The relevance of recent international agreements on fisheries and some perspectives on assessment and management of Mediterranean fisheries

Caddy J.F.

in

Lleonart J. (ed.).
Dynamique des populations marines

Zaragoza : CIHEAM
Cahiers Options Méditerranéennes; n. 35

1998
pages 169-181

The relevance of recent international agreements on fisheries and some perspectives on assessment and management of Mediterranean fisheries

J.F. Caddy
Fishery Resources Division,
Food and Agriculture Organization of the United Nations, Rome, Italy

SUMMARY - The paper looks at the impact on future scientific work in support of fisheries management which results from the FAO Code of Conduct for Responsible Fisheries and the United Nations Agreement on Management of Straddling and Highly Migratory Fish Stocks. These give particular importance to precautionary approaches, as spelled out in the guidelines for precautionary fisheries management developed by an FAO consultation. Some of the basic requirements for a precautionary approach are spelled out, including the use of Limit Reference Points which indicate dangerous situations for the stock. Some preliminary ideas for their use in the Mediterranean context are provided, and given the high unit prices of landings this also requires a bioeconomic approach. The importance of carrying out fisheries assessment work which is relevant to management approaches currently in use is stressed, which, for the Mediterranean, is suggested to include passive regulatory measures and the use of refuges and closed areas.

Key words: Fisheries management, precaution, fisheries regulations, stock assessment, reference points, fisheries research.

***RESUME -** "Importances des récents accords internationaux sur les pêcheries et quelques perspectives pour l'évaluation et la gestion des pêcheries méditerranéennes". Le document prend en compte l'impact des normes énoncées dans le Code de Conduite de la FAO pour une pêche responsable et l'Accord des Nations Unies sur les stocks chevauchants et les stocks de poissons grands migrateurs. Ces instruments internationaux mettent en valeur les approches de précaution telles que décrites dans les directives sur l'approche de précaution dans l'aménagement des pêches, développées par une Consultation de la FAO. Des besoins élémentaires pour une approche précautionnelle sont expliqués, ainsi que l'emploi des Points de Référence (Limites) qui indiquent des situations dangereuses pour les stocks. Des idées préliminaires pour leur utilisation dans le contexte de la Méditerranée sont données et compte tenu des prix élevés des débarquements une approche bioéconomique est nécessaire. Il a été souligné l'importance de conduire un travail sur l'évaluation des pêches qui tienne compte des approches actuelles en matière d'aménagement des pêches et qui, dans le cas de la Méditerranée, repose essentiellement sur des mesures de régulation passives et l'utilisation de zones de protection et de fermeture de la pêche.*

***Mots-clés :** Aménagement des pêches, précaution, mesures de gestion, évaluation des stocks, points de référence, recherche sur les pêches.*

Introduction

In 1995 there have been several major developments in international fisheries of importance and relevance to the assessment and management of global fisheries and hence also of relevance to the Mediterranean. Of principal concern here is international agreement on a Code of Conduct for Responsible Fisheries (FAO, 1995) and the United Nations Agreement on Management of Straddling and Highly Migratory Fish Stocks (UN, 1995). Additionally, as a continuation of these initiatives, the formulation of guidelines for precautionary fisheries management by a group of scientific experts in 1996 (FAO, 1996) has particular relevance to all levels in the assessment and management process.

Also of relevance are the conclusions of a number of international symposia which, over the last two years, have started to look for new management approaches in recognition of the general failure of conventional management approaches in the North Atlantic and elsewhere. The need for a new paradigm for assessment and management is now widely recognized (e.g., Kruse *et al.*, 1993), and this appears to have particular relevance for the situation in the Mediterranean, where, although an active approach to assessment and management has yet to be agreed upon, there appears, *de facto*, to exist constraints - which may, in part, be a consequence of the fishing strategy but also economic and social - that have mitigated a stock collapse which would seem inevitable in the circumstances.

Thus, while the lack of an active management intervention for many countries poses serious problems which need to be urgently addressed, fisheries managers of the region should not automatically resort to older formulas from other regions that have not been particularly successful and would not be easily changed. There is first a need for better understanding of the factors that have permitted resource continuity in the Mediterranean, even in the absence of an active management approach.

Before deciding on an active management framework, it appears appropriate to review what are the factors which have contributed to the surprisingly positive trends in fisheries landings in the Mediterranean, which, almost alone in marine areas of the northern hemisphere, do not seem to have shown a marked decline in multispecies yields.

The new international context for assessment and management

The new legal instruments mentioned above represent a step forward from the 1982 Law of the Sea, not only in interpreting its provisions, but in outlining for the first time in an internationally-agreed legal instrument a number of explicit considerations relevant to the way that scientific resource management should be carried out. Principally, the following main directions are supported:

(i) Not only should fisheries managers and their scientific advisors develop explicit Target Reference Points, but these must be set at a level below that mentioned in the Law of the Sea, namely the level of fishing effort/mortality yielding the maximum yield, the so-called MSY level.

(ii) The reason for (i) is that, for the first time, international agreements on scientific management recognize the considerable uncertainty of the assessment process at all stages, as well as the fact that effort overshoots beyond MSY are extremely difficult to reverse without major difficulty.

(iii) To aid in this situation, precautionary fishing strategies should be followed (FAO, 1996) so that, amongst other considerations, negative consequences of fishing be defined in advance and responses to these, when they arise, be rapid and where possible, prenegotiated.

(iv) Precautionary fishing strategies will require fishery scientists to explicitly assess the risk that their analyses may over-estimate the productivity of the resource and, for managers, to exert precaution in following the advice presented.

(v) One of the principal aids in this process is the formulation of Limit Reference Points, which represent conditions which it is hazardous to approach and where management should react rapidly and decisively to restore the stock to a safe condition.

