EXPLOITATION AND CONSERVATION OF SHRIMP RESOURCES

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INTRODUCTION

Shrimp are one of the most appreciated fishing resources at the international level, for which reason it reaches a high value per weight unit. The demand for shrimp is high, particularly in countries with high standards of living such as the U.S.A, Japan and the European Economic Community. Therefore, it accounts for a comparatively high importance in the world's fisheries production, although it only represents 2.5% of the total catch.

Shrimp are the most important fishing resource in Mexico, since their exploitation is important in both social and economic terms. Due to their value and the national and international demand, shrimp fisheries are also a significant source of employment and foreign currency. Despite coming between fourth and sixth place in terms of catch volume, shrimp occupy the first place in terms of their value per weight unit. This crustacean is caught on both Mexican coasts, with a production of around 70,000 tons per year, which represents 35% to 40% of Mexico's total annual fisheries production. Approximately 30% of Mexico's total shrimp catch is in the Gulf of Mexico. Historically, shrimp exploitation has been the most important fisheries activity in the Gulf of Mexico, both in terms of catch volume and generation of direct and indirect employment in the phases of extraction, processing and associated services.

The most important species that form the basis of the Gulf of Mexico shrimp fisheries occur in the whole region, including Mexican and US national waters. The species with the highest commercial value are the brown shrimp *Farfantepenaeus aztecus*, the pink shrimp *Farfantepenaeus duorarum*, the white shrimp *Litopenaeus setiferus*, and in the Mexican Caribbean, the pink-spotted shrimp *Farfantepenaeus brasiliensis.* There are other species that have become more popular in recent years, such as the rock shrimp *Sicyonia brevirostris* and the Atlantic seabob *Xiphopenaeus kroyeri*, which together with other less important species are known locally as *pacotilla* ("second-rate") and have lower commercial value.

MAIN FISHING GROUNDS

There are three main regions in the Gulf of Mexico where all species of shrimp are found, however the following are particularly important: 1) the coast of Tamaulipas and Veracruz where the brown shrimp is predominant; 2) Campeche Bay, with large concentrations of pink shrimp and white shrimp; and, 3) the Contoy zone in the Caribbean, where the main catch is the pink-spotted shrimp.

FISHERIES

There is a high demand for all life stages of shrimp for human consumption. Therefore, shrimp are caught from juvenile to adult phases. Throughout its history, the shrimp exploitation in the Gulf of Mexico has had different stages with the participation of several players. The three main shrimp species in the Gulf of Mexico are fished both by small-scale and industrial methods, moving sequentially from nursery areas to the open sea, and in the case of the white shrimp, parallel to the coastal zone.

Shrimp fisheries differ in cost, investment, job market and profitability. Small-scale fisheries require relatively small investments both in terms of equipment and boats. It is characterized by low energy consumption and generates employment for low-income fishermen. The fishermen start working at a tender age and, as consumption is mainly local, the unit value is lower than in other segments of the industry. Fishing gear varies and includes fixed and mobile techniques in order to catch shrimp of different sizes and ages.

Industrial shrimp fisheries, on the other hand, require greater investments in boats and equipment for offshore capture of adult shrimp. Therefore, the energy consumption is high. The organization of the industry is complex, including packing and distribution activities. In addition to employment that is directly related to fishing, the shrimp industry creates a variety of jobs related to product and service activities, including boat and plant operation, commercialization, etc. Trawling nets that operate on the sea floor while pulled by boats are the primary equipment.

