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The use of trawling nets in the Mediterranean. Problems and selectivity options

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SUMMARY – After a general presentation of the characteristics of Mediterranean trawling, the principal problems raised by this technique are exposed, in particular in terms of selectivity and discards of exploited species, but also of protected species. Negative impact of trawling on the habitats, as well as increasing difficulties for the profitability of the trawlers, which require great power consumption, are also tackled. The second part of the paper presents the available solutions for improvement, in particular those upheld by the European Commission and the GFCM, associating technical and management measures for the fisheries. The conclusion insists more particularly on the need for establishing a stock management strategy taking account of the impact on the ecosystem and integrating the analysis of the problems arising in all fishing activities.

Keywords: Trawling, Mediterranean sea, selectivity, technical management measures.

RESUME *– "Le chalutage en Méditerranée. Problèmes et options de sélectivité". Après une présentation générale des caractéristiques du chalutage méditerranéen, les principaux problèmes que pose cette technique sont exposés, notamment en termes de sélectivité et de rejets d'espèces exploitées, mais aussi d'espèces protégées. L'impact négatif du chalutage sur les habitats, ainsi que les difficultés croissantes pour la rentabilité des chalutiers qu'entraîne leur grande consommation énergétique, sont abordés. La seconde partie de l'article expose les solutions d'amélioration disponibles, notamment celles retenues par la Commission Européenne et la CGPM, associant mesures techniques et d'aménagement des exploitations. La conclusion insiste plus particulièrement sur la nécessité d'établir une stratégie de gestion des ressources tenant compte de l'impact sur l'écosystème et intégrant l'analyse de la problématique de l'ensemble des activités de pêche.*

Mots-clés : Chalutage, Méditerranée, sélectivité, mesures techniques de gestion.

Introduction

Of all the fishing techniques which are used in the Mediterranean Sea, trawling dominates the fishery sector economically. However it has always been the most controversial fishing gear. Since the beginning of the industrial era this fishing technique used the most sophisticated technology to increase its effectiveness but also to improve the safety of the crew and of the ship, to reduce the difficult working conditions at sea and to improve production quality. Although this evolution did not profit all the fleets equally, today Mediterranean trawling fisheries are able to land both mixed benthic and pelagic species for local consumption and more specialized and industrial produce for foreign markets such as deep crustaceans and sardines. Thanks to the size, the regularity and the variety of its landings, trawling strongly contributed in Europe to the human and animal consumption for two centuries and nowadays constitutes the keystone of the fishing economy for the majority of the Mediterranean fisheries.

Nevertheless, this evolution did not come about without excesses and the advantages of this technique are regularly questioned because of the mortality of juveniles and protected species and the waste of discards practised by most fisheries. For the two last decades, these problems have become such an important matter of concern that the scientific community within the General Fisheries Commission for the Mediterranean (GFCM) has been called upon to find a solution to improve trawl selectivity and to generally reduce the impact of this fishing activity on the environment.

This paper presents in general terms the most important problems of selectivity affecting the trawl fishing, and the various technical and management alternatives, which would make it possible to cure

or to sustainably prevent the negative impacts of trawl fishing on marine resources and on the ecosystem.

General characteristics of trawling in Mediterranean

Trawling is probably one of the most recent traditional Mediterranean fishing techniques. The first documents referring to it mention a fishing technique used in the lagoons of Albufera (Valencia – Spain) at the time of King Jaime 1st of Aragon using a bottom net ("ganguil") towed by two sailing vessels ("bou"). This fishing method was later taken to sea and during the XVII spread from Catalonia to Provence (Fig. 1) then to the Ligurian coast of Italy with the fishermen looking for better living conditions. This technique favoured a great deal of the important fishing development along the whole NW coast of the Mediterranean Sea during the second part of the XVIIII century but was also rapidly blamed for their excessive efficiency, their low selectivity and their impact on the sea-bed (Duhamel du Monceau, 1769).