(vi) Of particular relevance to the Mediterranean is the point that stock assessment is intended to be in support of management and that member countries of GFCM should take a top-down approach whereby the fishery administration is in close rapport with the industry and asks specific questions of their scientific advisors, rather than the present situation where, for the most part, there seems to be a discontinuity between the scientific work carried out and the management actions, which are rarely decisive or scientifically oriented.

(vii) The new provisions require that, for depleted stocks, actions be taken to restore them and degraded critical habitats important to their life cycles to a normal or sustainable and productive condition.

(viii) In order that management should benefit from the maximum inputs and consensus, there is an explicit requirement of these new international instruments for a maximum of transparency in the data collection, analysis and management process.

(ix) The role of closed areas and seasons is recognized among the technical measures mentioned in the Code and, in my view, they offer the best approach for precautionary management in protection of key stock components such as the spawners.

Reference points and their use

Target Reference Points (TRPs) represent desirable states for the fishery, and in the past have targeted fairly high rates of fishing such as MSY and F_{MAX}. The best-known example of a TRP is of course F_{MSY}, although, as hinted above, this is now considered a LRP rather than a TRP (Caddy and McGarvey, in press).

More recently, levels of effort to the left of MSY, such as $F_{0.1}$ and F_{LOW} have been used as targets (Fig. 1); see Caddy and Mahon, (1995), for further details and sources. The problem, also with these latter, more cautious TRPs, has been that uncertainty remains high as to the actual state of the fishery in relation to the TRP, so that even fisheries targeted at $F_{0.1}$ have suffered fishery-induced collapses, due either to measurement error or to erroneous and non-precautionary management and enforcement. The management response under purely TRP management can be expressed by the phrase "business as usual", implying that corrections to the fishery, either in terms of effort or quotas, are usually small.

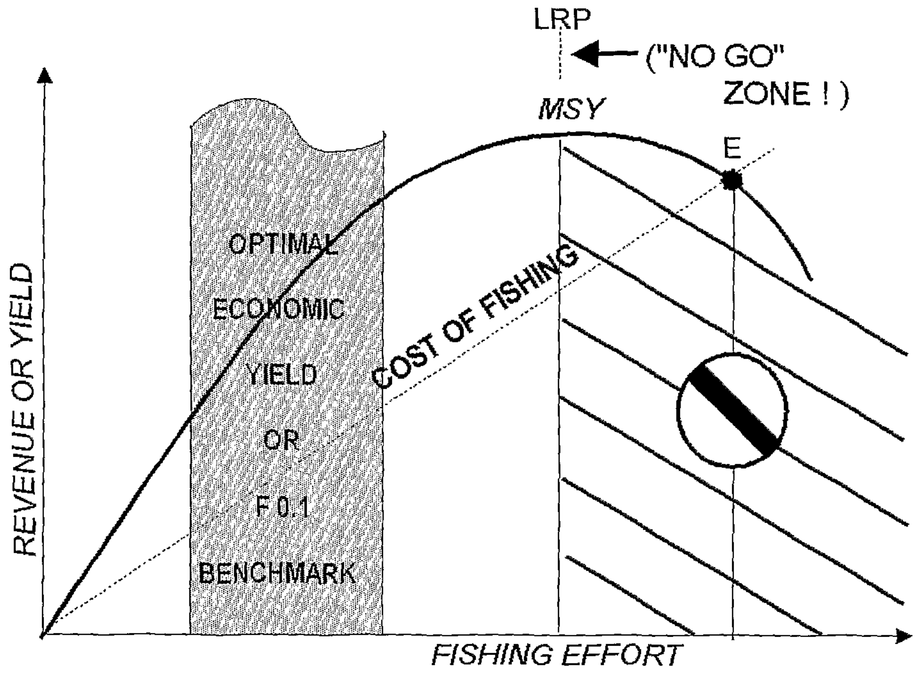

Fig. 1. Illustrating the concepts of the Limit Reference Point (in this case the fishing mortality corresponding to MSY) and Target Reference Points (inside the shaded area to the left of MSY).

Limit Reference Points (LRPs), also referred to as Threshold Reference Points in English, are intended to mark the onset of dangerous stock conditions where risk of collapse is high (Fig. 1), and their use requires recognizing explicitly the significant level of uncertainty which is characteristic of any attempt to meet a scientifically-defined management target set at lower levels of fishing effort (or higher levels of biomass). An example might be the term MBAL (Minimum Biologically Acceptable Limit) used in the ICES area. In theory, this concept implies the use of a MBAL as a LRP (even though, in practice, it could be noted that some MBALs established for individual stocks are effectively used as Target Reference Points and not as a representing conditions to be actively avoided).

Other examples of precautionary pairs of TRPs and LRPs could be values of F set as a proportion x of the natural mortality rate for the stock, e.g.,

F(Target) = x_{TRP}.M, and F(Limit) = x_{LRP}.M, where $x_{TRP} < x_{LRP}$)

Such an approach might be used to formulate a precautionary pair of LRPs and TRPs. The value of x_{TRP} should be less than 0.5 for small pelagics (e.g., Patterson, 1992) but could be somewhat larger for demersals (See Die and Caddy, in press).

The management strategy conceived with explicit use of LRPs should be quite different; as soon as evidence that one or more LRPs has been passed, the management response should be immediate, prenegotiated and should involve substantial cuts in catch and/or fishing effort until the stock has been restored to safe levels.

The use of Limit Reference Points still remains to be conventionalized. One procedure in the case of reference points defined in terms of fishing mortality as the control variable was suggested by Caddy and McGarvey (in press) as follows:

(i) Define a biologically limiting situation or 'worst case scenario' = LRPs for the fishery.

(ii) Estimate the current situation in relation to the LRP in the same units with which the LRP is measured. The current situation can thus be expressed in terms of one or more control variable(s), e.g., biomass, fishing mortality, spawning stock size, or even allowable by-catch of a protected species.