HISTORY OF SHRIMP FISHERIES

Shrimp fisheries in the Gulf of Mexico began in the 1950s and, as every other shrimp fishery, grew rapidly till reaching its exploitation maximum in the 1970s. Production reached its peak in the 1970s, at 39,000 tons, with the participation of up to 1,100 trawlers from Mexico, U.S.A. and Cuba (Fig. 23.1) (Gracia and Vázquez-Bader 1999). Since the 1980s only the Mexican fleet was involved in shrimp exploitation, and the number of fishing boats is currently below 700 and the total annual production dropped to approximately 20,000 tons. It should be mentioned that shrimp stock estimates before 1984 suggested a maximum sustainable catch of 10,000 tons in the Tamaulipas-Veracruz area, 30,000 tons for Campeche Bank, and 2,000 tons in the Mexican Caribbean (Arreguín and Chávez 1985). These joint estimates indicate a higher potential than the registered in recent decades, which reflect the level of exploitation that shrimp resources have suffered. Each of the main species has a particular history, which has affected its exploitation potential.

PINK SHRIMP

Pink shrimp, *F. duorarum*, fisheries were the most important in the Gulf of Mexico in the last century, in terms of volume, with an estimated maximum sustainable production ranging from 4,000 to 11,000 tons (abdomens) annually (Arreguín and Chávez 1985). This species' exploitation began in the 1950s and reached its maximum in the 1970s. Production has exhibited a sustained negative trend since 1980, resulting in the low levels registered in recent years, which are approximately 10% of the average annual production in the history of this species' exploitation. The industrial fisheries effort, which had reached its maximum, also registered a decrease due to the reduction in the available resources offshore (Fig. 23.2).

Concurrently, fisheries of small juvenile pink shrimp (1.2-11.5 cm total length) began inside the nursery areas in the 1980s, strongly increasing their exploitation. Growing 25 to 60-day old *F. duorarum* were overfished, as a result of which the population of new recruits was overfished (Gracia 1995).

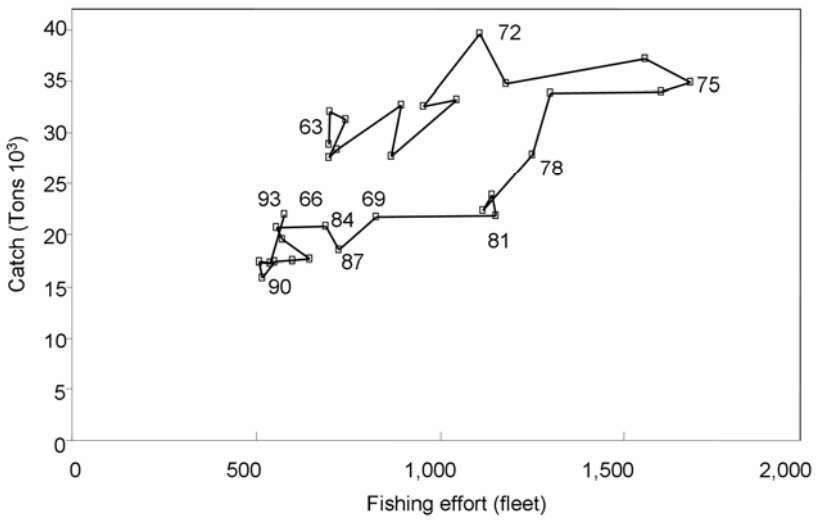

Fig. 23.1. Evolution of total catch and shrimp fisheries effort in the Gulf of Mexico.

WHITE SHRIMP

The fisheries of white shrimp, *L. setiferus*, reached their maximum in the 1970s, with annual production between 1,200 and 2,200 tons. The maximum sustainable production for this period was estimated at 1,650 tons (Gracia 1989). Similarly to the pink shrimp, a trend for sustained decrease occurred after the 1980s until very low production levels were reached. During their history, white shrimp fisheries were the subject of three types of fishing techniques. As with the majority of penaeids, initially there was a small scale white shrimp fishery carried out in costal lagoons and focusing on juveniles, with subsequent offshore fishing of the adults using trawlers. These two types of fisheries placed the resource at its maximum exploitation level in the 1970s. In addition to that, a new type of small-scale white shrimp fishery using drift nets came into use in the marine environment in the 1980s. These nets are most effective on adult shrimp at the reproductive stage of their life cycle, when they have large size and high economic value, in addition to high effectiveness and profitability relative to the low investment cost of this technique (Gracia 1996). The high rates of profit caused an explosive growth in this small-scale fisheries segment, particularly for reproductive white shrimp, which had an impact on the overall white shrimp population in the largest reproduction ground in the southern Gulf of Mexico. Gracia (1996) shows that this factor caused overfishing of the recruiting population, which in turn led to the collapse of the white shrimp fishing industry.

BROWN SHRIMP

The brown shrimp, *F. aztecus*, has become the most important species in the Gulf of Mexico, practically supporting the shrimp fisheries in the area, since it is the resource in best condition relative to other fisheries. The history of brown shrimp fisheries is similar to that of the other two main species, having reached its maximum exploitation level in the 1970s with an estimated maximum sustainable catch of 10,000 tons (Castro *et al.* 1982; Arreguín and Chávez 1985). Small-scale fisheries of young shrimp in the breeding areas began during this same

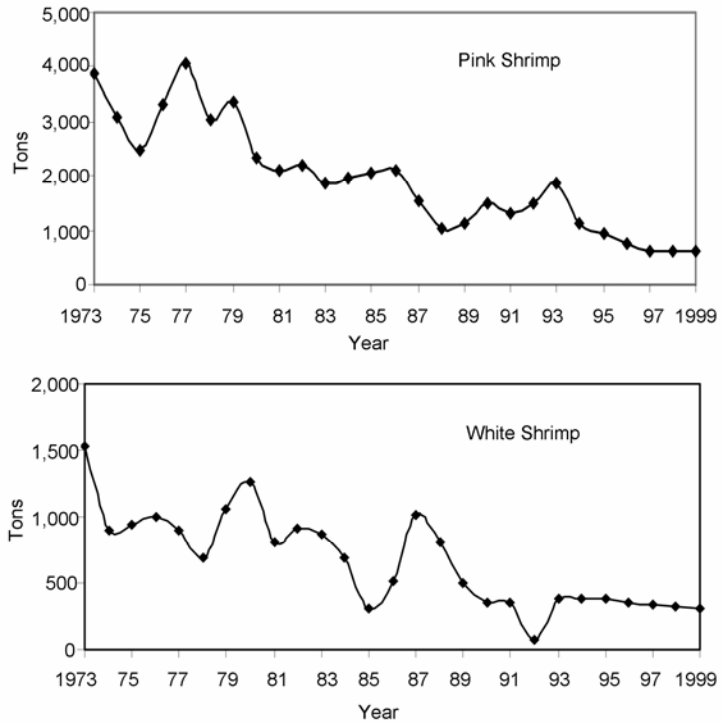

Fig. 23.2. Production of pink shrimp *Farfantepenaeus duorarum* and white shrimp *Litopenaeus setiferus* in the Campeche Bay.

period, mainly in the Laguna Madre de Tamaulipas and Laguna Tamiahua, in Veracruz. This activity currently accounts for about 40% of the total production of the species.

The establishment of small-scale fisheries of brown shrimp coincided with a negative trend in the offshore and total production, since they have an inverse relationship. The growth of small-scale fisheries led to overexploitation of the growing population, which had repercussions on the resident biomass of the adult population. Temporary bans on fisheries were brought into effect to correct this situation, both in the breeding zones (45 days in June-July) and offshore, where the period and length of the ban have varied (45 to 90 days in May-July). The results of this measure were very positive and production increased up to 72% of the average production since it began (Gracia 1997). However, the competition among sequential fisheries with the objective of obtaining the greatest catch has reduced the effectiveness of the ban (Gracia and Vázquez-Bader 1999) and could lead to overexploitation and consequent decrease of brown shrimp production (Fig. 23.3). The fisheries pressure on brown shrimp has also increased due to prolonged bans of more than six months in the Campeche Bay, in order to protect the pink and white shrimp, and the considerably increased shrimp populations when the ban was lifted in Tamaulipas, which led to a larger number of trawlers in the area. This move of the fleet to the Tamaulipas area has increased in recent years, in response to the decrease in white and pink shrimp production in the south of the Gulf of Mexico. Small-scale fisheries in the Laguna Madre, on the other hand, have become more intense during the period before the ban in order to increase production volumes. The increased fishing pressure as a result of small-scale and

