



PROMOTION OF COASTAL FISHERIES MANAGEMENT

1. LOCAL-LEVEL EFFORT REGULATION IN SENEGALESE FISHERIES

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by

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ABSTRACT

The analytical framework used throughout most of this study is directly inspired from transaction-cost economics, implying that a lot of attention is devoted to monitoring and enforcement costs involved in collective schemes. One of its most important contributions is to show that, with the help of these tools combined with conventional market power considerations, successes and failures of different groups of fishermen according to their technique and site of operation can be well accounted for.

The outline is as follows. In Section 1, background information regarding Senegalese small-scale marine fisheries are provided and the methodology of the study based on cross-section data is shortly described. In Section 2, an historical sketch of all recent effort-limiting schemes attempted along the Senegalese coast is presented. The methods used to limit fishing efforts, which vary according to the fishery concerned, are discussed with a view to understanding their rationales in the light of the specific circumstances surrounding them. Section 3, addresses the incidence of rule violations as perceived by the fishermen themselves, tackled by using the multinomial logit approach on the basis of our survey data. Section 4 is devoted to fitting a time-series econometric model to price and output data. Section 5 summarizes the main results of the study.

FOREWORD

Many countries are taking steps to enact enhanced coastal fisheries management plans to protect coastal fish resources and ensure sustainable development. In developing countries, coastal fisheries are predominantly undertaken by small-scale operators. These fisheries are often characterized, *inter alia*, by strong community ties amongst participants, high labour intensity, and relatively fragile livelihood conditions. Designing and implementing fisheries management plans in such a context remains quite challenging, even if fisheries management instruments are being progressively adapted to small-scale fisheries.

The FAO Fisheries Department Technical Programme *Promotion of Coastal Fisheries* (known as 234A4) has been developed to contribute to better coastal fisheries management through three inter-related types of activities:

- analysis, of existing coastal fishery management schemes, followed by proposals for how to improve them;
- testing, validation, and iterative adjustment of the proposed management approaches; and
- recording and dissemination of the lessons learned.

In its initial phase the Programme will focus on co-management mechanisms, including rights-based approaches and methods for control of fishing capacity. Special attention will be given to participatory approaches and the sustainability of results. The documents of the Programme are published in this FAO Fisheries Circular Series No. 957, “Promotion of Coastal Fisheries Management” as main title.

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EXECUTIVE SUMMARY

Essentially, success or failure of collective action depends on two sets of factors. First are the characteristics of the people concerned, such as the size of the group they are forming, the extent of their heterogeneity, and the social capital at their disposal understood as their tradition of co-operation in other areas than the one considered. Heterogeneity may result from a variety of sources, such as differences in exit opportunities, in time horizons, in resource uses or techniques adopted to exploit them, in skill levels or capital endowments, etc. Second are found the characteristics of the technical, economic, and political environment that bear upon the enforcement costs of a collective scheme. Technical aspects may refer to the physical attributes of a common-pool resource such as its location, its degree of compactness, the frequency and predictability of its produce flows, etc. ; or to the features of the technique used to extract these flows, or to build up a public good. Among economic aspects, let us mention in particular the market conditions prevailing for inputs and outputs involved in the collective activity concerned. Finally, political aspects mainly refer to the role played by state institutions, either impeding or supporting local-level collective initiatives.

Collective management of fish resources can be considered as especially difficult to achieve given their problematic characteristics : fish moves over widely spread areas, appears with low levels of predictability, is caught by a large variety of harvesting techniques, etc. [see Baland and Platteau, 1996 : Chap. 10]. The fact that during the 1990s several important fishing communities along the Senegalese coastline have adopted effort-restraining schemes on their own initiative deserves all the more attention as such attempts are a rare occurrence in fisheries. There are four central questions that need to be investigated :

- (i) Have these schemes been motivated by market power or by resource management considerations ? Indeed, by colluding with the purpose of limiting supply, fishermen may want to exercise market power so as to cause a rise in fish prices. Alternatively, they may desire to stop the dissipation of the resource rent and the depletion of the resource stock by putting an end to an open-access mode of operation.
- (ii) Are the schemes effectively run and have they proven to be sustainable ?
- (iii) What types of fishermen do appear to be most convinced or most supportive of effort-limiting measures ; and is it possible to understand the characteristics of supportive fishermen in the light of available economic theory ?
- (iv) What are the reasons behind the varying incidence of success of such measures in different points of the Senegalese coastline and regarding different techniques or species of fish ?

1. THE CONTEXT AND METHODOLOGY OF THE STUDY

1.1 Background information about Senegalese maritime fisheries

Fishing forms a vital sector of the Senegalese economy, particularly because, with oilseeds, fish is the most important export item, bringing valuable foreign exchange to the country. About 50,000 artisanal fishermen work in this sector with perhaps three times as many people engaged in fish processing and marketing in the informal part of the fish economy (there are 10,000 fishermen operating in the industrial sector). While the small-scale fishing subsector accounts for more than 60% of the landings destined for export markets (and processed by specialised export companies), its share in total fish output exceeds 75%¹. Almost 85 percent of artisanal fishermen operate in three areas — the Grande Côte (comprising Kayar and Saint-Louis), the Petite Côte (comprising Mbour and Joal), and the Cap Vert (corresponding to the Dakar area)— which are precisely those covered by our study. It is interesting to note that the capital stock of the small-scale fishing sector has increased rapidly during the last decade : thus, the number of pirogues operating in the different sites of artisanal fishing has increased by as much as 42 percent between 1994 and 1997. Although smaller than the average, the expansion of the artisanal fishing fleet in the most important ports remains quite impressive: 33 percent in the Cap Vert area, 31 percent in the Grande Côte, and 8 percent in the Petite Côte (CRODT, 1998 : Table 38 ; CRODT and DOPM, 1998 : Table 11).

Given such a rapid increase of the fishing capital stock, it is not surprising that there has been growing pressure on fish resources, particularly on bottom-dwelling species living in coastal waters which are considered to be overexploited (Barry-Gérard, Kebe, and Thiam, 1992 ; Barry-Gerard, Fonteneau, and Diouf, 1992). As for coastal pelagic species, biologists of the Centre de Recherche Océanographique de Dakar-Thiaroye (CRODT) believe that they are rapidly nearing optimum exploitation. Witness to this rising pressure is the adaptive tendency of small-scale fishermen to adopt mixed gears and to go to more distant fishing sites (a strategy that has been made possible by the introduction of so-called ‘pirogues glacières’, that is, pirogues equipped with ice boxes made of expanded polystyrene in which fish can be stocked and preserved for several consecutive days), but also the increasing incidence of conflicts between fishermen’s groups using different harvesting techniques and the growing tensions between artisanal and industrial operators. Public authorities are increasingly aware of the threat on fish resources as evidenced by the fact that the notion of ‘biological rest’ has been recently introduced in the fishing agreement struck with the European Community for the period 1997-2001.

The fact of the matter is that the artisanal fishing sector has undergone rapid transformation during the last decades, particularly under the impact of significant technical innovations, including the shift from cotton to nylon nets, the motorization of traditional pirogues (and their adjustment to permit the fixing of an outboard engine), the introduction of large purse seines capable of collecting large schools of pelagic fishes, the fitting of ice boxes to the pirogues designed for hook-and-line fishing, etc. As a result, the productivity of boats and fishing gears in the small-scale sector has increased enormously, compounding the effect of their sheer multiplication on fish landings.

¹ Note that the fish caught by foreign industrial vessels in the Senegalese waters and disposed of in foreign ports (rather than in Dakar) is not recorded. There is thus clearly an upward bias in the estimate of the contribution of the small-scale sector to total fish output and, above all, to total fish exports.

1.2 Methodological considerations

Fieldwork has taken place in two steps. First, a rapid appraisal of important fishing sites in the Petite Côte, the Grande Côte and the Cap Vert area has been undertaken with a view to identifying possible schemes of effort control. Hann, Mbour, Joal, Mouette, Tassinaire, Pilote Bar, Kayar, Saint-Louis, Yoff, and Soumbédioune have thus been visited between May and October 1996. In the last four sites only, evidence has been found of past or present genuine experimentation with such schemes. Among the dominant centres of artisanal fishing in Senegal, Mbour, Joal, and Hann therefore stand out as places where no organisation has been set up to limit fish landings while Kayar, Saint-Louis, and Soumbédioune appear, on the contrary, to have attempted to create arrangements of this kind (Yoff is a port of lesser importance). Second, in these sites where regulatory schemes have been tried, we have opted for in-depth inquiries on the basis of household questionnaires addressed both to fishermen and fishmerchants. The purpose was essentially to determine the level of support of these schemes among the fishermen as well as to examine whether some categories are more supportive than others and why. To answer those questions, econometric methods specially designed to deal with qualitative variables are amply resorted to using *stata* software. Note that, in addition to sites where attempts at limiting catches have been made, we have selected a fishing village where no regulation has ever taken place (Hann near Dakar). This is with the hope of understanding the reasons underlying the absence of regulatory measures. Also bear in mind that not all fisheries in the successful ports targeted for this study have been brought under a regulatory scheme, thereby adding observations which we can use to detect circumstances adverse to effort limitation. The household survey was conducted during the year 1997 (between April and July).

The stratified random sampling method has been applied so as to have adequate representation of different fishing techniques in use in each site as well as to distinguish between owners and crew within each technique and, when the need arises, between residents and immigrants within the owners' stratum. (Bear in mind that many crew labourers come from outside the fishing site, even from the rural hinterland, particularly in the purse seine fishery where unskilled and inexperienced fishermen are more easily accommodated provided that they are suitably supervised by a core group of expert crew). It is with the assistance of agents of the fishing department, of enumerators working for the CRODT, of local knowledgeable people (such as the 'notables de quartier'), and of persons bearing responsibilities in fishermen's organisations or in local associations of various types (such as mosque committees) that we have been able to properly define the criteria for sample stratification in each fishing site. In Table 1 are given the characteristics of the sample for each of the five aforementioned fishing sites.

Random selection of households within each subsample was made by choosing a central physical point in the fishing site and letting enumerators move in different directions and pick up every house out of a fixed number (which varied according to the site concerned) until the predetermined size of each subsample was eventually reached (the so-called random walk technique). Unfortunately, difficulties in meeting household heads for a long enough time to have the questionnaire filled up were much more serious than foreseen, as a consequence of which the actual sample size was significantly smaller than initially envisaged. Reduction of sample is especially noticeable with respect to crew labourers due not only to pressure on their limited time available for leisurely talks during the fishing season but also to reluctance of their owner-employer to let them speak outside their control. Eventually, crew labourers came to form about half the total sample of 320 households whom we could interview in good conditions².

² In Kayar, for example, we could interview only 17 crew labourers operating purse seines while the initial intent was to include as many as 30 of them in the sample. In Saint-Louis, eventual sample of crew labourers fishing with lines is only 8 people instead of the 15 initially scheduled. The worst case is that of crew operating bottom-set nets in the same site (7 fishermen interviewed instead of the 20 operators planned in the study sample scheme).

Table 1 : The structure of the sample as per fishing site, technique and ownership status

Fishing site	Purse seine		Line fishing		Line with ice		Bottom-set nets		Beach seine		Total	
	Own	crew	Own	crew	own	crew	Own	crew	own	crew	own	crew
Kayar	19*	17	15^o	12	-	-	11 ^{oo}	6	-	-	45	35
Saint-Louis	19	21	14	8	-	-	10	7	-	-	43	36
Soumbedio.	-	-	13	12	11	14	-	-	-	-	24	26
Yoff	11**	11	10	14	1	0	-	-	5	10	27	35
Hann	7	8	6	8	10	10	-	-	-	-	23	26
Total	56	57	58	54	22	24	21	13	5	10	162	158

* Among whom are 11 residents, 6 immigrants native of Saint-Louis and 2 immigrants from Fass Boye.

** Among whom 7 are residents and 4 are immigrants from Saint-Louis.

^o Among whom 8 are residents and 7 are from Saint-Louis.

^{oo} All of them are actually native of Saint-Louis.

We have pointed out above that the site of Hann has not known any decentralised scheme of effort control. It must be added now that experience of such schemes has been short-lived in Soumbedioune, thus making the latter site closer to Hann than to Kayar, Saint-Louis, and Yoff from the standpoint of effort regulation. