensu stricto* to fisheries research is relatively recent in the Mediterranean. We can consider that the first practical attempts to apply some mathematical population dynamic models to exploited stocks were carried out in France and Spain in the late 1960s. Most of these first analyses used **global production models**. However, these models of classic use in fisheries exploiting monospecific resources by means of a single type of gear, and for which they

[2] **Cadima, E.L.** (2002). Manual of fish stock assessment. FAO Fisheries Technical, 393: 170p.
Lleonart, J. (1993). Methods to analyse the dynamics of exploited marine populations: Use and development of models. Sci. Mar., 57(2-3): 261-267.
Quesada, M.A. 1991. Parametros biolódgicos de peces, crustaceos y moluscos del Mediterraneo occidental. Recopilación bibliografica (1950-1990). Inf. Tec. Inst. Esp. Oceanogr., 102: 173 pp.
Dremiere, P.Y. 1979. Parametres biologiques et dynamiques disponibles sur les principaux stocks halieutiques du Goife du Lion: sous-zone 37.2 du CGPM. FAO Fish. Rep., 227:111-127 p.

were designed, **prove to be quite disappointing when applied in the Mediterranean Sea.**
These models have a sort of "black box" vision of fisheries in which only one data entry, the fishing effort and only one data output, the catch, are observable. Moreover, they require long data series and a calibrated measure of the fishing effort, which must present a certain range of variation to facilitate the analysis of catch variation. This being so, and given the characteristics of Mediterranean fisheries and available data bases, **production models are considered to have limited applicability** for evaluation in this case. In the late 1980s and early 1990s, the limitations of production models induced a group of north western Mediterranean fisheries scientists to adapt **Virtual Population Analysis** (VPA) techniques to Mediterranean fisheries.

The **Length Cohort Analysis** (LCA) is a simplification of the Virtual Population Analysis (VPA) which assumes that the stock is in a state of equilibrium. The LCA is currently the most widely used method in the Western Mediterranean. It requires a knowledge of catch distribution by size classes and by gear and some estimation of the biological parameters of the species, and currently **represents a clear line of progress for population dynamics in the Mediterranean.**

We shall cite also the **Yield per Recruit** (Y/R) analysis used on various occasions in the western Mediterranean throughout the 1980s. It makes use of simple estimates of the requisite dynamic and biological parameters (Oliver, 1983). It can also use the more solid estimates of fishing mortality provided by VPAs and LCAs, together with length/weight and length/age relationships, estimating the yield (in biomass) of each recruit brought into the fishery for different vectors of mortality. Y/R curves can thus be built by varying effort (fishing mortality) or gear selectivity (length at first capture), providing an enormously useful overview of the state of the stock. However,

Direct evaluations of biomass have also been carried out to provide useful information when statistical information of fisheries is missing. However, **the results obtained until now using this methodologies have been very limited.**

2.2. An historical overview on the last 25 years

The early applications of stock assessment methods in the Mediterranean were promoted in the 1970s by the scientific Working Groups of the General Fisheries Council for the Mediterranean (GFCM). These were **Global Models** under equilibrium, also called production models (GFCM, 1972; Charbonier and Caddy, 1986; Pereiro and Fernandez, 1974; Oliver, 1983) [3]. However, they

[3] **Charbonier, D. & J.F. Caddy**.- 1986. Report of the technical consultation of the General Fish Council for the Mediterranean on the methods of evaluating small scale fisheries in the Western Mediterranean. Sète, France, 13-16 may, 1986. *FAO Fish. Techn. Rep.*, 362, 155 pp.
GFCM. 1972. Rapport de la troisieme session du Groupe de travail du CGPM sur 1'evaluation et 1'exploitation des ressources demersales. Athenes, 6-11 mars, 1972.
Oliver, P. 1983. Los recursos pesqueros del Mediterraneo. Primera parte: Mediterraneo occidental.Etud.Rev.CGPM, 59:135 p.

proved to be **not very useful for the analysis of Mediterranean fisheries,** mainly due to their severe theoretical restrictions, but also to the impossibility of distributing the effort among the different species to which the model is simultaneously applied that constituting an additional problem. To solve it, there were various attempts to apply the so-called **Composite Production Models** (GFCM, 1972; GFCM, 1980; Garcia, 1983; Caddy and Garcia, 1984; Chavance and Girardin, 1985; GFCM, 1988).

The normal use of **analytical models** in the Mediterranean, actually LCA, was due to a co-operative research project of France, Italy and Spain, funded by the European Union, called "FARWEST - Study for assessment and management of fisheries in the western Mediterranean" and carried out in the period 1990-1994. As a consequence of this co-operative activity, in 1993 a Working Group on Population Dynamics (DYNPOP) was established in the framework of the International Commission for the Scientific Exploration of the Mediterranean (ICSEM/CIESM) with the support of the International Centre for Advanced Mediterranean Agronomic Studies (CIHEAM). DYNPOP incorporated, in the period 1992-1996 (CIHEAM, 1995; CIHEAM, 1998) scientists from the eastern and mainly southern parts of the Mediterranean. Thanks to that, **Length Cohort Analyses have been used during the last ten years to assess the main stocks and increasingly complete and reliable assessments are available.**

However, **the availability of reliable data is again the main problem to use Virtual Population Analysis** (VPA) based on long series of catch-at-age data and it was only possible to use Length Cohort Analysis (LCA) based on pseudocohorts built using length frequency data.

For this reason, a group of Spanish fishery scientists developed a **programme package based on LCA and Y/R analysis adapted to Mediterranean fisheries** called VIT (Lleonart and Salat, 1992). The program and the models underlying VIT software are conceived for the analysis of fisheries where the time depth of the information available is limited and where the technical interaction among fishing gears is an important factor to account for. Data management routines (input), and tables and graphics output have also been conceived to analyse and to provide advice of Mediterranean fisheries. This software, designed to analyse the important competitive gear situation in the Mediterranean, was updated and translated into English in 1997 (Lleonart and Salat, 1997)[4] and recently it has also been adapted to a more friendly version for

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Pereiro, J.A. and Femandez, A. 1974. Aplicacidn de los modelos de produccidn de Schaefer y Fox a las pesquerfas de Palinurus, Aristeus, Mullus, Pagellus y Solea de la plataforma balear. Bol. Inst. Esp. Oceanogr., 181: 27 pp.

