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Economic dimension of the collapse of the 'false cod' *Epinephelus aeneus* in a context of ineffective management of the small-scale fisheries in Senegal

D Thiao[1]*, C Chaboud[2], A Samba[3], F Laloë[4] and PM Cury[2]

[1] *Centre de Recherches Océanographiques de Dakar-Thiaroye (CRODT), BP 2241, Dakar, Senegal*
[2] *IRD, UMR EME 212 (Exploited Marine Ecosystems), Centre de Recherche Halieutique Méditerranéenne et Tropicale IRD – IFREMER and Université Montpellier II, Avenue Jean Monnet, BP 171, 34203 Sète Cedex, France*
[3] *Institut Sénégalais de Recherches Agricoles, Cité ISRA n°103, BP 03, Dakar RP, Senegal*
[4] *IRD, UMR GRED 220 (Gouvernance, Risque, Environnement Développement), IRD – UPV Montpellier III, 911 avenue Agropolis, BP 64501, 34394 Montpellier Cedex 5, France*
** Corresponding author, e-mail: d_thiao@yahoo.fr*

Small-scale fisheries are often seen as a solution for ensuring sustainability in marine exploitation. They are viewed as a suitable alternative to industrial fisheries, particularly when considering their social and economic importance in developing countries. Here, we show that the booming small-scale fishery sector in Senegal, in the context of increasing foreign demand, has induced the collapse of one of the most emblematic West African marine fish species, a large grouper *Epinephelus aeneus*, historically called 'false cod' by European fishers. The overexploitation of this species appears to be on account of the increasing effort sustained by a growing international demand and important subsidies, which resulted in a relative stability of the average economic yield per fishing trip and an incentive for continuing targeting this species to almost extinction. It is a critical time for addressing and mitigating the pressure of the small-scale fisheries to prevent declines of fish species that are highly valued by northern markets. A balance between conservation and exploitation is necessary to maintain ecological viability while considering the socio-economic importance of the small-scale fisheries. However, a new strategy is needed for conservation that will consider and articulate simultaneously the concerns regarding unmanaged and growing small-scale fisheries, rampant subsidies and increasing foreign demand.

Keywords: conservation, foreign demand, grouper, overexploitation, price

Introduction

Comprising more than two-thirds of the total landings, the small-scale fishery in Senegal represents the largest marine fishing sector during the past four decades. Characterised by remarkable development as a result of the promotion of free access to the marine resources, the fishery provides considerable food products and substantial foreign currency earnings and employment. Following the globalisation of the marine products market, small-scale fisheries underwent significant changes. Its characteristics of multigear and multispecific fisheries combined with the use of more sophisticated technologies (i.e. motorisation, navigation tools, on-board ice storage boxes) facilitate a great capacity for adaptation to fluctuating marine resources and seafood demand. Such a situation contributes to a marked increase in fishing pressure and adaptation to new markets.

An investigation of the dynamics of the exploitation of the 'false cod' *Epinephelus aeneus* for over the past three decades, based on an analysis of available fishery data, demonstrates that the intensification of the Senegalese small-scale fisheries in the international seafood market context could constitute a threat for fisheries sustainability and for its conservation. It appears that sustained export of fish that involves a continuously increasing price is a major reason for the collapse of one of the main high-quality fish species in Senegal.

Background of the exploitation of false cod

Past exploitation

Groupers along the West African coast have been fished for centuries. Since the 16th century, small-scale fisheries have been targeting these resources in Senegal and Mauritania using canoes. During this time period, European fishers started fishing off the West African coastline (Chauveau 1989). Until the 19th century, European fishers thought that grouper species from along the West African coasts belonged to the cod family, which at that time was an important commodity in the trade between European countries and their overseas colonies (West Indies, Réunion Island and Mauritius).