(iii) Estimate, even approximately, the variance in the control variable around the best estimate of the current situation.

(iv) Choose a value for the TRP† that, for the given level of uncertainty, has a low and specified probability of exceeding the LRP. (One procedure in the case of reference points defined in terms of fishing mortality is suggested in Caddy and McGarvey, in press)

One clear advantage of this type of approach is that a high expenditure on statistics and data gathering reduces the variance around the estimate of the current position, hence allowing a fishery to be carried out for the same probability or risk of overshoot of the LRP as when variance is high and a precautionary low exploitation rate is mandatory.

A simple hypothetical example of such an approach is shown in Fig. 2, which might be based on regular surveys of resources to determine both biomass and age/size composition of the stock, hence the recent mortality rate experienced by the stock using catch curve analysis.

"Top-down" and "bottom-up" approaches

The emphasis so far in the Mediterranean context has always been on the so-called "bottom-up" approach to assessment in support of management, unfortunately often accompanied by a lack of continuity at the interface between science and management and an emphasis in Mediterranean fisheries research too exclusively on biological aspects. The scope of this approach seems limited to area C of Fig. 3.

An alternative approach has been progressively adopted by FAO in other regions that can be called a "top-down approach", that is to place emphasis on establishing a management structure first (Area A of Fig. 3) which allows prompt response to changes in the resource base, followed by definition of fishing options, the reference point(s) that this requires, a study of fleets, their performance characteristics and the mechanisms of control of fleet size, replacement and capitalization (Area B). The scientists play a similar role in Area C as previously but with the main emphasis on monitoring the resource, establishment of technical reference points and determination

† *Note*: The TRP as used here is not necessarily a result of direct analysis in this situation but could be derived in a secondary fashion from purely statistical considerations once the LRP has been defined by biological analysis.

of the position of the *fishery in relation to them.* They would also be expected to respond to specific demands for information from a government-industry committee whose role is to advise the management authority on management measures.

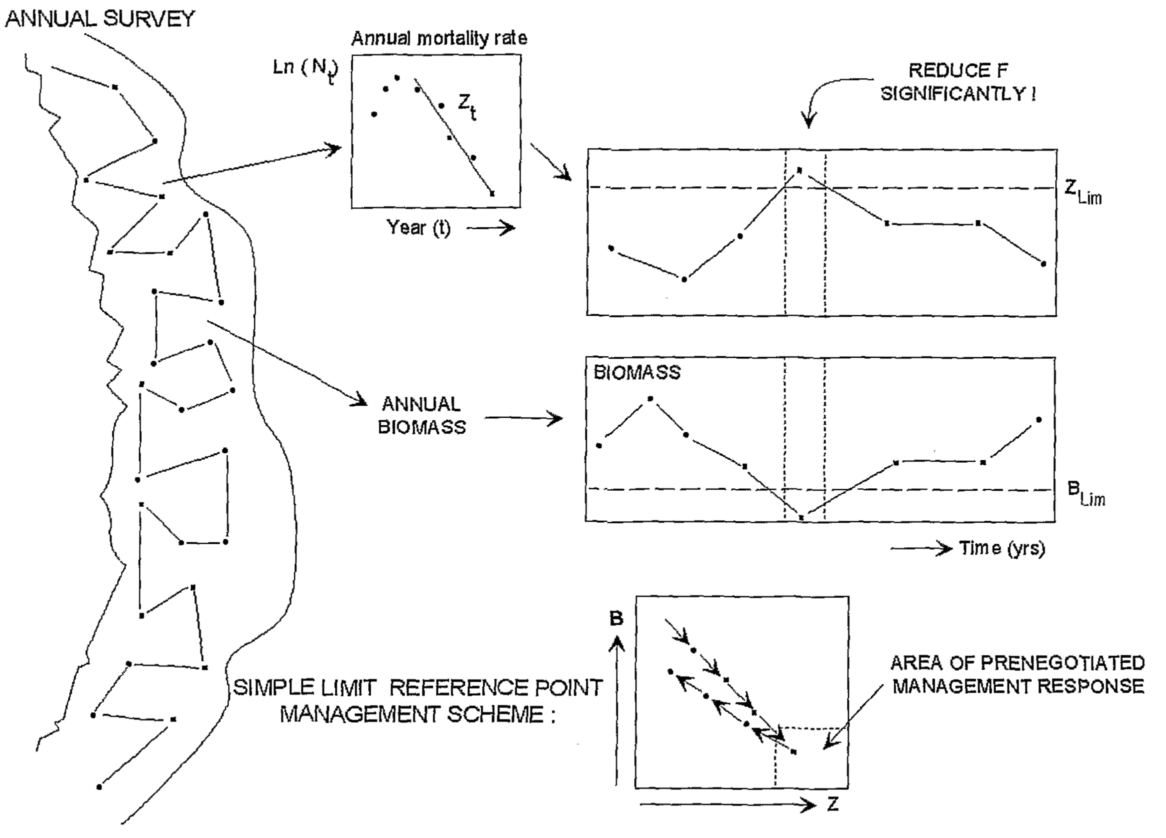

Fig. 2. A simplified hypothetical Limit Reference Point management system is illustrated, with an *annual survey* providing estimates of biomass and total mortality rate *(from* ageing catch samples). Limit Reference Points are established in terms of biomass and Mortality rate (B_{LIM} and Z_{LIM}) and management reaction triggered when conditions indicate that the *fishery has entered* the danger area on the other side of one or other of these LRPs. At this point, a prenegotiated management response agreed with the fishing industry reduces effort radically, allowing stock recovery within 1 or several years.

The fishery managers should ideally also be constrained by a formal management plan, in whose development the fishery scientists would be one of the parties involved. This last approach seems the one most favoured in the Code of Conduct. Fig. 3 shows in schematic form the main characteristics of a scientifically-based management system.

Some questions arising from the specific characteristics of Mediterranean fisheries

(i) *Research.* Some of the special characteristics of the Mediterranean environment and ecosystem may constrain the models we use and the basic assumptions underlying them. Thus, if we feel that the ecosystem is stable, we can use simple yield/recruit models with confidence, as well as equilibrium models for the fishery. If, however, we feel there are short-to-medium-term fluctuations, we should probably use dynamic production models or analytical simulations such as described by Punt and Hilborn (1996). If the fluctuations are of *regular periodicity*, there may be a possibility of forecasting, but if there is a consistent trend due to extrinsic pressures on the environment, these will also need to be taken into account. (Fig. 4 illustrates some of these options.)

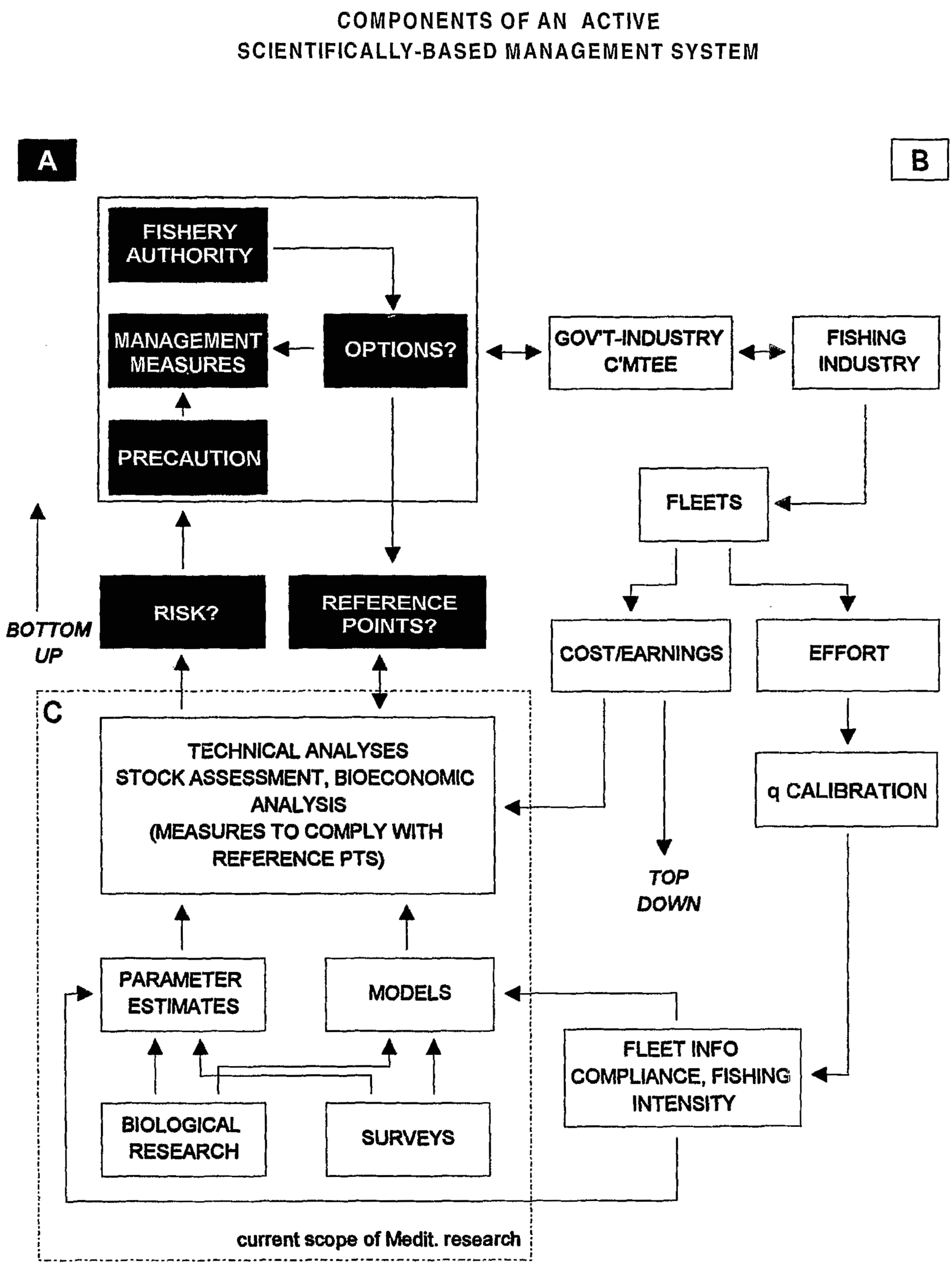

Fig. 3. Illustrating the whole 'management cycle', showing the broad slope of Mediterranean research (A) which has been almost exclusively in 'bottom-up' mode and often dissociated from the management process (A). Area B, and a 'top-down' approach to management advice is suggested for serious consideration by regional scientists and managers working together.

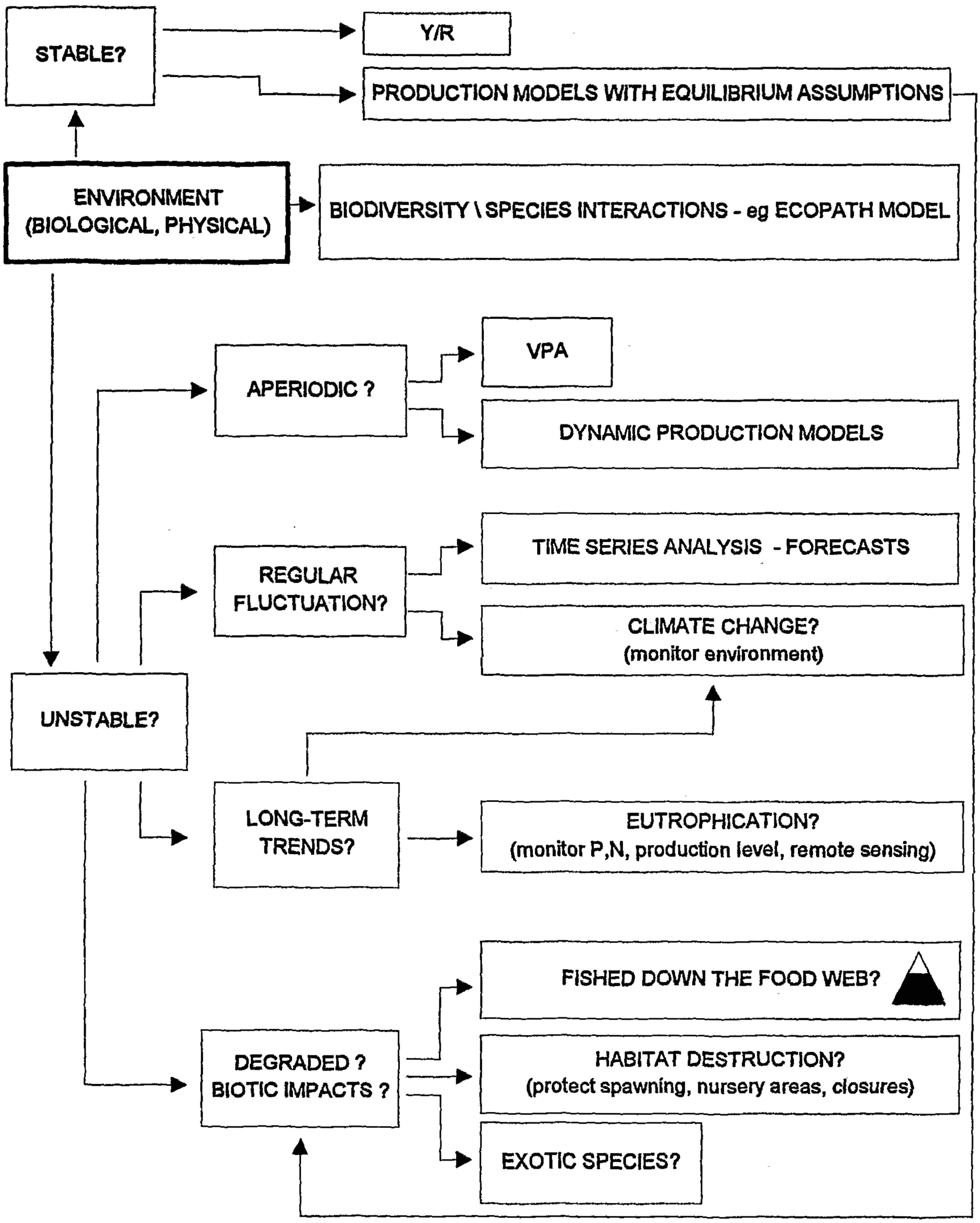

Fig. 4. Illustrating how environmental and biotic conditions may affect the appropriate and possible approaches to be taken to stock assessment of resources.

(ii) *Management.* Some of the special characteristics of the Mediterranean from a fisheries management perspective were summarized in GFCM (1995), which emphasized the existence of narrow shelves often lying within territorial waters, with steep shelving slopes. Unlike the more extensive shelf areas of the North Atlantic, a significant proportion of the shelf and slope areas are only partly vulnerable to trawl fisheries. The small-mesh multispecies trawl fisheries, nonetheless, exert a high fishing intensity, harvesting a large proportion of the demersal stock as juveniles. In some areas, nonetheless, for resources such as the hake, *Merluccius merluccius*, larger older individuals of species harvested by trawls on the shelves may be taken by gear such as longline or trammel nets in rocky and deeper waters at or below the shelf edge.

Despite some common fishing areas, a large proportion, especially of the continental shelf of the southern Mediterranean, remains within national waters. The Mediterranean, in fact, provides relatively few examples of areas where demersal resources are shared by more than two countries, making shared stock management issues a much smaller component of the fisheries management problem than elsewhere and encouraging the view that management measures can be achieved separately within most statistical sub-divisions of GFCM.

Such analyses as have been conducted to date on the selectivity of small mesh trawl gear, e.g., Dremière (1984), have illustrated that these gears are aimed at the main densities of younger fish of 0+ to 2-3 year old fish, with relatively few older individuals found in the stock. According to conventional analyses based on larger mesh gear, the selection curve and availability at age of this type of gear should be asymptotic, as described by authors from the North Sea such as Beverton and Holt (1957) (Fig. 5). If this were the case, given the 3-4 years availability to trawling prior to maturity for species such as the hake, at fishing mortality rates close to 1.0 the abundance of spawners should be greatly reduced once the age at maturity has been passed. This makes it difficult to explain the remarkable stability - and even increase - over the last 20 years of intensive fishing of stocks such as those of the hake.

It seems, however, that one unexpected aspect of such fine mesh gear and its area of operation is that the catchability and/or availability of older individuals falls off significantly with age, as judged by several cohort analyses reported in the literature and by a number of publications describing comparative fishing experiments as was the natural mortality into the first years of life (Fig. 5).

The conventional conclusion that arises from the description of this fishery is that the size at first capture should be increased up to, and possibly above, the 40-mm stretched mesh discussed frequently in GFCM and elsewhere. A problem with most of the calculations of yield per recruit reported so far, however, is that they do not take sufficient account of the rapid change in a number of factors during the first 2 years of age, when, for most demersal species, the stock is already recruited or partially recruited to the fine-mesh gear. Fig. 5 shows some of the problems that have been mentioned so far, including difficulties due to the incorrect use of Bertalanffy growth curves which intercept the abscissa prior to t = 0, the fact that natural mortalities of ages 0+ and 1+ are almost certainly significantly higher than for 'fully-recruited' age groups, as well as problems of accounting for deaths from discarding and the possible non-asymptotic nature of the selection curves of small-mesh trawls. Some implications of these factors taken together have been discussed by Abella *et al.* (this volume).

A further and apparently contrasting perspective provoked by the above description is that, although the number of survivors at maturity must be rather small, there appears to have been an adequate survival for most species, and notably for hake, to ensure the maintenance of an adequate recruitment.

The question that must be asked at this point is: Where are these spawners located and what is their vulnerability to fishing? This question is, of course, basic to one common approach to fisheries management which has been gaining ground recently, namely that of maintaining an adequate escapement to spawning or minimum spawning biomass. If this model of management is followed, the first research and management priority from a precautionary perspective is to identify and control those factors which could adversely affect this escapement. The first is certainly an increase in fishing pressure of the fishery on juveniles, and the GFCM has pronounced in this regard the need for a control, and even reduction, of fishing pressure. The second - and more controversial, given the conclusions in the preceding paragraph - is that fishing pressure on the mature cohorts should not be allowed to increase, at least until a considerably improved survival through the trawl fishery for juveniles has been achieved.

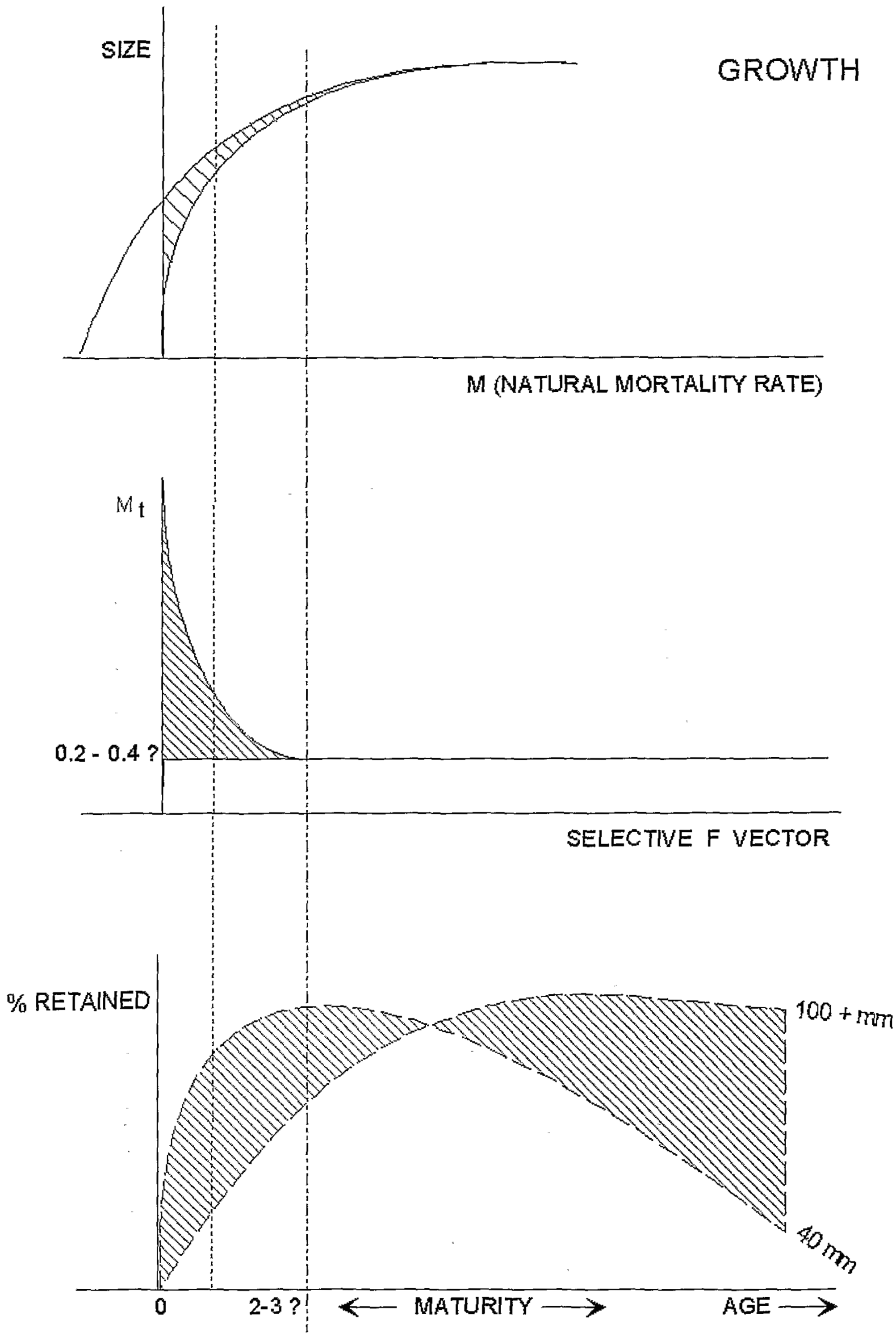

Fig. 5. Illustrating the implications of a size at first capture and recruitment in the first year of life on the use of parameter estimates in yield modelling. Upper: Care must be taken in the use of von Bertalanffy relationships for growth if the growth curve intersects at a distance from the origin. Middle: The natural mortality rate of a fish species with duration of life of several years and more will certainly experience a higher value of M in the first 2 years of life, descending to adult values subsequently. Bottom: Trawl selectivity for small-mesh cod ends may show a decline in either availability or catchability with age, especially if the fishery is targeted on a high density of younger fish, and the larger, older mature fish tend to be distributed elsewhere.

To determine which of these two approaches is more valid, one could draw attention to the overriding importance given by the recent international accords to maintaining continuity of the resources. This would appear to give priority to considerations aimed at keeping population fecundity above those relevant to increasing the sustainable yield, unless the achievement of this latter without affecting population fecundity can be guaranteed. This statement appears to provide one clear framework for a series of investigations and population simulations, aimed at investigating the optimal strategy for fisheries management. A more prosaic approach would be to consider the relative value of mature fish and those which would not be marketable (say ages 0+ and 1+?) in the oversimplified case that the only source of mortality prior to capture of these age groups was predation.

A non-discounted value of young fish rendered unmarketable, for instance by a prohibition of landing, could still be assigned, based on their probability of entering the age classes that are legally marketable. This relationship could be expressed by:

$V_t = V_{t+r}/N_t$

where

V_t = 'Value' of 1 unmarketable very small, young, fish of age t in the sea,

and

V_{t+r} = value of 1 older survivor of the same cohort at the first age of legal marketing r years later when this price has now been established. N_t is the number of fish at age t that have the expectation of producing one survivor r years later.

This calculation could be performed under at least two sets of assumptions as to how to calculate the value of N_t that provides 1 survivor:

The first would be to solve the conventional equation:

$N_{t+r} = N_t . \exp(-M.r) = 1$

for the value of N_t, assuming M to be constant.

The second approach would be to subscript M and make the biologically more reasonable assumption that M progressively declines with age from (say) M(0+) = 1; M(1+) = 0.6, M(2+ and older) = 0.3, values which seem compatible with those for similar young groundfish studies in the MSVP experiment in the North Sea (Sparholt, 1990).

What becomes clear from this second set of calculations is that the relative values V_t and V_{t+r} diverge much more widely with the second calculation, showing what is anyway rather obvious, namely that mature fish are relatively more valuable than in the first calculation (since there is a much lower probability of them surviving to maturity), if higher values of M are assumed for juveniles[†].

Management objectives

Additional questions may be raised here as to the overriding objective of fisheries management. Is it to maximize the yield or to provide the market with a variety of different products, or maximize the net economic return from the fishery?

These latter objectives imply that the management emphasis selected must also rest on a bioeconomic analysis of the fishery and not a simple yield-per-recruit analysis.

[†]*Note*: A discounting of the value of fish in the sea would emphasize still further the disadvantages of delaying capture implied above.

These then are the circumstances that provoke a reflection on the strategy of management that should be followed. It seems evident that maintaining spawning continuity, from precautionary considerations, should be of greater importance than maximizing physical, or even economic, yield, and this would seem to dictate the type of analysis that needs to be made in support of management change.

If maximizing the landed value for fishermen is a management objective, a further extension of this analysis would be to establish, through bioeconomic analysis, a safe level of escapement and spawning biomass while also taking into account the level of incidental mortality through by-catch of smaller species and the value of small fish on certain Mediterranean markets.

On one point the two contrasting analyses above (the conventional one aiming at exclusively protecting young fish) and the objective of protecting a minimum spawning biomass are in agreement, i.e., in relation to the need to reduce the fishing intensity of the small-mesh trawl fishery. Where they differ relates to whether or not a fishery for larger fish should be initiated or allowed to grow if already established.

Management redundancy and passive regulatory measures

An important feature of any precautionary management system is that there should be a degree of redundancy; in other words, if there should be failure of the primary management system, such as quota control or effort control due perhaps to poor information, the management system should have safety checks incorporated to prevent population depletion. This can be achieved, for example, by technical measures such as closed areas, which prevent access to critical components of the stock, or by refugia, which include both technical measures and characteristics of the method of fishing and/or gear that prevent full exploitation.

Like obstacles to trawling placed in shallow areas of *Posidonia*, these may be referred to as 'passive' management measures, since they require less active responses by managers than active measures such as quotas. For obvious reasons, in areas such as the Mediterranean, such approaches have a great attraction.

The classical overall view here may be that, assuming yield from other smaller species is not important, a change over from a dominant trawl fishery to a dominant longline fishery may be desirable in the long run. Personally, I believe that such a transition implies a number of risks and unknowns. Even assuming such a transition could be achieved, to be successful it would not involve simply transferring fishing effort immediately from the small-mesh trawl to the long-line fishery, since there are currently not enough large hake to make a significant increase in old fish mortality, either commercially feasible or desirable.

One would have to first drastically reduce fishing mortality in the small-mesh trawl fishery by at least 50% in order to build up a population of older fish that could only then be progressively exploited more intensively by gear targeting older fish.

Even if during this period of build up of the population of larger hake the mesh size of trawls was increased progressively to (say) 60 mm, since sexual maturity of hake begins some 2-3 years after first availability to the 40 mm mesh gear, this would imply a transition period of seriously reduced catches of small hake before build up of the long-line fishery could be contemplated. Even then the risk that the spawning stock could be depleted would have to be taken seriously into account.

Another view is that the current trawling strategy with fine mesh gear, which does not fully exploit deeper or rocky areas, may, in itself, constitute a refugium for at least a proportion of mature fish, and that, in consequence, the encouragement of fisheries on the shelf edge and slope for larger fish - although, according to some calculations, offering an advantage in terms of single species management - should be restrained in the light of its possible impact on a spawning stock that may be close to the minimum sustainable limit for species such as hake. Fig. 6 illustrates a possible framework for 'passive' regulation, taking these ideas into consideration.