[4] **Caddy, J.F. and Garcia, S.** 1982. Production modelling without long data series. FAO Fish. Rep., 278: 309-313.
Chavance, P. and Girardin, M. 1985. Niveaux d'exploitation en 1982 et potentialites regionales de la pecherie chalutiere algerienne. Application d'un modele de production composite. FAO Fish. Rep., 347:113-125 p.
Ciheam, 1995. Cahiers Options Mediterraneennes, 10 :
Ciheam, 1998. Cahiers Options Mediterraneennes, 35 :
Garcia, S. 1983. Un exemple de 1'utilisation des modeles de production composites en Mediterranee espagnole. FAO Fish. Rep., 305: 97-105 p.
GFCM. 1972. Rapport de la troisieme session du Groupe de travail du CGPM sur 1'evaluation et 1'exploitation des ressources demersales. Athenes, 6-11 mars, 1972.

PC thanks to the COPEMED support. All that has facilitated research on the population dynamics of many Western Mediterranean stocks (Lleonart, 1993; Farrugio et al, 1994). VIT software can also be downloaded and installed from the COPEMED homepage or installed from the CD-Rom published by CIHEAM-COPEMED in 2001 (Franquesa and Lleonart ed., 2001) [5].

The sampling effort of the 1980s has also enabled a few conventional VPAs to be applied to some stocks (Oliver, 1993; Aldebert et al, 1994). In this analysis the results obtained when using and VPA or an LCA on annual pseudocohorts were compared, and in general, good agreement has been found between them (Oliver, 1994, Oliver et al, 1995).

We must also mention that **these analyses are highly sensitive to the estimates and biological parameters used.** Uncertainty about the Von Bertalanfy Growth Function parameters and particularly, natural mortality (Caddy, 1991) hinders correct stock assessment. Special efforts have therefore been made to improve the accuracy of these estimates (Lleonart, 1993; Farrugio et al, 1994; Djabali et al 1993). Abella et al. (1997) have analysed the problem of different natural mortality at age on LCA assessments. These methods have been applied to all kinds of species (demersals, large and small pelagics) but only to a quite limited number because of the lack of proper data.

A special meeting of the Working Group on Population Dynamics (DYNPOP) was held in Zaragoza (Spain) in January 1998 to analyse the impact of the mortality rates for different age-classes on population dynamics and stock assessment in the Mediterranean (CIHEAM, 1998) [6].

GFCM. 1980. Rapport de la Consultation technique pour revaluation des stocks dans les divisions statistiques Baleares et Golfe du Lion. GFCM. FAO Fish. Rep., 227.

GFCM. 1988. Rapport du groupe de travail ad hoc sur 1'amenagement des stocks dans la Mediterranee occidentale. FAO Fish. Rep., 386.

Lleonart, J., and Salat, J. 1992. VIT un programa para analisis de pesquerfas. Inf. Tec. Sci. Mar., 168-169: 116pp.

Lleonart, J., and Salat, J. 1997. VIT: Software for fishery analysis,. User's manual. FAO Computerised Information Series. Fisheries, 11: 107 pp.

[5] http://www.ua.es/copemed/en/index.htm . **Franquesa, R. and J. lleonart** (editors). 2001. Bioeconomic Management Tools for Mediterranean Fisheries. ISBN 84-669-5494-6.

[6] **Abella, A.J., J.F. Caddy & F. Serena**.- 1997. Do natural mortality and availability decline with age? An alternative yield paradigm for juvenile fisheries, illustrated by the hake *Merluccius merluccius* fishery in the Mediterranean. *Aquat. Living Resourc*. 10:257-269.

Aldebert, Y. and Recasens, L. 1994. Methodes d'approche du stock de merlu du Goife du Lion. Premiers resultats. In Farrugio et al. (1994).

Ciheam, 1998. Rapport technique sur la Réunion DYNPOP sur l'impact des taux de mortalité par âge sur la dynamique des populations et le diagnostique des stocks exploités en Méditerranée.

Caddy, J. 1991. Perspectives sur les activités futures en matière d'évaluation des stocks dans le Méditerranée occidentale. FAO Rapportvsur les pêches, 227: 149-154 p.

Djabali, F., Mehailia, A., Koudil, M. and Brahmi, B. 1993. Empirical equations for the estimation of natural mortality in Mediterranean teleosts. NAGA, the ICLARM quarterly, January 1993.

Oliver P. 1993 – Analysis of fluctuations observed in the trawl fleet landings of the Balearic Islands. Scientia Marina, 57 (2-3): 219 - 227.

Oliver, P. 1994. Dinamica de la poblacion de merluza (Merluccius merluccius L.) de Mallorca Microfichas IEO, 2.

Oliver P. ,E. Massuti & O. Reñones, 1995. Methods of approach on the population dynamics of hake (Merluccius merluccius) in Majorca (NW Mediterranean). Cahiers Options Mediteraneennes, 10: 25-26p.

Among demersals, Hake and red mullets are the species of fishes on which more analyses and assessments have been performed (Flamigni, 1984; Giovanardi et al., 1986; Orsi-Relini and Arnaldi, 1986; Karlou and Vrantzas, 1989; Martin and Sánchez, 1992; Oliver and Morillas, 1992; Ungaro et al., 1992; Vassilopoulou and Papaconstantinou, 1992; Recasens, 1992; Hadjistephanou, 1992; Vrantzas et al., 1992; Stergiou et al., 1992; Levi et al. 1993; Aldebert et al., 1993; Tursi et al., 1994; Ungaro et al., 1994; Oliver et al., 1995; Papaconstantinou and Stergiou, 1995; Arneri and Jukic, 1996; Ungaro and Marano, 1996; Tursi et al., 1996; Aldebert and Recasens, 1996a and 1996b; Ben Mariem and Garbi, 1996; Fiorentino et al. 1996; Ben Mariem et al., 1996; Ardizzone, 1998; Abella and Serena, 1998; Bouaziz et al. 1998a and 1998b; Voliani et al., 1998; Lembo et al. 1998; Papaconstantinou, 2000).

Two species of crustaceans (norway lobster and red shrimp) have also been studied (Yahiaoui et al., 1986; Demestre and Lleonart, 1993; Sardà and Lleonart, 1993; Demestre and Martin, 1993; Spedicato et al., 1995; Ragonese and Bianchini, 1996; Colloca et al., 1998; Fiorentino et al., 1998; Orsi-Relini and Relini, 1998).