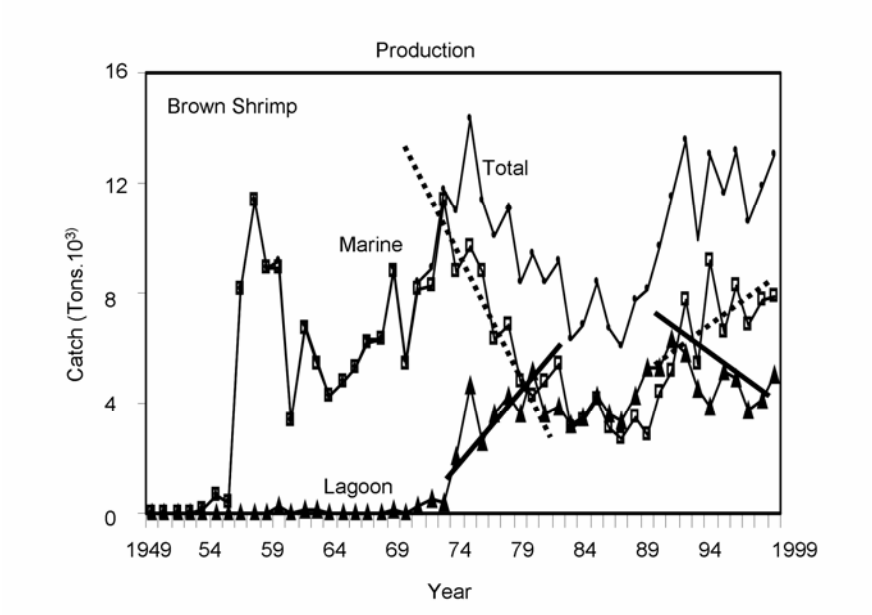

Fig. 23.3. Production of brown shrimp *Farfantepenaeus aztecus* by small-scale and industrial fisheries in the Tamaulipas-Veracruz area. The dashed lines indicate the offshore and total catch decrease as small-scale catch in coastal lagoons increases (full line), and vice-versa.

industrial fisheries will not only reduce the benefits of the ban, but will also tend to affect the status of the shrimp populations that are in better conditions in the Gulf of Mexico.

RELATIONSHIP BETWEEN FISHERIES

The constant increase in small-scale fishing effort is coupled with the corresponding pressure on offshore fishing, which is already at the maximum recommended level for shrimp resources. Therefore, total fisheries efforts over the different shrimp populations have reached a level never before achieved in the shrimp exploitation history. As a result, the total shrimp production exhibited a negative trend in the 1980s. This led the shrimp fisheries in the Gulf of Mexico to a new situation, with a maximum total annual production 40% lower than the maximum registered in the 1970s (Fig. 23.4).

The reduction in the total production of Gulf of Mexico shrimp is mainly due to collapses in the white and pink shrimp fisheries in the Campeche Bay (Fig. 23.2). Both fisheries exhibited a drastic catch reduction, placing them below 20% of the maximum annual average production of each fishery. There are several reasons for this collapse: 1) contamination; 2) loss of trawling areas; 3) degradation of nursery areas; 4) increased small-scale fisheries efforts; and 5) higher fishing power of the industrial fleet (Gracia 1995).

The mentioned factors are not exclusive of each others and can interact and affect the status of the populations (Fig. 23.5). The main factor responsible for the production decrease is the substantial increase in small-scale fisheries efforts aiming at the early juvenile pink shrimp, and juvenile and adult white shrimp through a new small-scale marine fishery (Gracia 1997, 1998; Gracia and Vázquez-Bader 1999). On the other hand, it is necessary to mention that a decimated population is more susceptible to external negative factors and does not have the same potential to take advantage of favorable environmental “windows”. This is a fundamental aspect

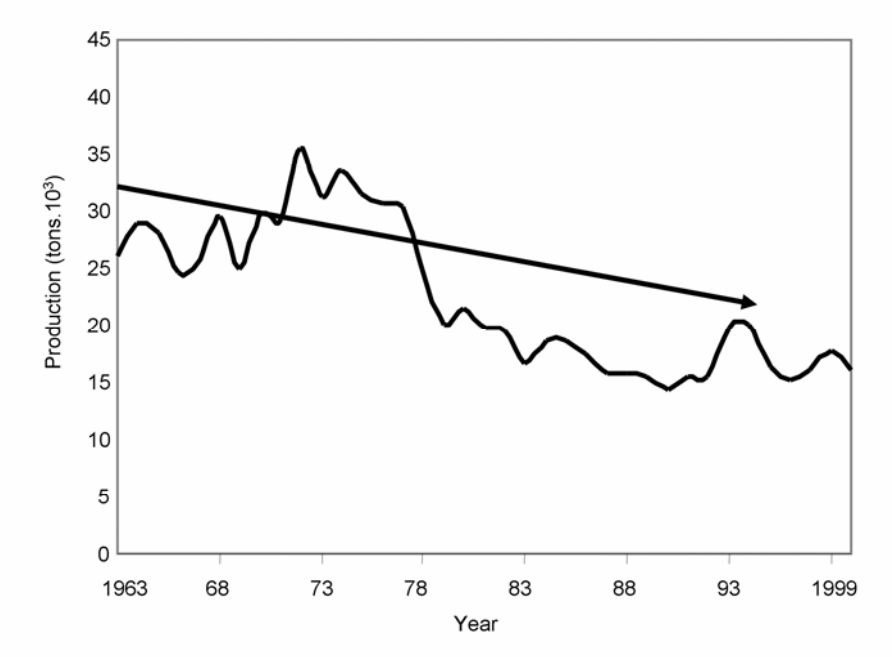

Fig. 23.4. Total shrimp production trend in the Gulf of Mexico.

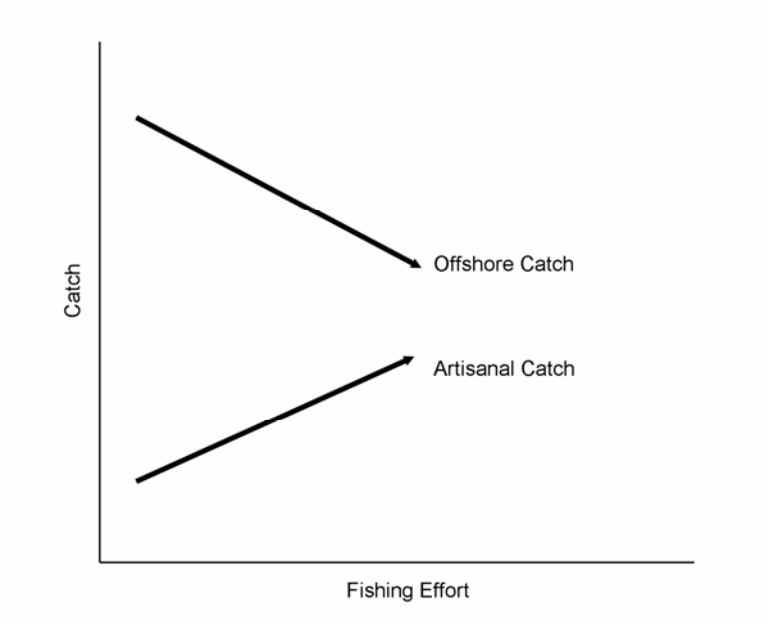

Fig. 23.5. Interaction between sequential fishing and shrimp production.

derived from the reproductive strategy of these organisms (Gracia 1991, 1996) which allowed their success in the ecosystem as well as the development of large fisheries.

The increase in the small-scale fisheries effort on juvenile shrimp leads to increased overexploitation of the population in growing phase, as mentioned above. Using modeling techniques it has been estimated that the biomass incorporation to the marine populations is reduced by 1:3, 1:4 and 1:9 for the white, pink and brown shrimp, respectively, through the current small-scale fisheries techniques (Gracia 1998). The decrease of the offshore biomass due to small-scale fisheries also has repercussions on the reproductive potential which, according to some estimates (Gracia 1997), can be comparatively more important than the decrease due to industrial fishing. On the other hand, small-scale marine fisheries of the white shrimp concurrently to industrial offshore fisheries have caused the overexploitation of the recruiting population of the species (Gracia 1996). Together these factors have led to a reduction of the total available biomass, with consequences on the reproductive potential of the species and the optimum use of the shrimp fishing grounds.

Although the uncontrolled growth of small-scale fisheries is one of the causal factors for the collapse of the fisheries of white and pink shrimp, in addition to putting the brown shrimp at risk, industrial fisheries have also led to the growth of the total fishing effort. The accumulated total fisheries effort on the different stages in the shrimp life cycle is translated into high levels of exploitation, which have raised the fisheries pressure and affected the reproductive potential of the populations.

MANAGEMENT STRATEGIES

Shrimp fisheries management must consider the protection of the reproductive stock, given the excessive pressures exerted on it. This is related to the debate on stock-recruitment relationship in penaeid shrimp. The literature documents this relationship for many species, including those from the Gulf of Mexico (Gracia 1991; Cervantes 1999). Therefore, it is possible and desirable to consider the minimum limits of reproductive biomass. In addition, collapses in the stock corroborate the need to establish management strategies regarding critical levels of the reproductive stock. One strategy could be to concentrate management activities on the main generations and maintain the stock around 20% of the virgin reproductive biomass (Gracia 1996). This would preserve shrimp populations (in the asymptotic part of the curve) with an adequate reproductive potential to respond positively to environmental changes (Fig. 23.6), so that with a given reproductive population size an increase in recruitment of up to 100% can be achieved if the environmental conditions are favorable (Gracia 1991).

Considering different fisheries, this reference point could be linked to information on the different stages of the shrimp life cycle and be used in the design of strategies aiming at a minimum loss at each stage. The design of these management strategies requires information on the following: 1) shrimp recruitment in the nursery and offshore areas; 2) effort level of different fisheries; 3) biological parameters; and 4) critical levels of the stock-recruitment relationships. Control of organism at different stages can basically be assured by: 1) catch quotas; 2) reduction of fisheries effort by special and/or temporal bans; 3) monitoring the catch per effort unit in the different fisheries. The success of the management strategies clearly requires vigilance and enforcement of the regulations.

The control of the fishing effort is one of the critical aspects for the conservation and use of shrimp resources. The different players in these fisheries constantly request increased shares

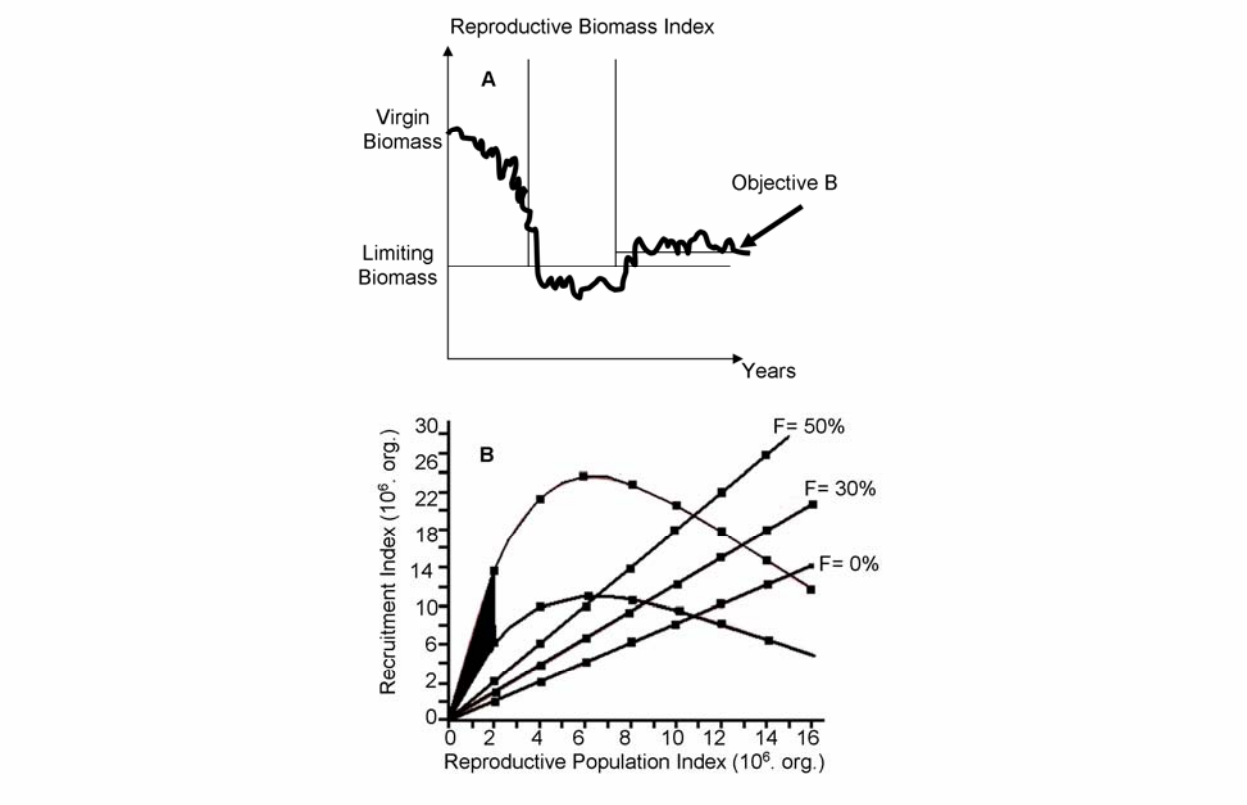

Fig. 23.6. Reference limits of the reproductive biomass (A) and model (B) of shrimp stock recruitment (according to Gracia 1991). Objective B is the level of reproductive biomass required to maintain adequate reproductive capacity for successful usage of favorable environmental conditions, which can cause variable stock-recruitment relations. The straight lines in the model represent the points of equilibrium at different fisheries levels.

of the shrimp biomass and despite the established limits on the fishing effort, as well as control mechanisms such as temporary bans, political and social pressures frequently come into play to reduce or annul their effectiveness. However, the recognition of the biological limitations of the fisheries resources is urgently required for their conservation and optimal exploitation.

It is also necessary to mention that the use of the wild shrimp is presently facing a new scenario, where strong pressure is being exerted on the price due to the offer of cultured shrimp, mainly from Asia. The market for smaller shrimp is the most affected and one alternative is to obtain larger sizes that have a higher value. However, this would require the reorientation of exploitation strategies of the small-scale and industrial fisheries, and to consider a series of social, political and economic factors.

The establishment of a management strategy based on the release of some organisms could, in first place, reduce overfishing of the growing segment of the shrimp population and increase shrimp size, and at medium term, increase the reproductive potential of the populations. Studies of resilience in shrimp populations show that they have the capability of a high recovery response after overexploitation (Gracia 1996). Management measures directed toward correcting the overfishing of growing brown shrimp show that the protection of juveniles and their recruitment have led to substantial increases in production (Gracia 1997). These characteristics

allow us to have great expectations regarding the recovery and sustainable exploitation of shrimp resources if appropriate strategies are established.

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