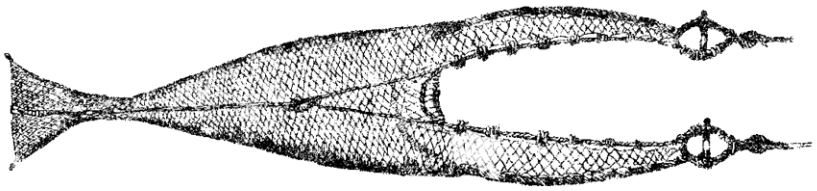

Fig. 1. "Ganguil" or "bou", bottom trawl used in XVIII century by Provençal fishermen (Gourret, 1934).

Nowadays, about 84,000 fishing units are operating in the Mediterranean and trawling is practised by little more than 10% of this fleet and contributes with roughly a little more half of the whole catch, which stresses the importance of the economic role of this metier. These trawlers have on average a tonnage between 30 and 100 GRT and a maximum length between 12 to 35 m LOA (Oliver and Franquesa, 2005; Breuil, 1997 and FAO-Fishstat, Eurostat). These trawlers operate about 180 days per year from the shore to depths up to 800 metres; although most of them limit their haul to depths of less than 300 metres. All Mediterranean trawlers tend to specialise in multi-species fisheries, which means they may catch hundreds of different species. Mono-specific trawl fisheries are very rare and, practically, limited to deep shrimp trawl fisheries or mid-water fisheries targeting small pelagic fish. Given that there is no EEZ (Exclusive Economic Zone) in this sea, and that the jurisdictional national waters are generally less than 12 miles, many fishing grounds are located in international waters and are shared by different countries.

Various types of trawl are used for the catch of the different benthic or pelagic species that the market needs. These gears are schematically towed cone-shaped nets; the large mouth of the net allows several fish schools living far apart to be caught. The mouth is kept open vertically by floats and ballast and horizontally, the mouth is spread open by trawl doors ("otter-boards"), a horizontal beam or the traction, side by side, of two vessels. The effectiveness of these nets globally depends on the dimensions of the volume of water that enters the net and on its ability to retain the targeted preys in codend (selectivity).

Main problems

Selectivity

Bottom trawling is frequently blamed for its low selectivity and for being first of all the main sources of discards. The production of small fishes in Mediterranean is a long-term story coming probably from the fact that the large fish were mainly allotted to the market and the small ones kept for the fishermen's own consumption. This "poor" fish became progressively one of the bases of the

Mediterranean traditional seafood which every tourist coming on the Mediterranean littoral knows very well.

With the increase in the interest for small fish by local consumers and tourists, the use of small mesh sizes in trawl codends is become a common practice for most of trawling fisheries leading sometimes to massive catches of juveniles of the most important species when the trawlers are operating on the nurseries. This phenomenon particularly affects stocks of red mullet or hake. These juveniles, which should be discarded, are often illegally sold for the traditional and lucrative market of small fish and sometimes constitute almost 60 % of the turnover of these vessels.

Hake is the most important species for trawl fishery in the Mediterranean and often constitute a shared stock between different Mediterranean fleets. The bulk of hake (*Merluccius merluccius*) catch for most trawler fisheries is of smaller length size than at first maturity. The case of hake fishery in the Gulf of Lions is a good example of this situation, where the average size of fish caught by the trawling fleet is only 17.9 cm (Lleonart, 1990), whereas maturity is reached between 28 and 34 cm, depending on the sex (Recasens, 1992), and the minimum landing size according to national legislation is 20 cm. Red mullet (*Mullus barbatus*) is another species affected by a massive harvest of juveniles by the Mediterranean trawlers and the main reason is also the use of codend mess sizes that are too smal and illegal (Voliani and Abella, 2001).

Excessive intensity of fishing effort can push the reproductive part of the population below a critical point. This dangerous situation is called recruitment overfishing, and can cause the complete collapse of the fishery if the large specimens are also intensively exploited (Abella *et al.,* 1997). This potential risk has rapidly become a subject of concern for most exploited fish stocks so the scientific community on behalf of the GFCM fixed minimum legal sizes for the most important species in the Mediterranean and the minimum legal mesh size of the cod-end to 40 mm (GFCM 2007).

Unfortunately, these measures that derived from a compromise between biological parameters and market constraints, proved to be inefficient for the protection of species. According to several selectivity studies, the 40 mm, diamond mesh size appeared to be insufficient for the adequate protection of hake stock and a larger mesh size should be required but would lead to an important loss of marketable species which would not be acceptable in the context of a multi-specific fishery.

Discards

Discards are commonly the part of the catch thrown back into the sea by the fishermen because it did not have any commercial interest. They include in variable proportion, non commercial species, spoiled specimen, and illegal size fish according to the level of compliance to the regulation. They sometimes also include broad quantities of *algae* and invertebrates as a result of the impact on the seabed.

According to different observations in several Mediterranean fisheries, trawling is responsible for the bulk of the discards (Carbonell *et al*., 1998). Discards of Mediterranean trawling are the consequence both of the low gear selectivity, of the fishing practice but also of the interest of the market for the by-catch. According to the season or the fishing area, a sudden contribution to the catch of excessively large quantities of low value species can lead to important quantities of discards. According to the large species diversity of the littoral waters and continental shelf, discards can be particularly important for coastal trawling, reaching between 23 to 67% of the total catch for the depths lower than 150 m (Carbonell *et al*., 1998).

Trends in developing deep-water fisheries targeting deep shellfish (red shrimp, Norway lobster) have also lead to high discard levels, concerning both non-commercial species and juveniles of commercial species (e.g. Gadidae), representing sometimes 56 to 77% of the total catch in weight (Tursi *et al*. in Gordon *et al.,* 1998). Pelagic trawling can be seasonally responsible for discards when the mixture between anchovy and sardine is too important for sorting the catch.

The survival of the discarded species can be also questioned and, although a large proportion of discarded crustaceans may survive, observations made in Catalan trawl fisheries in water tanks at sea show that survival rates of fish are highly heterogeneous and vary widely according to species (Sánchez *et al*., 2004).

Threatened species

The increasing extent of trawling activities on the continental shelf and the slope also give rise directly or indirectly to some collateral damage on certain protected or threatened species, which can sometimes result in irreversible effects.

The elasmobranch group is the most affected by the destruction of their habitats, of their eggs and the capture of juveniles. According to Aldebert (1997) 30 years of steady bottom trawling in the Gulf of Lions have resulted in about 50% reduction of commercial chondrichtyans in the commercial landings. From various other observations (Relini *et al*., 2000) most of the sting rays (*Dasyatis sp*.) living in depths from 0-50 m undoubtedly appear to be threatened by intense activities of bottom trawling on the shelf while *Chimaera* and small Squalidae living in depths between 200-500 m are mainly affected by deep-shrimp trawling. On the other hand, if pelagic trawling may incidentally catch some individuals of protected elasmobranches and commercial pelagic sharks (*Alopias vulpes* and *Prionace glauca*), the impacts on these species are in general limited to few catches mainly between May and August during most of the activity of pelagic trawling.

Even though the populations of marine mammals do not seem very much affected in the Mediterranean by trawling, incidental catches of turtles are frequently reported when trawlers are fishing illegally in coastal areas, within the three nautical mile limit, close to their nesting grounds. (Camiñas, 1997c, Bradai, 1995).

On other hand, if trawling does not cause direct mortality to seabirds, discarding at sea has contributed to make seagulls, terns and shearwaters strongly dependent on trawler activities (Oro and Ruiz, 1997; Abelló *et al*., 2000) and also to the large development of these species at the expense of the other populations breeding in the neighbouring areas.

Impact on habitat

Bottom trawl and dredges are obviously designed to scrape the seabed for catching bottom fish and shellfish with maximum efficiency and consequently disturb to some extent the sediment and resident communities. By destruction of the habitats of endemic populations and with the development of scavengers attracted by the destruction of the epifauna, trawling causes important changes in the ecosystem structure. These effects indirectly induce some selection, depending on the capacity of renewal of the affected ecosystems.

The most typical and well-known ecosystems, the Mediterranean seagrass beds, are mostly constituted by the endemic angiosperm species *Posidonia oceanica*. This species provides habitats and food resources for a diversified fish fauna and act as an important nursery area for many species. Extension of human activities on the sea shore and the direct mechanical impact of fishing, particularly of bottom trawling, have lead to significant regression of the meadows in several areas (Harmelin-Vivien, 2000).

Deep bottom fisheries of Spain, Italy, Algeria and Tunisia are targeting Norway lobster (*Nephrops norvegicus*) or red shrimp (*Aristeus antennatus* and *Aristeomorpha foliacea*) on slopes, down to a depth of 1000 m. Side-scan sonar pictures of otter door furrows on these deep bottoms show the evidence of a severe physical impact. The benthic communities in deep waters are often extremely vulnerable to physical disturbance and the recovery after impacts of trawling might take a long time in deep water.

Over fishing capacity and fuel price

From the 80s until the end of 90s, under the pretext of developing employment or improving safety and quality many national or regional development policies have thoughtlessly contributed to increase the fishing capacity of their "mobile gear" fleet (i.e. trawlers and purse seiners) beyond the resource potentialities. These "modernization" programs seeking an industrialization of the fisheries led these fleets to specialize in a mono-specific production, which is more difficult to assess in a context of low productivity such as that of the Mediterranean waters.

The ensuing decrease in captures, the versatility of the market demand and a steady increase of the fuel price have progressively weakened the profitability of these vessels in spite of various fuel saving measures and subsidies (Arnason, 2007). With over 18% of the landing value this irreversible evolution of the fuel cost has put most of the larger trawlers in an uncomfortable financial situation and calls into question to some extent the future of this technique.

Solutions

Trawl selectivity is mainly determined by the codend mesh size. One of major reasons of the low selectivity of Mediterranean trawl fisheries is that these meshes are often too small to allow non-target organisms to escape. Therefore, the conservation regulations for trawlers have concentrated on the improvement of the codend mesh size selectivity.

Following the recommendation of General Fisheries Commission for Mediterranean sea (GFCM), 2 workshops were organized in Sète (France), in February 2005 (FAO, 2007) and in Barcelona (Spain) in April 2007 (FAO, 2008) as well as various selective devices which have been tested in the Mediterranean to review their possibilities of implementation in the different fisheries.

Technical solutions

To reduce the quantity of discards and catches of juveniles, various technical modifications of trawlers can be applied; such as larger codend meshes, square mesh codends, separator panels or sorting grids; their efficiency and their implementation depending on fisheries and specific local conditions.

Increasing the codend mesh size

This is the simplest way to improve trawl selectivity. For example, for a better protection of hake stock, the mesh size should be above 40 mm and would be around 60 mm (Fig. 2) to reach the 25 cm of the first maturity length of this species (Fiorentino and Ragonese, 2000). The main disadvantage of such a measure is an important loss of marketable by-catches. The adoption by fishermen of greater mesh sizes is difficult to achieve when trawler activity is shared with the same gear both on deep-water shrimp beyond 400 m of depth, on hake on the continental shelf edge and sometimes on red mullet in very shallow waters. (Gordon *et al*. 1998). Effectively, in a context of multi-species fisheries, with several species being caught simultaneously, it is hard to rely solely on mesh size, since nets take in large and small species without distinction.

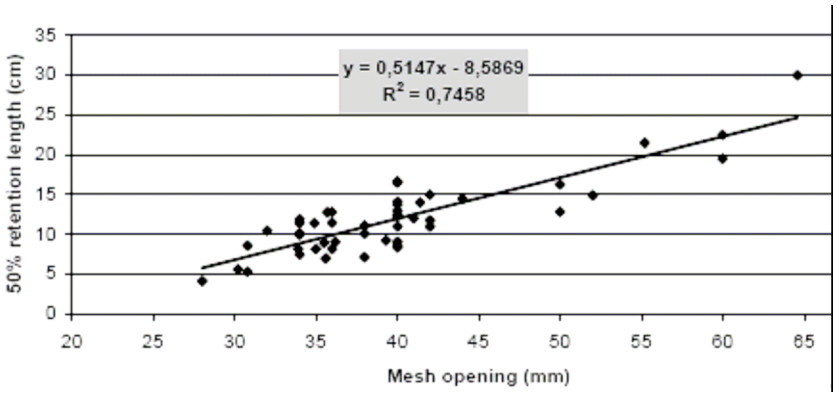

Fig. 2. Relationship between L50 and codend mesh size for hake (from Fiorentino and Ragonese, 2000).

On the other hand, the traditional hanging of the panels of a trawl net give the mesh a diamond shape which tend to close up during trawling. This reduction of the codend mesh opening, which can increase with the towing speed and catch weight, consequently limits the escape of the fish which may suffer greater injuries leading to subsequent death.

Square mesh codend

This selectivity system consists of hanging a net panel along its bar mesh line, like a tennis net, to change the diamond shape of the mesh to a square one, keeping it continuously open (Fig. 3). Considering the results obtained by the different studies carried out in the Mediterranean Sea, the use of 40 mm square mesh codend presents incontestable advantages for most of the Mediterranean species and the ecosystem, keeping out considerably smaller fish than an ordinary codend with diamond mesh of the same size (Bahamon *et al.*, 2007). These studies also suggest that, immediately after implementation, the yield-per-recruit (Y/R) would be reduced by up to 20% for hake, which is one of the main species concerned but that, within five years, the Y/R of this species would increase by more than 50%. Taking into account the overall positive aspects of the square mesh codend, the European Council in its last regulation concerning management measures for the sustainable exploitation of fishery resources in the Mediterranean Sea (EEC n°1967/2006) decided to adopt it as main technical solution for the improvement of bottom trawl selectivity.

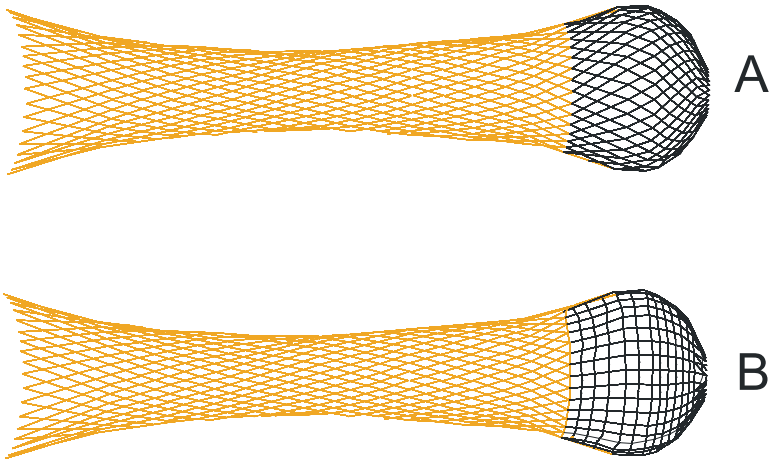

Fig. 3. Traditional diamond mesh codend (A) and square mesh codend (B).

Nevertheless, this long term benefit for the exploited population and consequently the efficiency of the square mesh codend could probably be questioned if insufficient survival rates could be found for the fish escapee through the meshes. On the other hand, some questions concerning the importance of economic losses for some species in some areas due to the multi-species nature of most Mediterranean fisheries. This is why the GFCM has recommended (resolution GFCM/31/2007/3) to develop a gradual implementation of this selectivity device taking into account the different technological, biological, ecosystem and socio-economic aspects of each fishery. This multi-disciplinary approach would lead to a better acceptability of this measure by the fishing sector.

By-catch reducing devices (BRDs)

BRDs are other interesting opportunities for helping by-catches to escape live as well as small fish and large protected specimens. They operate by restricting the passage of unwanted by-catches and guiding it out through some form of escape hole or exit (Fig. 4). Fixed generally behind the codend they consist generally of a sorting grid physically deflecting the incidental catches to an escape trap placed either on the upper or on the lower part of the trawl, depending on the behaviour of the species which must be released and fishing conditions. They include various types and designs: either a rigid device such as metallic or plastic grids or funnels or smooth devices such as a "net panel excluder". Some models are more efficient than others, according to the nature and quantity of the catch and usual by-catch, presence of sediment and/or debris in the catch.