Technical gear interaction, has been studied in some places were more than one gear are operating on one species (Demestre et al., 1997) [7].

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[7] **Abella, A.J. & F. Serena**.- 1998. Stato di sfrutamento del nasello nei compartimenti di pesca di Livorno e Viaregio. Biologia Marina Mediterranea, vol.5, fasc. 2.

Aldebert, Y., L. Recasens & J. Lleonart.- 1993. Analysis of gear interactions in a hake fishery: The case of the Gulf of Lions (NW Mediterranean). *Sci. Mar.*, 57(2-3):207-217.

Aldebert Y., Recasens L. 1996 – Méthodes d'evaluation du stock de merlu du golfe du Lion. *FAO Fish. Rep.*, 537: 157-164.

Aldebert, Y. & L. Recasens. 1996. Comparison of methods for stock assesssment of European hake *Merluccius merluccius* in the Gulf of Lions (Northwestern Mediterranean). *Aquat. Living Resour.* , 9 (1):13-22.

Ardizzone G.D. 1998 – Un tentativo di valutazione delle condizioni di *Merluccius merluccius* e *Mullus barbatus* nei mari italiani. *Biol. Mar. Medit.* 5 (2): 151-168.

Arneri E., Jukic S. 1986 – Some preliminary observations on the biology and dynamics of *Mullus barbatus* in the Adriatic Sea. *FAO Fish Rep.* 345: 79 – 85.

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Ben Mariem S., Gharbi H., Ezzeddine-Najai S. 1996 – Le rouget de roche (*Mullus surmuletus*) en Tunisie : Evaluation des stocks et aménagement des pecheries. *FAO Fish. Rep*. 533 (Suppl.): 269-284.

Bouaziz A., Bennoui A., Djabali F., Maurin C. 1998 – Reproduction du merlu *Merluccius merluccius* (Linnaeus, 1758) dans la région de Bou-Ismail. *Cah. Options Méditerr.*, 35: 109-117.

Bouaziz A., Semroud R., Djabali F., Maurin C.1998 –Estimation de la croissance du merlu *Merluccius merluccius* (Linnaeus, 1758) de la region centre de la cote algérienne par analyse des fréquences de tailles. *Cah. Options Méditerr.*, 35: 35-41.

Caddy, J.F. and Garcia, S. 1982. Production modelling without long data series. FAO Fish. Rep., 278: 309-313.

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Chavance, P. and Girardin, M. 1985. Niveaux d'exploitation en 1982 et potentialites regionales de la pecherie chalutiere algerienne. Application d'un modele de production composite. FAO Fish. Rep., 347:113-125 p.

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Ciheam, 1998. Cahiers Options Mediterraneennes, 35 :

Colloca F., Gentiloni P., Agnesi S., Schintu P., Cardinale M., Belluscio A., Ardizzone G.D. 1998 – Biologia e dinamica di popolazione di *Aristeus antennatus* (Decapoda: Aristeidae) nel Mar Tirreno Centrale. *Biol. Mar. Medit.* 5 (2): 218-231.

Demestre, M. & P. Martin.- 1993. Optimum exploitation of a demersal resource in the Western Mediterranean: the fishery of the deepwater shrimp *Aristeus antennatus* (Risso, 1816). *Sci. Mar.* 57 (2-3): 175-182

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Hadjistephanou N.A. 1992 – Assessment of five demersal marine fish stocks of Cyprus for the year 1989. *FAO Fish. Rep*. 477: 23-34.
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Martin P., Sanchez P. 1992 – Length distribution and total mortality rate Z of Merluccius merluccius, Mullus barbatus and Eledone cirrhosa exploited by the trawling fleet in 1982 and 1991 off the Catalan Coast (NW Mediterranean). Rapp. Comm. int. Mer Médit., 33: 301.
Oliver P., Morillas A. 1992 – Etat d'exploration du Merlu (Merluccius merluccius L.) et de Rouget (Mullus surmuletus L.) des Iles Baléares. Rapp. Comm. int. Mer Médit., 33: 304.
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Orsi Relini L., Relini G. 1998 - Long term observations of *Aristeus antennatus*: Size-structures of the fished stock and growth parameters, with some remarks about the "recruitment". *Cah. Options Méditerr*. 35: 311-322.
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Papaconstantinou C. 2000 – The biology and the management of Hake (*Merluccius merluccius)* in the Greek Seas. Working paper presented at WG on Demersals. Séte (France) 21-23 March 2000: 17p.
Pereiro, J.A. and Femandez, A. 1974. Aplicacidn de los modelos de produccidn de Schaefer y Fox a las pesquerfas de Palinurus, Aristeus, Mullus, Pagellus y Solea de la plataforma balear. Bol. Inst. Esp. Oceanogr., 181: 27 pp.
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Sardà, F. & J. Lleonart.- 1993. Evaluation of the Norway Lobster (*Nephrops norvegicus* L.) ressource off the "Sarola" bank off Barcelona (Western Mediterranean). *Sci. Mar.* 57 (2-3): 191-197.
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Tursi A., Matarrese A., D'Onghia G., Sion L. 1994 – Population biology of red mullet (*Mullus barbatus* L.) from the Ionian Sea. *Mar. Life* 4 (2) : 33-43.
Tursi A., Matarrese A., D'Onghia G., Sion L., Maiorano P. 1996 – The yield per recruit assessment of hake (*Merluccius merluccius* L. 1758) and red mullet (*Mullus barbatus* L. 1758) in the Ionian Sea. *FAO Fish. Rep*. 533 (Suppl.): 127-141.
Ungaro N., Rizzi E., Marano G. 1992 – Note sulla biologia e pesca di Merluccius merluccius (L.) nell'Adriatico pugliese. Biologia Marina, suppl. al Notiziario SIBM, 1: 329-334.

Small pelagics such as sardine and anchovy have also been the object of analysis through population dynamics procedures (Bouchereau et al., 1986; Chavance et al., 1986; Djabali et al., 1990; Pertierra and Perrotta, 1993; Gingolani et al., 1996; Gingolani et al., 1998; Sinovcic, 1998; Santojanni et al., 1999; Vidoris and Kallianiotis, 2000).

However**, these assessment methods prove not to be very suitable for assessing the coastal pelagic stocks**. These stocks vary greatly at different times and places as recruitment fluctuates for biotic or abiotic reasons. This makes it extremely difficult or impossible to predict either the biomass or the recruitment of these stocks. On the other hand the assessments show, in general, a lack of pressure on the stocks of sardine, which is probably due to low market demand.

For this reason, some scientists, critical of the evaluation methods based on fishing data, are opting for the application in the Mediterranean of **Direct Methods of evaluation** such as ichthyoplankton surveys applying the **Daily Egg Production Method** to evaluate the Spawning Stock Biomass of fish stocks and **biomass hydro-acoustical surveys**. (Chavance, 1980, GFCM 1982; Oliver and Pastor 1986; Chavance and Girardin, 1986; Lazar et al., 1986; Miquel and Alvarez 1990; Regner, 1990, Miquel et al. 1991; Abad et al 1991; Abad et al 1992; Rubin et al 1992; Garcia 1992; Palomera and Pertierra 1993; Garcia and Palomera, 1996; Abad et al., 1996, Somarakis and Tsimenides, 1997; Casavola et al., 1998; Casavola, 1999; Quintanilla et al., 2000, Patti et al., 2000; Guennegan et al., 2000). A comparison between the DEPM, acoustic surveys and population dynamics models showed that their results appear to be quite consistent (Pertierra and Lleonart, 1996) [8].

Ungaro N., Rizzi E., Marzano M.C. 1994 – Utilizzo del modello di Beverton e Holt, "rendimento per recluta (Y/R)", per la risorsa *Mullus barbatus L.* nell'Adriatico pugliese. *Biol. Mar. Medit.*1 (1): 317-318.

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[8] **Abad, R., Miquel, J. and Millan, M.** 1991. Resultados de la campana de evaluacidn acustica ECOMDED 90. Inf. Tec. Inst. Esp. Oceanogr., 104:17p. Abad, R., Miquel, J., Millan, M. and Iglesias, M. 1992. Resultados de la campana de evaluacidn acustica ECOMED 91. Inf. Tec. Inst. Esp. Oceanogr., 131:16p.

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Somarakis, S. & N. Tsimenides.- 1997. A daily egg production method biomass estimate of the northern Aegean sea anchovy stock. *Ozeanografika*, 2:133-148

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Vidoris P., Kallianiotis A. 2000 - Production Model of *Engraulis encrasicolus L.*, 1758, in the Thracian Sea. Paper presented at WG on small Pelagics. Fuengirola (Spain) 1-3 March 2000: 4 p.

Trawl surveys constitute also a useful tool in assessment of demersal fisheries and have been used in several Mediterranean countries (Ardizzone and Corsi, 1997; Campillo et al. 1989, Gil de Sola 1992,). The main source of error in this case is due to intercalibration problems for the trawl surveys between the different surveys, vessels and countries. The most appropriate sampling methods, the coverage issues and the cost are additional problems to be taken into account. Since 1994 the MEDITS project is being carried out in the four European Mediterranean countries with extensive trawl surveys at the end of spring carried out in all European waters (Bertrand and al., 1998, Abella et al. 1999). The main target of this project was to get abundance indices comparable between the different areas studied. This has been made possible by the standardisation of the methodology (location of the trawl stations, same gear operated in the same way by each participant, common format for the computer files, etc...). Some results have been published and gathered in monographic issues (Bertrand and Relini, 1998; Relini et al., 1999).

These direct methods have been used to assess biomass but **few or no scientific advice for management or management actions are taken from these assessments**

We must also mention that different **statistical methodologies** of regression analysis, generalised linear modeling (GLM) and time series analysis, have been used by several authors to analyse various fisheries, in particular series of catches and CPUEs (Stergiou and Christou, 1996; Stergiou et al., 1997a; Daskalov, 1998; Goñi and al., 1999; Lloret et al., 2000a)[9]. Actually, these methodologies have not been sufficiently used in the Mediterranenan, taking into account that appropriate data bases could probably be identified in some areas.

[9] **Ardizzone, G.D. & F. Corsi (Eds.)-** 1997. Atlas of Italian demersal fishery resources. Trawl surveys 1985-1987. *Biol. Marin. Medit.*, 4(2):568 pp.

Bertrand, J., L. Gil de Sola, C. Papaconstantinou, G. Relini & A. Souplet.- 1998. An international bottom trawl survey in the Mediterranean: the MEDITS programme. In: J.A. Bertrand & G. Relini (co-ordinators). *Demersal Resources in the Mediterranean. Actes de Colloques IFREMER* nº 26: 76-93.

Bertrand, J.L. & G. Relini (co-ordinators).- 1998. *Demersal Resources in the Mediterranean. Actes de Colloques IFREMER* nº 26

Campillo, A., Aldebert, Y., Bigot, J.L. and Liorzou, B. 1989. Donnees sur la distribution des principales especes commerciales du Goife du Lion (et plus particulierement des groupes 0 et 1). Rapp. internes DRV-89. 041-RH/IFREMER.

Daskalov, G. 1999. Relating fish recruitment to stock biomass and physical environment in the Black Sea using generalized additive models. *Fisheries Research.* 41, pp.1-23.

Gil de Sola, L. 1992. Resultados de las campañas de prospeccion pesquera de la especie Eledone cirrhosa en la plataforma continental del NO Mediterraneo español. Inf. Tec. Inst. Esp. Oceanogr., 140: 103 pp.

Goñi, R., F. Álvarez & S. Adlerstein.- 1999. application of generalized linear modeling to catch rate analysis of Western Mediterranean fisheries: the Castellón trawl fleet as a case study. *Fish. Res.* 42:291-302.

Lloret, J., J. Lleonart & I. Solé.- 2000a. Time series modelling of landings in Northwest Mediterranean Sea. *ICES J. Mar. Sci.*, 57:171-184.

Relini, G., J. Bertrand & A. Zamboni (Eds.)- 1999. Sintesi delle conoscenze sulle risorse da pesca dei fondi del Mediterraneo centrale (Italia e Corsica). Biol. Mar, Medit. 6 (suppl. 1). 868 pp.

Stergiou K.I. & E. Christou. 1996. Modelling and forecasting annual fisheries catches: comparison of regression, univariate and multivariate time series methods *Fisheries Research* 25: 103-138.

Stergiou K.I., E. Christou, G. Petrakis. 1997a. Modelling and forecasting monthly fisheries catches: comparison of regression, univariate and multivariate time series methods *Fisheries Research* 29: 55-95.

The methods referred to above analyse stocks alone, ignoring **interspecies relationships** and the **environment**, even though the need for analytical systems to describe these interactions is increasingly evident. Such systems would introduce new data into the findings of monospecies analyses, which ignore the limits imposed by the carrying capacity of the system. Likewise, the existence of marked fluctuations in captures apparently independent of exploitation (Astudillo and Caddy, 1988; Oliver, 1993), and which point to the concept of recruitment windows (Pauly, 1987; Bakun and Agostini, 2000, Agostini and Oliver 2002), further complicate the situation, stressing the need to observe marine systems as a whole and pointing out the limitations of "conventional" population dynamics modelling

Actually, catches are often made up of a large number of species, making calculations for a single species of limited value for management. For this reason an **integrated multispecies approach** is needed (Caddy, 1993; Lleonart and Recasens, 1996; Caddy, 1997; Merella et al, 1998; Stergiou, 1999; Lloret et al., 2000b). Because of the oligotrophic character of the Mediterranean, local events like wind-driven mixing, river discharge and advection of waters from adjacent areas can play an important role in local fertilisation (Estrada, 1996) and fishery productivity (Lloret et al., 2000b; Daskalov, 1999; Regner, 1996; Caddy et al., 1995). There are some attempts to carry out **ecosystem simulation on Mediterranean fisheries** (Stergiou and Koulouris (2000), Tudela (2000)) [10].

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Agostini, V. & P. Oliver, 2002. Environment variability and small pelagic fisheries in the Mediterranean Sea. Informes tecnicos de Copemed, 7.

Astudillo, A. and Caddy, J.F. 1986. Periodicidad de los desembarcos de merluza (Merluccius merluccius) y salmonete (Mullus sp.) en la isia de Mallorca. Int. Symp. Long term changes mar. Fish. Pop., Vigo: 221-234.

Bakun,A. & V. Agostini. 2001. Seasonal patterns of wind-induced upwelling/downwelling in the Mediterranean Sea. Sci.Mar.,65 (3):173-257.

Caddy, J.F.- 1993. Some future perspectives for assessment and management of Mediterranean fisheries. In: J. Lleonart (Ed.) *Northwestern Mediterranean Fisheries. Sci. Mar.*, 57(2-3):121-130.

Caddy, J.F.- 1997. Mediterranean and Black Sea (5). In: Fao Marine Resources Service, Fishery Resources Division Review of the State of World Fishery Resources: Marine Fisheries. *FAO Statistical Area 37* FAO Fisheries Circular No. 920 Rome, 1997, 173 pp.

Caddy, J. F., Refk, R., Do-Chi, T 1995. Productivity estimates for the Mediterranean: evidence of accelerating ecological change. *Ocean & Coastal Management*, 26:1, pp. 1-18.

Estrada, M. 1996. Primary production in the northwestern Mediterranean. *Scientia Marina* 60 (supl. 2): 55-64.

GFCM, 2000. Report of the Second Session of the GFCM Scientific Advisory Committee. Madrid, 2000. FAO Fisheries Report No. 602

Lleonart,J. 1999. Precautionary approach and Mediterranean fisheries. CIESM Workshop Seruies, 7: 15-24.

Lleonart, J. & L. Recasens.- 1996. Fisheries and the Environment in the Mediterranean Sea. In: J.F. Caddy (ed.) Resource and environmental issues relevant to Mediterranean. *General Fisheries Council for the Mediterranean.* No. 66. Rome, FAO, 142 pp. 5-18.

Lloret, J., J. Lleonart, I. Solé and J.M. Fromentin.- 2000b. Fluctuations of landings and environmental conditions in Northwest Mediterranean Sea. *Fisheries Oceanography* 000195 (in press).

Merella, P.,P.Oliver,F.Alemany & E.Massuti,1998. Approach to a multiespecies VPA considering hake-anchovy trophic interaction in the north-western Mediterranean. Cahiers Options mediterraneennes, 35: 261-272.

Oliver P. 1993 – Analysis of fluctuations observed in the trawl fleet landings of the Balearic Islands. *Scientia Marina*, 57 (2-3): 219 - 227.**Pauly,D.** 1987. Managing the peruvian upwelling ecosystem: a synthesis, p.325-342. In D.Pauly and L.Tsukayama (Eds.) The peruvian anchoveta and its upwelling ecosystem: Three decades of change. ICLARM Studies and Reviews, 15: 351p.

Stergiou, K.I.- 1999. Precaution in fisheries within the context of ecological and environmental changes. CIESM Workshop Series nº7: 33-36

The **Scientific Advisory Committee of GFCM** met for the first time in Rome in 1999. The fishery scientists of SAC at their third meeting held in May 2000 in Madrid (Spain) introduced important new elements to assess and manage Mediterranean fisheries. SAC recognised the opportunity to establish biological reference points in order to **improve fisheries management within a Precautionary Approach** (CIESM, 1999), pointing out that **biological reference points can help decision makers in defining the action to be taken in order to reach management objectives** (GFCM, 2000). Regarding SAC activity in relation to assessment and advice for management, the work carried out by the Subcommittee of Stock Assessment (SCSA) is particularly relevant. There is an ftp page[11] where all documents of SCSA and its working groups are available. This information is also available at the COPEMED website.

Furthermore, and considering that **the Code of Conduct for Responsible Fisheries establishes that conservation and management measures should be based on the best scientific evidence available. SAC** analysed all available scientific information in the region, produced in the period 1985-1999. More than 100 evaluations were selected and analysed. It has to be indicated that most of the evaluations correspond to the stocks of the northern and western part of the region. In general, the assessments are based on the application of Length Cohort Analysis (LCA) together with a Yield per Recruit Analyses (Y/R) based on short series of data. SAC also pointed out that important non-published information, relevant to stock assessment and already existing in some countries, were not available.

SAC recommended *inter alia*, to update and improve the quality and coverage of fishery data and statistics, to increase the number of assessments in the southern and eastern areas and make sure that all the assessments will be **carried out on a regular basis.**

Since 1996 the **FAO COPEMED Project** is working in the field to advise, technically support and establish networks to facilitate co-ordination to support fisheries management in the Western and Central Mediterranean. COPEMED have faced the main issues related to stock assessment through their activities producing relevant results in the context of information and data (Coppola, et al, 1999, Coppola, 2000) and in the study of socio-economic indicators in some specific areas (Alboran Sea and Gulf of Gabes). COPEMED has also been

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Stergiou, K.I. and Koulouris, M.- 2000. Fishing down the Hellenic marine food waters. CIESM Workshop Series 12 (in press)

Tudela, S.- 2000. Assessment of the primary production required to sustain a fully exploited NW Mediterranean fishery: implications for the exploited ecosystem. CIESM Workshop Series 12 (in press)

[11] **FTP://CUCAFERA.ICM.CSIC.ES/PUB/SCSA**.

training regional experts and developing new tools to assess and manage Mediterranean fisheries (Franquesa and Lleonart, 2001) [12].

Finally, we must comment on the fact that while it may be difficult to understand resource behaviour prior to exploitation, using monospecific methods and ignoring environmental factors, it is equally difficult to comprehend the fishery system as a whole if we leave out the **socio-economic factors** of exploitation.

2.3. Some relevant events regarding Mediterranean stock assessment and management to be taken into consideration

After the previous items, it is evident that the applicability of current exploited fish population dynamic models to the particular problems of Mediterranean fisheries, constitutes a matter of major concern for fishery scientists in the Mediterranean. This matter has been discussed continuously over the last 30 years. The following quotations, refer to relevant meetings where the major problems related to stock assessment in the Mediterranean were discussed. Perhaps in some cases the problems considered are on the borderline between assessment and management, however these issues have to be considered essential when we are trying to select the most suitable assessment methods.

Mediterranenan scientists faced this problem probably for the first time **in October 1979. The First Technical Consultation of GFCM on Stock Assessment in the Balearic and Gulf of Lyons Statistical Divisions** was held in Palma de Mallorca (Spain). During that meeting a Critical Analysis of assessment Methods in the Mediterranean (FAO, 1980) was carried out. The discussion was based on a document prepared by John Caddy (1980) on *"Perspectives sur les activités futures en matiere d'evaluation des stocks dans la Mediterranee occidental".* This document established three different succesive stages when analytical models are used depending on the data available:

1. *Des estimations ponctuelles de la valeur des paramètres provenant **d'échantillons occasionnels** de composition per taille/âge permettent l'application de modèles de rendement simples.*

[12] **CIESM,** 1999. Precautionary Approach to local fisheries in the Mediterranean Sea. CIESM Workshop Series, 7:89 pp.
GFCM, 2000. GFCM, 2000. Report of the Second Session of the GFCM Scientific Advisory Committee. Madrid, 2000. FAO Fisheries Report No. 602.
Coppola, R., 2000. Inventory of the Artisanal Fishery Communities in the Wstern and Central Mediterranean. Informes y Estudios Copemed, 6 (CD-Rom)
Coppola, R., I. De Leiva and P. Oliver. 2000. Enciclopaedia of living marine resources of the Mediterranean. Informes y Estudios Copemed, 3 (CD-Rom)
Franquesa, R. and J. lleonart (editors). 2001. Bioeconomic Management Tools for Mediterranean Fisheries. Ciheam-Copemed (CD-Rom). ISBN 84-669-5494-6.

2. ***Plusieurs années successifs*** *(5+?) d'estimations ponctuelles se sont accumulées, permettant une certaine analyse séquentielle des données*.

3. ***Le reffinement des estimations*** *de mortalité, de biomasse et de composition d'âge permet de développement de prédictions quantitatives plus exactes*.

At that moment, it was considered to be in the first stage, due to the lack of appropriate data. Unfortunately, more than 20 years later, it is not so clear that this first stage had been overcome.

Regarding the difficulties found at that time, the Technical Consultation made the following comments:

- ***L'imprécision des données*** *de base en ce qui concerne tant les statistiques de capture et d'effort que les paramètres biologiques utilisés dans les modèles analytiques*.

- *La nécessité de ne pas se contenter d'analyses ponctuelles de l'état d'exploitation des pêcheries; au contraire* ***il convient de donner une continuité aux programes*** *en tenant toujours en considération la normalisation des méthodes de travail dans le temps et dans l'espace*.

- *L'intérêt particulier pour* ***les évaluations résultant de campagnes de prospection*** *... on peut obtenir, grâce à une normalisation adécuate des méthodes, des indices de biomasses fiables plutôt que des valeurs absolues. Une avantage de cette méthode est qu'elle est relativement indépendante d'autres sources de données, comme par example les statistiques officielles; il convient cependant de ne pas sous-estimer l'intérêt de ces dernières*.

In October 1992, the Committee of Marine Vertebrates and Cephalopods of the International Commission for the Scientific Exploration of the Mediterranean Sea (ICSEM/CIESM) organised and held a Workshop on Methods for analysing fish population dynamics in the Mediterranean Sea in Trieste (Italy). The main conclusions of this workshop (Lleonart, 1993) were:

- **The age (or length)-structured models are more useful and appropriate to the Mediterranean** than those based on catch-effort data analysis.

- However the same workshop stated that the models used to analyse the dynamics of fish populations must be suited to the real catch data and biological and demographic parameters. In this regard, **the availability of reliable data was identified as the main shortcoming** in the assessment of Mediterranean fisheries.

In September 1994, the **Seventh and last meeting of the GFCM Technical Consultation of Stock Assessment in the Balearic and Gulf of Lyons Statistical Divisions** was held in Sete (France). This Technical Consultation carried out an analysis of the state of the art of stock assessment in the Western Mediterranean. A report (Oliver, 1996) was presented where some relevant issues were pointed out. Among them, and independently of other aspects already mentioned, two important additional issues can be highlighted:

First, concerning **Catch Composition**, and despite the inherent complexity of multi-species landings in Mediterranean ports, **there is an identifiable series of around 15 target species** which, in biomass or in economic terms, constitute the basis of production. These species represent 70-80 percent of all landings, the landings of at least eight of them are over 2 percent of the total catch, and in two cases over 15 percent. This situation allows us to establish that, in the Mediterranean, **the applicability of the current stock assessments methods, whose validity has sometimes been put in doubt due to the complexity of multispecies landings, can be fully accepted.**

Secondly, fisheries administrators (and it is they who are supposed to be responsible for fisheries management) **sometimes fail to set clear Management Objectives** with clear priorities (e.g. increasing the extracted biomass, maintaining specific fish sizes in the market, increasing the economic value of catches, maintaining or raising employment levels, etc.), which makes it very hard for fisheries scientists to formulate sound scientific management criteria.

In May 1995 The Twenty-first Session of the General Fisheries Council for the Mediterranean (GFCM) was held in Alicante (Spain). In this meeting the issue of the **Effort-Based Management System** was discussed providing very useful elements regarding the definition of **Management Objectives.**

Several paragraphs from the report of this meeting have been selected:

39. " **The Council agreed that choosing direct effort control, as opposed to a control of landings as a method of limiting fishery impacts on the stocks,** was often necessary because of the small-scale nature and diversity of Mediterranean fisheries which was not conducive to real time monitoring of catches in a catch quota control framework."

54. The Chairman **noted the evident deficiencies of the current FAO database on fleet sizes and characteristics operating in the Mediterranean**, and the need for transparency and burden sharing of the costs and restraints required by a system of effort control. This should also be shared by distant-water vessels operating in the Mediterranean. Adherence of all States fishing in the Mediterranean to the key provisions of the Compliance Agreement, especially those relating to the preparation and updating of vessel registries for

all boats over 15 m was important, even prior to ratification of that Agreement, and would constitute a de facto commitment to flag State responsibility.

55. **The Secretariat was requested to prepare a simple and comprehensive questionnaire to collect data on fishing vessels and distribute it immediately to all member countries.** The Council agreed to a deadline for submission to the Secretariat of complete data on national fishing fleets operating in the Mediterranean in 1994-5 by the time of the October 1995 meeting of the FAO Council. The data should be broken down into vessel categories over and under 15m OAL (overall length), and these two categories should in turn, be divided into sub-categories of vessels predominantly operating active and passive fishing gear respectively. Each sub-category should include a breakdown of vessels by total HP and/or total Gross Registered Tonnage (GRT) as available.

At this meeting the following resolution was also adopted:

GFCM Resolution 95/4

The Council calls on its member countries to prepare a list of fishing boats in operation from national ports in the Mediterranean and provide this information to the GFCM Secretariat by October 1995 in the form specified in the report of the Twenty-first Session of the General Fisheries Council for the Mediterranean.

Unfortunately, seven years later the list of fishing boats in operation from national ports in the Mediterranean has still not been completed.

In July 1995 a **Group of Independent Experts to Advise the European Commission on the Fourth Generation of Multi-annual Guidance Programmes** was established to report to the European Commission. The work carried out by this group is relevant regarding the establishment of an effort-control system in Mediterranean fisheries, based on the assessment of levels of fishing mortaly.

Effort is a measure of the activity of the fishing fleet. The term is, however, ambiguous as it is used in two different contexts: As a **measure proportional to the fishing mortality** (Fisheries biology), **but also as a measure proportional to the variable costs of the fishing vessel** (Fisheries economics).

One of the key problems in reducing fishing mortality through effort control is to ensure that the effort parameters which are selected for control are relevant to fishing mortality. There are numerous examples of attempts to control effort through decommissioning, reduction of allowable days at sea etc. which have failed to achieve the primary objective, to reduce fishing mortality.

The relation between fishing mortality and effort is usually expressed as a simple linear relationship :

$$F = q E$$

where E is effort and q is the slope, usually referred to as catchability. However, operational definitions of effort which are appropriate according to this criterion are hard to get at for two reasons :

- **the relation between individual input factors** (vessel size, power, gear characteristics, days at sea, etc.) **and fishing mortality has not been much investigated and is rarely known** (Alvarez et al, 1999)[13], even on a qualitative basis.

- **current data collection systems and data bases in many cases do not contain information on crucial effort parameters**. Vessel characteristics and basic type of main gear may be available, but parameters relating to dimensions or other gear characteristics are not, and relevant data on activity (days absent, trips, hauls) are quite often not available either.

In the context of the scientific advice for an effort-based management, effort can be considered as composed of two elements: a capacity element and an activity (utilisation) element. The capacity element can in turn be considered as composed of a capacity related to the vessels (numbers and size/power) and a capacity related to the gears used (including the fishing gear proper, gear handling equipment, catch handling equipment and equipment used to search). The activity element should express the utilisation of the available capacity in terms that are relevant to fishing mortality. The measures of activity that are relevant to fishing mortality are variable between fleets - it may be the time the fishing gear is in the sea, search time, number of sets etc. In some cases simple measures such as time at sea may be relevant. In brief :

E = Capacity (vessels) * capacity (gear) * activity

Management measures addressing one of these parameters without restraining others may therefore not be efficient in reducing effort and thus fishing mortality.

In consequence, to propose levels of fishing mortality. The fishing mortality to be used as reference points for medium term management are dependent on the objectives of the management.

[13] **F. Alvarez, F. Alemany, E. Ferrandis.** 1999. Modelling the Relationship between Fishing Effort and Effective Fishing Mortality in Western Mediterranean Trawl Fleets: The Case of Hake and Stripped Red Mullet Fisheries in Balearic Islands. Final report. Report of the Project EU-DG XIV, 96/025.

Furthermore, **Management objectives** can roughly be divided into two groups :

1. **Objectives concerned with the sustainability of stocks and fisheries**, e.g. maintenance of spawning stocks size above a critical minimum size.

2. **Objectives concerned with maximisation of output from the fisheries**, e.g. maximisation of yield or socio-economic benefits to society.

There is an increasing awareness that these two sets of objectives must be considered as hierarchical: **the sustainability of fisheries must be ensured before objectives concerning output maximisation can be pursued.** This hierarchy is implicit in the precautionary principle and is also the basis for the biological advice given by advisory bodies.

The fishing mortality associated with the two sets of objectives can be used as **reference points for medium term management** within a hierarchical framework corresponding to the hierarchy of the objectives. These reference points must be seen in close association with the objectives: **reference points relating to sustainability must not be regarded as targets but must be seen as upper limits to fishing mortality, whereas reference points relating to yield maximisation may be seen as targets provided that sustainability is ensured at these levels** (Oliver, 2001)[14].

3. Suitability of different assessment methods

The main elements to be taken into account when the most suitable assessment methods to be used to provide advice for fisheries management have to be identified, are: The definition of clear **management objectives** with clear priorities and the availability and reliability of the **data at disposal**. **Vague management objectives and the lack of appropriate data constitute the real drawback for the establishment of a harmonised assessment methodology at regional level in the Mediterranean on a regular basis.**

The key elements related to these issues in a Mediterranean context can be extracted from the analysis performed in the previous paragraphs:

3.1. Management objectives

Fisheries administrators sometimes fail to set clear Management Objectives (see page 12). **The GFCM agreed to choose direct effort control, as opposed to a control of landings, as a method of limiting fishery impacts on stocks** (see page 13).

[14] **Oliver, P.** 2001. State of Mediterranean resources in relation to their sustainable management within the "Precautionary Approach to Fisheries". Recent initiatives and proposals to fill the gaps. CIESM Workshop Series, 12: 53-56 pp.

To assess levels of fishing mortality (F), **assessment methods has to estimate actual F and options of reference F**. The relation between fishing mortality (F) and effort (E) is usually expressed as a simple linear relationship:

$$F = q E$$

In relation to management, effort can be considered as composed of two elements : a capacity element and an activity (utilisation) element:

$$E = \text{Capacity (vessels)} * \text{capacity (gear)} * \text{activity}$$

Management measures addressing one of these parameters without restraining others may therefore not be efficient in reducing effort and thus fishing mortality (see page 15).

Furthermore, **management objectives can be divided roughly into Objectives concerned with the sustainability of stocks and fisheries and objectives concerned with maximisation of output from fisheries**. It seems evident that **sustainability of fisheries must be ensured before objectives concerning output maximisation can be pursued**. In consequence, fishing mortality associated with the mentioned two sets of objectives can be used as reference points for medium term management. Reference points relating to sustainability must not be regarded as targets but must be seen as upper limits to fishing mortality, whereas reference points relating to yield maximisation may be seen as targets provided that sustainability is ensured at these levels (see page 15).

Unfortunately, the relation between individual input factors and fishing mortality has been not much investigated and is rarely known and current data collection systems and data bases in many cases do not contain information on crucial effort parameters (see page 14).

3.2. Data needs

Administrators have to establish management objectives for scientists but also to provide data. In fact this has been a matter of concern for Mediterranean fishery scientists for a long time. Probably the failure to develop marine population dynamics for exploited stocks in the Mediterranean is mainly due to the lack of fishery statistics and databases.

In short, the data needed are: **historical series of catch data, catch-at-age data or length frequency data, effort data and some index of abundance** (for instance catch per unit effort) with at least minimal coverage and reliability.

However, catch and effort statistics remain a weak point, as the official statistical data are still often very far from reflecting the reality (see page 3).
SAC, to increase the number of assessments, is recommending inter alia, to update and improve the quality and coverage of fishery data and statistics carried out on a regular basis (see page 10). The availability of reliable data was identified as the main shortcoming in the assessment of Mediterranean fisheries. (see page 12)

On the other hand, one of the key problems in reducing fishing mortality through effort control is to ensure that the effort parameters which are selected for control are relevant to fishing mortality (page 14). In this context, in 1994, GFCM noted the evident **deficiencies of the current database on fleet sizes and characteristics operating in the Mediterranean**, and called on its member countries to prepare a list of fishing boats in operation from national ports. Unfortunately, seven years later the list has not still been completed (see pages 13-14).

3.4. Assessment Methods

At first, it is important to point out that **in the Mediterranean there is an identifiable series of target species** which, in biomass or in economic terms, constitute the basis of production. This fact allows us to establish that the applicability of the current stock assessment methods, whose validity has sometimes been put in doubt due to the complexity of multi-species landings, can be fully accepted (see page 12).

Global production models, based on catch-effort data analysis, prove to be quite disappointing when applied in the Mediterranean Sea and production models are considered to have limited applicability (page 2). In fact, Global Models are not very useful for the analysis of Mediterranean fisheries (page 3) and age (or length)-structured models are considered more useful and appropriate to the Mediterranean (see page 12).

As has already been said, the availability of reliable data is considered one of the main shortcomings in the assessment of Mediterranean fisheries. However, **scientists have tried to assess fisheries with several tools, using the data available**. In this context, the **Length Cohort Analysis (LCA) represents a clear line of progress for population dynamics in the Mediterranean** together with the Yield per Recruit Analysis using the estimates of fishing mortality provided by this method (page 2).

Actually, Length Cohort Analyses have been used during the last ten years to assess the main stocks and increasingly complete and reliable assessments are available. For this reason **a software called VIT has been developed, based on LCA and Y/R analysis adapted to Mediterranean fisheries and designed to analyse the enormously important competitive gear situation in the Mediterranean** (see pages 1 and 4). However, these assessment

methods prove not to be very suitable to assess the coastal pelagics stocks (see page 6).

Direct evaluations have also been carried out to provide useful information to allow the performance of these assessment methods when statistical information of fisheries is missing. However, the results obtained so far have been very limited. (see page 3). Direct Methods of evaluation such as ichthyoplankton surveys applying the Daily Egg Production Method to evaluate the Spawning Stock Biomass of fish stocks and biomass hydro-acoustical surveys are used to assess coastal pelagic resources. Trawl surveys are used on demersal resources. However, so far few or no management actions have been taken from these assessments (see page 7).

Moreover, in the context of stock assessment, from a methodological point of view, it is evident and there is wide agreement on **the need for analytical methods to observe marine systems as a whole**; to describe interspecies relationships in an integrated multispecies approach and the environment and on the limits imposed by the carrying capacity of the system (see page 9). It is equally difficult to comprehend the fishery system as a whole if we omit socio-economic factors of exploitation (see page 10).

Considering also that the **Code of Conduct for Responsible Fisheries establishes that conservation and management measures should be based on the best scientific evidence available** (see page 10) and that **SAC is recommending to improve fisheries management within a Precautionary Approach,** it is evident that when the suitability of assessment methodologies is under discussion the need for prompt action must be considered as a major condition.

4. Conclusion

GFCM asked SAC to review the data needs, outputs expected and pros and cons of existing stock assessment methods as well as their suitability to Mediterranean stocks and fisheries. As stated before, conservation and management measures should be based on the best scientific evidence available. Obviously this evidence has to be provided by a scientific assessment which will have to be performed using the data bases at disposal.

In summary, taking into consideration all issues already commented in previous items and assumed that Control of fishing effort is the method for limiting fishery impacts on the stocks in the Mediterranean, the Length Cohort Analysis (LCA) is, at present, the only current option available to assess and provide advice in a harmonised way and on a regular basis for the management of Mediterranean fisheries.

In the medium term, in order to improve the assessment based on LCA, the use of Virtual Population Analysis (VPA) is recommended as soon as

longer (around 10 years) and more reliable data bases are available. Permanent and long series of annual total catch by species, fisheries and gears together with sampling programs to distribute the catch by ages and obtain the strength of cohorts and fishing mortality by year should be built up as soon as possible.