At the beginning of the 20th century, the first scientific descriptions of the West African resources and fisheries were made by Gruvel (1908). The author referred to the two

grouper species as 'cod' (*Serranus caninus* and *Serranus aeneus*), the name used locally in Senegal. The second species, whose common name is 'white grouper' (www.fishbase.org), is locally called 'Thiof' in Senegal; its specific name being *Epinephelus aeneus*. This species was formerly called false cod or African cod (Cadenat 1948), because of the technique used in its preparation as a salted and dried fish, which is similar to that of the Atlantic cod *Gadus morhua*. It was described as a target species for artisanal fishers based in Saint-Louis, then the main fishing centre in the north of Senegal (Gruvel 1908). Fishers caught considerable quantities of large sparids (*Dentex vulgaris*) and false cod *Epinephelus aeneus*, which sometimes constituted most of the catch (Gruvel 1908), a pattern that was later confirmed by Leca (1934). Despite the fishing effort targeting this species, the resource was not considered to be overexploited until the Second World War (Postel 1950).

Three decades after independence

Following Senegal's independence in 1960, Lourdelet (1966) highlighted the importance of the handline fishery targeting false cod between Dakar and Saint-Louis. At that time, this was the most expensive species on the local market, at between 50 and 150 FCFA (Franc de la Communauté Financière Africaine) per kg. FCFA is the national currency of Senegal and seven other countries of West Africa, having a fixed exchange rate with the Euro (1 Euro = 656 FCFA and, in April 2012, 1 Euro = 1.3 US$). In 1964, the catch reached 3 570 t and represented almost 20% of Senegalese fish taken by handlines (Lourdelet 1966). In the 1980s, despite its high price, false cod were mainly sold on the local market, representing about 20% of the urban fish market (Chaboud and Kébé 1989).

From the 90s to the first decade of the 21st century

At the end of the 20th century, the fishery underwent dramatic changes. In 1994, the development of an export market for high-quality demersal species, such as groupers, sparids or cephalopods, was enhanced by the 50% devaluation of the local currency. At present, most of these high-value species are directly exported to European and Far East markets (Swartz et al. 2010). Consequently, the Senegalese households' fish demand was mainly reoriented towards small pelagic species of low value (mainly sardinellas — *Sardinella aurita* and *Sardinella maderensis*). During this period, the development of the Senegalese small-scale fisheries was strongly supported by external aid and public subsidies, which enabled fishers to buy cheap fuel, more efficient outboard motors, fishing gears, and navigation tools such as GPS (Chaboud and Kébé 1989). This policy was regarded as a success towards the overall development of the small-scale fisheries. However, it neglected to address the central questions of access, regulation and degradation of natural capital. During the past 10 years, a new policy has aimed to limit overcapacity and overexploitation through the implementation of marine protected areas (Thiao 2009), fishing licences and fees for small-scale fishing units; however, with limited success. Here, we analyse the dynamics of the collapse of the false cod, within the ecological as well as the economic and social context of a small-scale fishery in a developing country.

Material and methods

Fishery data

The data used were extracted from the database of the Oceanographic Research Centre of Dakar-Thiaroye (CRODT) in Senegal. These data are collected through the small-scale fisheries sampling process, as detailed in Laloë and Samba (1990), Pech et al. (2001) and Thiao (2009). This sampling system, which uses stratified random sampling, has been continuously refined since the beginning of the 1970s. Data are summarised by landing centre, gear and period (fortnightly). Data collection is conducted regularly in the eight main landing centres along the Senegalese coast where more than 90% of the catch is landed. Three main landing centres are located on the northern coast of Senegal, namely Saint-Louis, Kayar and Soumbedioune, where the grouper fishery has traditionally been active.

Exploitation status of the false cod

The status of the false cod fishery is quantified using four indicators: the abundance index, ex-vessel price, landed value, and the economic yield per trip, corresponding to the market value of the average catch per trip. This economic yield can be seen as the average expected turnover of a given vessel that targets false cod during a fishing trip. The period covered by the data collected from the fishing activity surveys (effort and catch) extends from 1974 to 2006. On the northern Senegalese coast, false cod is mainly targeted by handline fishing units, operating daily from the landing centres. Thus, the catch per unit effort (CPUE, kg fishing trip^{-1}) of the handlines better reflects abundance in this region. The abundance of false cod is estimated using an abundance index (AI), corresponding to the weighted average CPUE (Equation 1) of the three landing centres (Saint-Louis: SL, Kayar: KY and Soumbedioune: SB):

$$\mathrm{AI} = \frac{1}{\text{Total catch}}(\mathrm{Catch}_{\mathrm{SL}} \times \mathrm{CPUE}_{\mathrm{SL}} + \mathrm{Catch}_{\mathrm{KY}} \times \mathrm{CPUE}_{\mathrm{KY}} + \mathrm{Catch}_{\mathrm{SB}} \times \mathrm{CPUE}_{\mathrm{SB}}) \quad (1)$$

The CPUE in a given centre is estimated using the following formula (Equation 2):

$$\mathrm{CPUE} = \frac{\sum_{i=1}^{N} C_i}{N} \quad (2)$$

where C_i is the false cod catch of a sampled handline fishing trip i, N is the total number of handline trips sampled per year in which the catch of false cod is not zero. The fishing trips with zero catch are not considered because they may correspond to fishing units targeting other species (Cury and Roy 1988). In addition, the CPUE obtained from the scientific surveys between 1988 and 2004 are used to validate the trend in the abundance index calculated for handlines. The gear used for these scientific surveys is a bottom trawlnet that mainly targets demersal species. The bottom trawlnet is towed at approximately 3.5 knots

(i.e. approximately 6.5 km h^{-1}) at each station for 30 min (Laurans et al. 2004).

The economic factors of the exploitation were analysed by using the false cod ex-vessel prices expressed in FCFA. The effort and catch data were collected since 1974, but the ex-vessel price time-series is available only from 1986 to 2006. For the most targeted demersal species, the price differences observed between the different landing centres are negligible. Thus, for any given species, an average ex-vessel price is estimated from the data collected at the different sampling centres. The ex-vessel prices of six of the most targeted demersal species were compared to highlight the particularly marked trend observed for false cod. The other five species examined were red pandora *Pagellus bellottii*, bluespotted seabream *Sparus caeruleostictus*, bluefish *Pomatomus saltatrix*, false scad *Decapterus rhonchus*, and cuttlefish *Sepia officialis*. In order to take inflation into account, the ex-vessel prices were deflated. Therefore, considering P_t as the average ex-vessel price at date t (current price), I_t and I_{1986} respectively, the consumer price index at time t and 1986, the deflated price (base 100 in 1986), was calculated using the following formula:

$$P'_t = \frac{I_t}{I_{1986}} \times P_t \qquad (3)$$

To estimate the global economic value of the false cod exploitation, the landed value (LV) and the gross economic yield per fishing trip (EY) were calculated. They were estimated by multiplying the deflated price by the cumulated total catch of the three northern centres and the average CPUE (AI):

$$\text{LV} = \text{Total catch} \times P' \quad \text{and} \quad \text{EY} = \text{AI} \times P' \qquad (4)$$

Dynamics of the collapse of the false cod

Trends in the catch

The total catch of false cod has markedly decreased since the mid-1970s (Figure 1). The catch varied between 1 000 and 1 300 t from 1975 to 1977, then the cumulated catch from the three main northern fishing centres reached an average of 790 t per year until 1985, varying notably (CV = 15%). During the period 1975–1985, there was a large decrease in the catch at Kayar. Thus, between 1975 (the highest catch in Kayar being 1 260 t) and 1985, there was a decrease of 67%. In the other two centres where there was less exploitation of false cod, catches were fairly stable during this decade.

From 1986 to 1997, the decrease in catch continued in Kayar, but at a lower rate. In the other two centres, there was also a general decreasing trend, with some fluctuations, particularly in Saint-Louis. Starting from 1997/1998, a second marked decrease affected the total catch in the three centres. This declining trend continued until 2006 and then accelerated, leading to the total cumulative catch of the three fishing centres falling below 120 t per year since 1999. In 2006, the cumulated catch was only 64 t, of which 62% was landed in Kayar. This level of catch in Kayar in 2006 was only 3.2% of the catch recorded in 1975.