Research into the effectiveness of grids has been conducted in many parts of the world and recently in the Mediterranean Sea (FAO-GFCM, 2007). Although the grids offer undeniable advantages in terms of selectivity and survival after escape for some species and workload on board by reducing sorting time and quality improvement, their use may present some difficulties particularly for small trawlers and in case of important plugging and opening obstruction by fish or detritus.

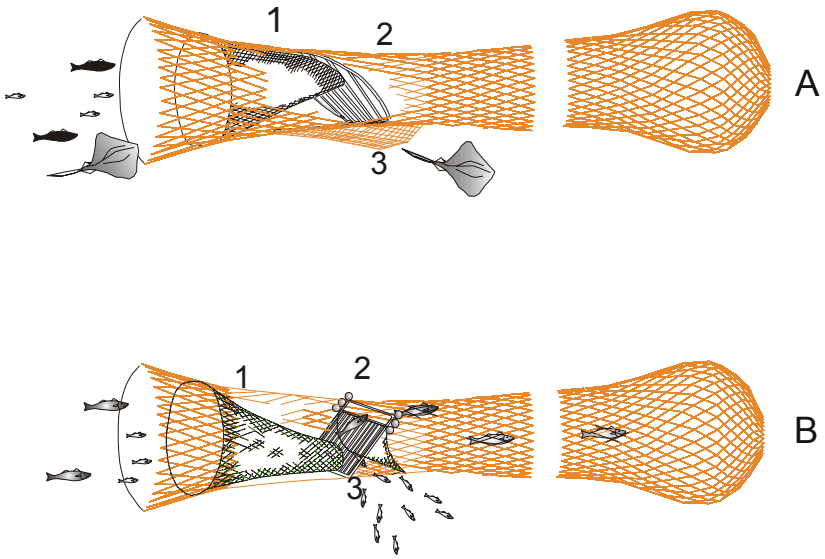

Fig. 4. BRDs "Super shooter" for the escape of large specimens such as rays and turtles (A) and "Dejupa" (from Ercoli *et al*., 1997) for the escape of juveniles (B); funnel (1), sorting grid (2), escape panel (3).

Separator panel

It is an another selectivity system based on behaviour differences between species. The typical design may be found in many shrimp fisheries and consists of a single panel inserted horizontally by splitting the trawl totally or partially, in two levels. The selectivity process is completed by the use on the upper part of the trawl of meshes large enough to allow the escape of juveniles. The rigging and position of this panel is nevertheless critical to the efficiency of this system.

Although these selectivity devices are clearly a long–term economic value for the fisheries, fishermen may be reluctant to embrace such devices, claiming that such devices result in the loss of commercial species and income; particularly in shallow waters and some areas of the continental shelf. Effectively, in a context of multi-species fisheries, however, with several species being caught simultaneously, it is hard to rely solely on mesh size, since nets catch large and small species indistinctly. A compromise must therefore be found between the type of device, the benefit in terms of selectivity and the capture loss.

Management measures

There is a common acknowledgement that the improvement of selectivity by a selectivity device alone is not enough for the protection of overexploited species and ecosystems. Other measures are generally needed such as fishing effort reduction, closed areas and seasons.

Ban and shifting gear alternatives

The critical situation of Mediterranean trawling incites some scientists to propose a total prohibition of this technique following the precautionary principle; this simplistic solution should nevertheless be avoided and temporary restrictive measures will be preferred in the absence of other alternatives and as long as all possible mitigating solutions have been tried. Indeed, the risk of more serious consequences for the resource and the ecosystem as the activity transfer on more fragile sectors or more sensible age classes must above all be carefully evaluated.

In the same way, the shift of trawl fishing for an another technique with less impacts must take into account the risk of profitability loss due to a lower fishing efficiency or a lack of know-how at least during the first years of exploitation.

Fishing effort reduction

Because the trawling effects are both the result of the gear characteristics and the fishing practice, selectivity and environmental impact are also to a certain extent problems of fishing effort. With this aim, the limitation of gear size, towing time and maximum number of annual days at sea, are elementary and efficient measures to reduce mortality of juvenile and vulnerable species.

Restricted temporary fishing area and seasonal closures

They are solutions of management which aim to protect juveniles, breeders of commercial or protected species when they are particularly abundant and vulnerable. The objective is to restrain or to ban temporarily the most aggressive fishing gears from sensitive areas during a restricted period of time. The advantage of these attractive management measures is that they are very flexible and do not stop the fishing activity but they do present several drawbacks such as the increase of fishing effort in neighbouring areas and the difficulty to apply an effective control. For these reasons, until now managers have preferred a permanent ban of critical activities such as for example trawl nets within 1.5 nautical miles from the coast and on meadows of *Posidonia*. Nevertheless, the development of satellite positioning (VMS) would offer good opportunities for the temporary protection of nurseries when they occur far from the coast on the continental shelf or on the slope.

Minimum landing sizes

This was the first management measure to reduce the selectivity problem linked in particular to the market of juveniles. Nevertheless, according to better knowledge of exploitation patterns they need to be updated and better fitted to the biology of the species which are threatened or in bad conditions. For example, because the first maturity age for hake is 25 cm, the new European Council Regulation proposes a progressive increase of the minimum landing size of hake which will rise from 15 cm to 20 cm on 1st January 2009. On the other hand, according to the protandrous hermaphroditism of black spot sea bream, the minimum landing size for this species has been increased from 25 to 33 cm to keep an equilibrium between the two sexes.

Specific measures for protected species

They have been adopted through different international conventions and agreements such as Mediterranean Action Plan (under Barcelona Convention) and the Convention on International Trade in Endangered Species of Wild Fauna and Flora (Washington Convention); among them a list of endangered or threatened species, the control of trade of protected species and of human activities which are incompatible with the conservation of these species.

Conclusion

Until these recent years, to reply to the increasing demand in fish products the development of fleets using high harvesting techniques was the priority of all fishery policies in the Mediterranean Sea. Trawling has been one of the main beneficiaries of this industrial development (Bas, 2006). But, in spite of these efforts of modernisation, the fish production from the Mediterranean Sea remains deficitary, hardly supplying a quarter of the whole consumption of the Mediterranean countries (Breuil, 1997). In return, as for all technology progress, the improvement of "work instrument" has led to an uncontrolled increase of fishing effort bringing several negative consequences for the resource and the ecosystems.

Today, trawling is blamed for major harmful impacts on resource and ecosystem and subject to be definitively banned from some sensitive areas. Effectively, the high catch of juveniles has become inherent to many trawl fisheries as well as the high levels of discards and by-catches. In several areas, many species, which are vital for the economic survival of local fishing communities, are in danger of collapsing and the mortality of threatened organisms is becoming a growing cause for concern.

To face up to the alarming situation of several Mediterranean fish stocks, several scientists and Regional projects (SGMED/UE, GFCM, FAO-COPEMED, FAO-ADRIAMED) have underlined the

need to bring about a strong effort in the improvement of the Mediterranean trawl selectivity (GFCM 2007). The recent studies carried out in the Mediterranean Sea have shown the potential benefits of the different selectivity systems for the major part of endangered species and the ecosystems, confirming the interest in developing selectivity studies to more trawling fisheries.

Nevertheless, the success of the implementation of these measures depends both on effective control mechanisms, including the market, and on the willingness of fishermen to accept them. Actually, no technical solution appears sufficient without a regulation of the access and fishing effort and its acceptability by the fishermen.

Moreover, the future of trawling in the Mediterranean Sea should be deeply reconsidered. There is undoubtedly no way for a high harvesting strategy: the majority of species of the continental shelf are fully or over-fished and most exploited deep species are considered highly vulnerable. Other ways of "masse production" should be developed and trawling activities should be further integrated into a fishery strategy that is perhaps less productive but more economical, more respectful of the ecosystem and better fitted to the socio-economic needs of the neighbouring area.

Such a management system necessarily requires on one hand a multi-disciplinary approach taking into account the technical and socio-economic context of each fishery and on the other hand, the implication of the whole fishery industry in the decision-making process of fishery control.

More generally, because the general interest and objectives are ultimately the same, conservation policies regarding endangered species or habitats and fisheries management should not be considered separately and be applied through measures combining ecological and socio-economic requirements.

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