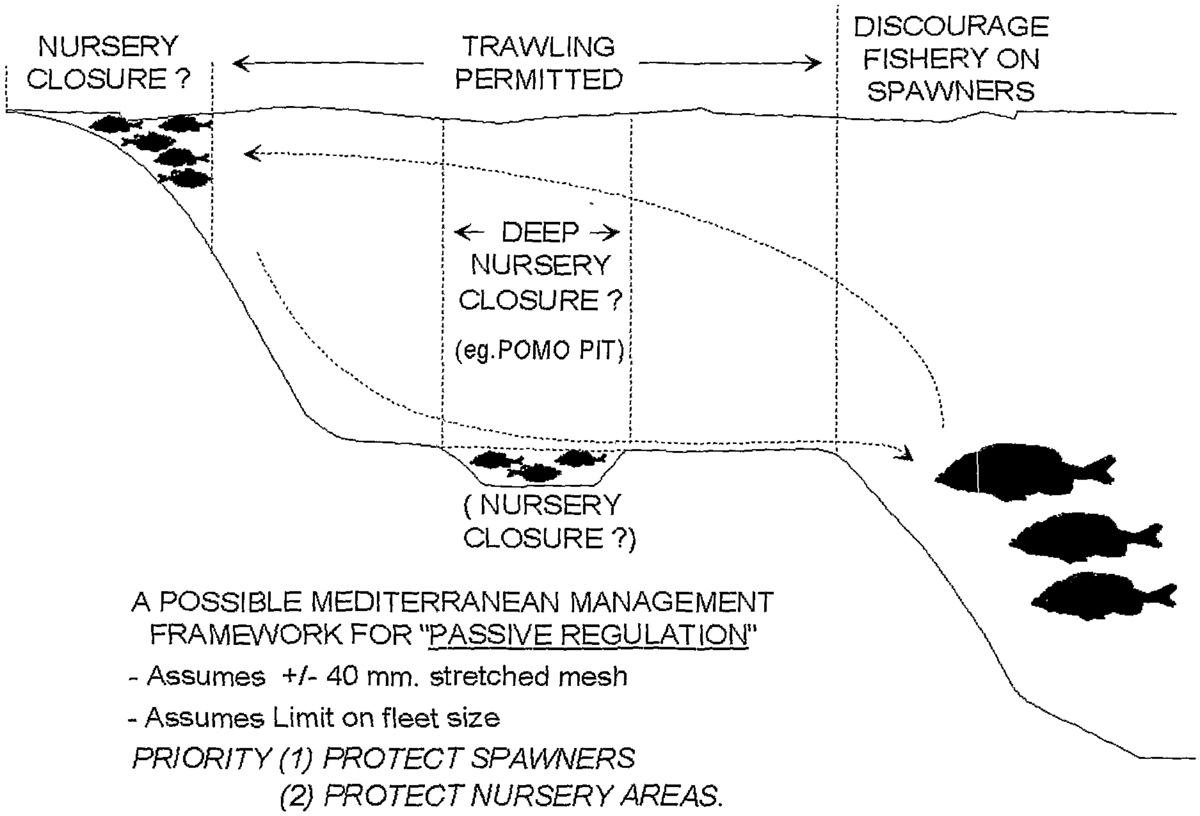

Fig. 6. Illustrating that, although protection of very young fish is essential and reduction of trawling effort is beneficial, there may be good reasons why it is important not to direct fishing effort onto large mature survivors of the juvenile fishery, and therefore to consider providing some areas of refuge for the spawning stock.

References

Abella, A., Caddy, J.F. and Serena, F. (this volume). Estimation of the parameters of the Caddy Reciprocal M-at-Age model for the construction of natural mortality vectors. *(POPDYN proceedings?)*

Beverton, R.G.H. and Holt, S.J. (1957). On the dynamics of exploited fish populations. *Fish. Invest. Lond.*, Ser. 2, Vol. 19, HMSO, London, p. 533.

Caddy, J.F. (1990). Options for the regulation of Mediterranean demersal fisheries. *Natural Resource Modelling,* 4(4): 427-475.

Caddy, J.F. and Mahon, R. (1995). Reference points for fisheries management. *FAO Fish. Tech. Pap.*, 347: 83.

Caddy, J.F. and McGarvey, R. (in press). Targets or limits for management of fisheries? *North-American Journal of Fisheries Management,* 16(3) (in press).

Die, D. and Caddy, J.F. (in press). Sustainable yield estimators from biomass: Are there appropriate reference points for use in tropical fisheries? *Fish. Res.*, (in press).

Dremière, P.-Y. (1984). Régulation des maillages dans les pecheries au chalut: conséquences biologiques et économiques; application à la Méditerranée; étude des problèmes liés a la réglementation du maillage des chaluts dans le Golfe du Lion. *Rapp. Convention CEE,* XIV-B-1 83-1-MO8-P1, p. 29.

FAO (1995). *Code of Conduct for Responsible Fisheries.* FAO, Rome, p. 41.

FAO (1996). Precautionary approach to fisheries. Part 1. Guidelines on the precautionary approach to capture fisheries and species introductions. *FAO Fish. Rep.,* 350/1, p. 52.

GFCM (1996). Resource and environmental issues relevant to Mediterranean fisheries management. *GFCM Studies and Reviews,* 66, p. 142.

Kruse, G. *et al.* (1993). *Proceedings of the International Symposium on Management Strategies for Exploited Fish Populations.* Alaska Sea Grant college Program Report No. 93-02, University of Alaska, Fairbanks.

Patterson, K. (1992). Fisheries for small pelagic species: An empirical approach to management targets. *Rev. Fish. Biol. Fisheries*, 2: 321-38.

Punt, A.E. and Hilborn, R. (1996). Biomass dynamic models. User's manual. *FAO Computerized Information Series (Fisheries)* No. 10, FAO, Rome, 1996, p. 62 + disk.

Sparholt, H. (1990). Improved estimates of the natural mortality rates of nine commercially important fish species included in the North Sea multispecies VPA model. *J. Cons. Perm. Int. Explor. Mer*, 46(2): 211-23.

United Nations (1995). Agreement for the implementation of the Provisions of the United Nations Convention on the Law of the Sea of 10 December 1982 relating to the Conservation and Management of Straddling Fish Stocks and Highly Migratory Fish Stocks. General Assembly, United Nations, New York, Doc. General A/Conf. 164/37, 8 September 1995, p. 81.