Trends in abundance

There was a marked decrease in the abundance of false cod from 1974 to 2006 (Figure 2). Highest values were recorded in the 1970s with a maximum CPUE of 15.5 kg per fishing trip in 1974. A decade later, this declined to only 6.0 kg per fishing trip, but rose slightly to 8.5 kg per fishing trip in 1984/1985. However, since the middle of the 1980s, the abundance index again decreased to low levels. Since 1998, the CPUE catch hardly reached 1 kg per fishing trip. The abundance level in 2006 was only 5% of its 1974 level. The CPUE of the scientific surveys confirms this dramatic

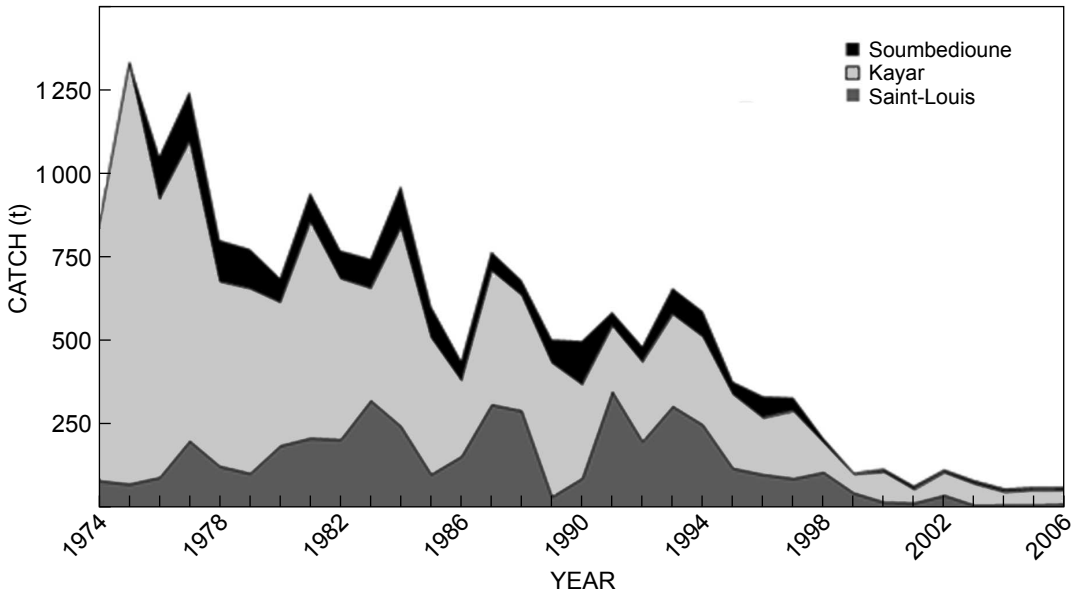

Figure 1: Total catch of false cod at the three main Senegalese northern landing centres, 1974–2006

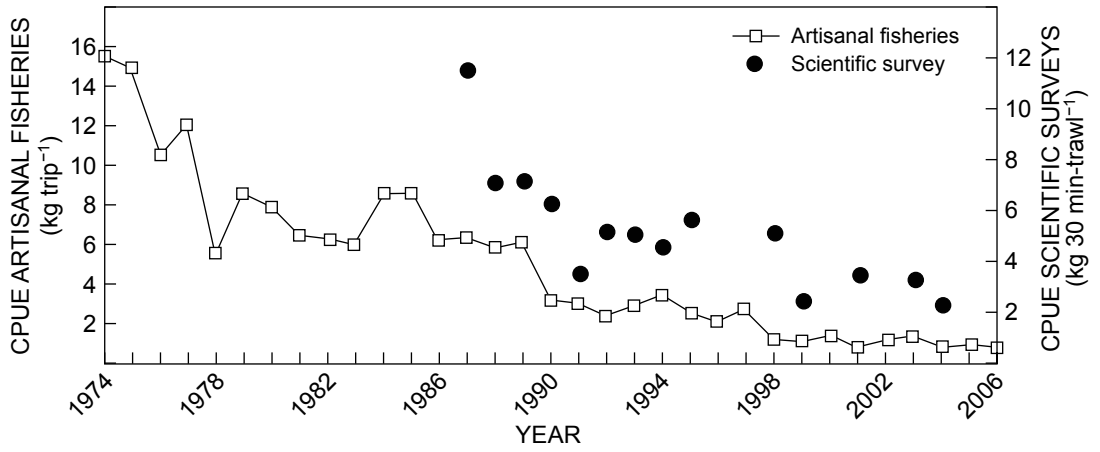

Figure 2: Abundance of false cod estimated using the CPUE of hook and line used in the small-scale fishing canoes and scientific surveys

decrease in abundance of false cod. From 1987 to 2004, there was a fivefold decrease in the level of the abundance index.

The Food and Agriculture Organization/Fishery Committee for the Eastern Central Atlantic (FAO/CECAF) scientific working groups concluded in 2004 and 2007 that there was a real risk of extinction of false cod and they recommended a moratorium on the exploitation of this species along the Senegalese and Mauritanian coasts (FAO 2006, 2012). In addition, Ould Meissa (2008) showed that in the Mauritanian EEZ, the probability of catching false cod by a vessel targeting this species had declined markedly from 60% in 1995 to around 10% in recent years. Observations by Senegalese fishers supported the scientific evidence on the collapse of the false cod stock off the Senegalese EEZ. They all agree that the best chance to catch significant quantities of this species is to operate in the waters of Guinea and Sierra Leone where the stocks seem be in a better state. Thus, the fishers buy licences in those countries in order to exploit this resource there.

Economic dimension of the collapse of the false cod

Fish price in a globalised market

Facing the strong increase in world demand of marine products (Delgado et al. 2003, Swartz et al. 2010), the marketing system of Senegalese small-scale fisheries has developed in a manner to benefit from an increasingly favourable international context. Previously inclined towards local market demands, the outlets of the small-scale fisheries catch became gradually diversified by the development of fish trade marketing that focused more on the external market. This trend was strongly supported by foreign aid agencies with the implementation of structural adjustment plans. Local seafood market absorbed about 80% of the small-scale fisheries catch in the beginning of the 1980s. This ratio has fallen to around 60% during the 2000s and is dominated by small pelagic fish (Thiao 2009).

The consequence of the strong increase in the prices of the main export species was compounded by the 50% devaluation of the national currency in 1994 (Figure 3). Thus, for six of the main export fish (false cod, seabream, bluefish, red pandora, false scad and cuttlefish), the deflated ex-vessel prices at least doubled between 1993 and 1994. The situation has since stabilised for all but one of these species, the exception being false cod. The ex-vessel price of this fish, which was already the highest since the 1980s, followed a consistent positive trend. This markedly increased the attractiveness for targeting false cod compared to the other export fish.

Since 1994, most of the false cod catch has been exported to developed countries, which resulted in a booming price increase from 1 100 FCFA per kg in 1994 to 2 000 FCFA in 1997. This marked increasing trend continued during the 2000s and the ex-vessel price attained 6 500 FCFA per kg in 2006. Obviously, the prices of export species like false cod are mainly determined by world market conditions rather than local ones. Hence, the increase in the price should not only be considered as a simple response to the collapse of the stock. This price increase had a significant effect on the fishers' incomes, thereby encouraging overexploitation of this species.

Dynamics of incomes from fishing

Following the change in ex-vessel price, the trend in false cod landed value and economic yield was influenced by two important time periods (Figure 4). Before the devaluation, cod landing value and economic yield showed opposite trends. For the landed value, there was a relatively moderate increasing trend from 1986 to 1993, from 216 million FCFA in 1986 to 615 million FCFA in 1993. During this period, the economic yield decreased from 3 428 FCFA to 2 019 FCFA per fishing trip.

The price boom after the devaluation induced a strong rise in both the landed value and the economic yield, being threefold compared to their 1993 levels. During the following years, these two indicators increased until 1997 (with a maximum of 7 700 FCFA for the economic yield per fishing trip) and 1998 (with a maximum of 2.76 billion FCFA for the landed value).

From 1999 to 2006, despite the continuous decrease in total catch, the increase in the ex-vessel price was strong enough to maintain relative stability in the landed value (around 1.90 billion FCFA) and the economic yield per trip

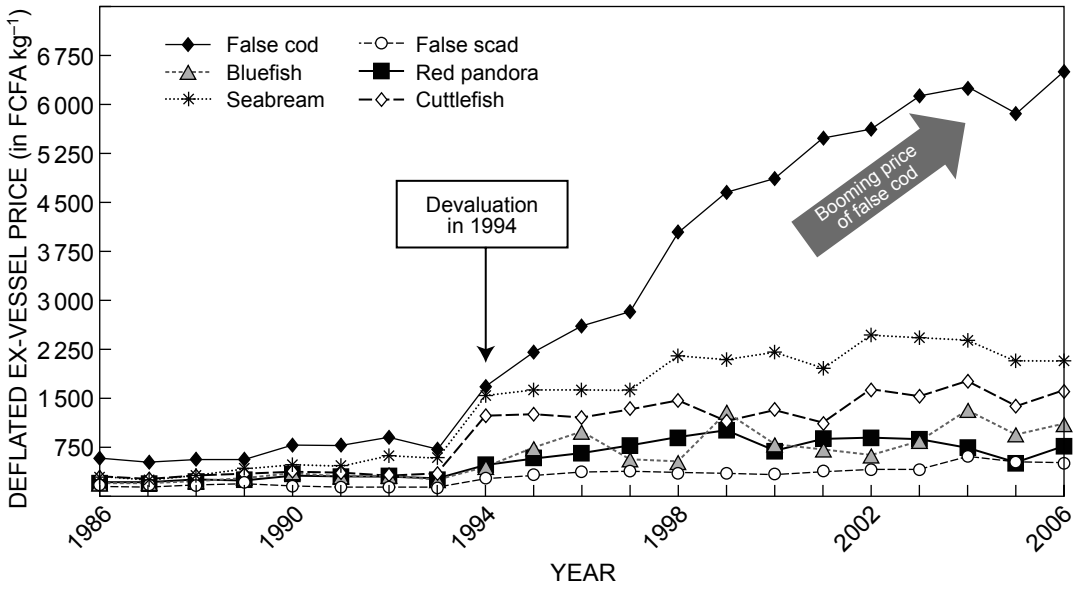

Figure 3: Deflated ex-vessel prices of six of the most targeted demersal species in Senegal (base 100 in 1986)

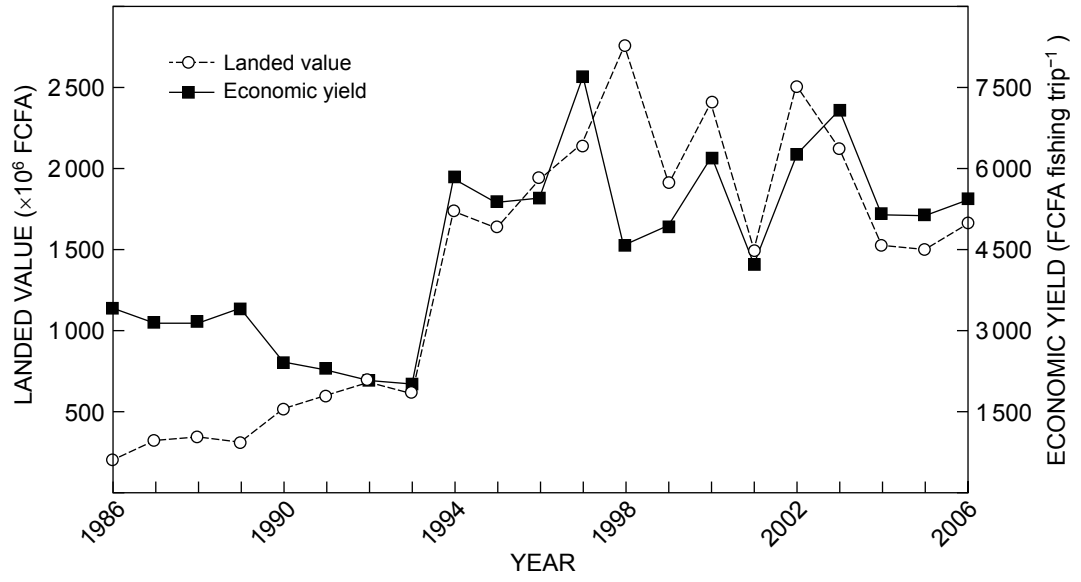

Figure 4: Landed value and economic yield of false cod caught by the small-scale fishing canoes in northern Senegal

(5 600 FCFA). This period reflected the true dynamics of the false cod overexploitation. Its high demand made false cod so profitable that the fishers targeted them incessantly, without regards to the possible eventual collapse of the fishery and even the local extinction of the species.

Ineffective management of the small-scale fishery

Fishing overcapacity

The development and modernisation of the small-scale fleet (Chauveau et al. 2000) is an ongoing process in the fishery, which renders any attempt to reduce the fishing pressure difficult. Indeed, for several decades the Senegalese small-scale fisheries were affected by significant changes, which progressively led to greater fishing pressure and overcapacity (Gréboval and Catanzano 2005). The small-scale fishing fleet has doubled in size over the past two decades, from about 6 400 fishing canoes in 1985 to 12 600 in 2005 (Thiao 2009), and the fleet size continues to expand. Moreover, despite the fact that the traditional wooden canoes are still used, since the middle of the 20th century, technical innovations have affected the small-scale fishery, particularly the increase in fishers' mobility and diversification in the number of targeted species. During recent years, the Senegalese government has implemented measures to reduce the harmful overcapacity of small-scale

fisheries, with limited success. In 2006, a fishing permit system was initiated to modify access into the fishery by granting a limited number of fishing permits. The implementation of this fishing permit was initially considered a bold move to regulate the fishing pressure of the Senegalese small-scale fisheries. However, five years later, this permit system appears to have been ineffective. Many small-scale fishers were reluctant to limit their activities and despite legal sanctions against non-compliant fishers, public authorities were not able to impose the adoption of fishing permits.

Conservation of threatened species

The experimentation of seasonal closures and coastal marine protected areas to insure a better balance between the fishing activities and the capacities of renewal of the resources proved to be ineffective because of a lack of acceptance by the fishers. The first seasonal closure in Senegal was initiated for two weeks in July 1996 for octopus *Octopus vulgaris*. This initiative, which aimed to avoid the exploitation of individuals weighing <350 g, was renewed the following year for 45 days (1 June–15 July 1997). Thereafter, it was extended to other species, in particular to the shellfish *Cymbium pepo* (in 1998) and coastal shrimp *Penaeus notialis* in the estuaries of Sine Saloum and Casamance rivers (in 2000). The generalisation of the biological respite to the whole small-scale fisheries remains hypothetical on account of the potential socio-economic impacts that discourage the fishing communities and companies that depend mostly on marine resources. Moreover, on the northern coast, there is a seasonal trend in the abundance of false cod. During the cold season, the migration of aggregated individuals from Mauritanian to Senegalese northern coast waters appears to be in response to the contrasting hydrodynamic conditions between Mauritania and Senegal (Cury and Roy 1988). A seasonal closure could therefore be effective in protecting migrating false cod if both countries could agree to a joint management strategy for their common resource. However, this has not been achieved. Nevertheless, *E. aeneus* is classified as a Near Threatened species in the IUCN Red List (Therry et al. 2008), but this has no legal repercussions: the classification only serves to inform, at the international level, about the species' status. To protect the species, its classification in the Convention on International Trade of Endangered Species (CITES) annex list remains a long legal process that will require careful consideration and attention, and is currently not feasible.

Economic incentives

The current viability of Senegalese small-scale fisheries, as in similar cases elsewhere (Von Moltke 2011), relies mainly on economic incentives, such as tax exemptions and promotion of exports. Tax exemptions mainly concern the fuel and equipment such as engines and fishing gears. From an amount of 0.25 billion FCFA of tax exemptions in 1981, it reached 5.45 billion FCFA in 2006 (Thiao 2009). Despite the lack of official data, subsidies are important with respect to fishing equipment. In 2003, those exemptions were estimated to be 2.43 billion FCFA (Thiao 2009). In that year, the total amount of exemptions granted to Senegalese small-scale fisheries was about 7.40 billion FCFA (Stilwell et al. 2010). However, combined with free access to resources, tax exemptions enabled the acquisition of larger canoes and more sophisticated fishing equipment. Moreover, fishing exports to developed countries that offer high prices for good-quality species (Swartz et al. 2010) are strongly supported by foreign aid agencies such as the European Union Commission and the Japanese International Cooperation Agency, which facilitates improvements in landing, storage and transport of fish products (e.g. landing docks, isotherm boxes, refrigerating cars, ice and processing plants). This policy, which improved fishing income, also had significant macroeconomic impacts. The fisheries sector is now one of the main net exporters in Senegal. However, this has resulted in a deficit in good-quality sea products for the local Senegalese market. For example, false cod, which was a highly desirable fish for consumption, is no longer available on the local market as a result of low catch and strong external demand. Consequently, false cod has become emblematic in Senegal, particularly among the younger generation, the majority of whom have never eaten or even seen the fish.

Conclusion

The trajectory of the collapse of the Senegalese false cod has been described and linked to the opportunistic nature of small-scale fisheries (Pech et al. 2001, Pauly 2006, 2007, Teh and Sumaila 2007) in a globalised seafood market, and in a favourable economical context for fishers who benefit from public subsidies. The price dynamics of false cod in the markets of developed countries may have important consequences, leading to the fishers targeting these fish. In this context, the flexibility of Senegalese small-scale fisheries may lead to an indefinite increase in fishing mortality for false cod while its ex-vessel price also increases. If we want this flexibility to be used as a management tool, any policy or action aiming to discourage the export should be considered. Similar policies have already been implemented by the Mauritanian government (since October 2008) to stop the shortage of three main species (grey mullet *Mugil cephalus*, bluefish *Pomatomus saltatrix* and meagre *Argyrosomus regius*), which are important for local consumption. However, since the resource is shared with neighbouring countries, a national ban on export of *E. aeneus* may not be effective enough in restoring this species.

The public policies to improve the management of the Senegalese small-scale fisheries and to rebuild major fish stocks are as yet ineffective. Serious socio-economic and managerial constraints have to be overcome by the Senegalese government to reduce the fishing pressure, restore and conserve the coastal ecosystem, regulate economic incentives that tend to increase fishing capacity, and discourage the export of endangered species. Challenging management measures are necessary to restore the false cod stock off Senegal's coast. In the absence of such collective commitment, the Senegalese false cod will likely continue to follow the same trend of its well-known counterpart, the Canadian 'true cod' *Gadus morhua*. Our study demonstrates that approaches considering small-scale fisheries as the most viable alternative to industrial fisheries must be questioned. Such an alternative should not lessen our resolve to achieve a well-managed small-scale fisheries in terms of regulation

of the fishing pressure and the fish export in a global market context. Nevertheless, as in the industrial fisheries, the Senegalese small-scale fisheries remains a major source of employment and revenues. Fisheries provide 75% of animal protein consumed by the their population (Thiao 2009), but while the industrial fisheries production is almost entirely exported, small-scale fisheries play a vital role in terms of food security in the country. Such economic and social importance deserves to be considered in any policy aiming at regulating small-scale fisheries.

Given its high trophic level (4.0, see fishbase.org), the false cod may be very important in terms of ecosystem integrity and resilience. Its collapse should be seen as an indicator of global non-sustainability of the Senegalese fisheries. Therefore, like other endangered species, its conservation should be a priority in a global sustainability approach to the small-scale fisheries. Moreover, as for the Canadian cod (Rose 2007), beyond the fishing pressure there may exist several concomitant causes for the collapse of false cod such as environmental changes (Rice 2002), climate variability (Drinkwater 2002) or complex trophic relationships (Frank et al. 2011). Such complexity is a major characteristic of the West African marine ecosystems (Cury and Roy 1991), which should be further investigated to quantify the vulnerability of false cod. However, strong measures need to be implemented as soon as possible to avoid a critical situation that may jeopardise the possible recovery of the resource, as in the case of the Atlantic cod off the Scotian Shelf (Frank et al. 2011). Moreover a new strategy is needed for sustainable exploitation of false cod by considering three major aspects: ineffective management of small-scale fisheries, rampant subsidies and increasing foreign demand.

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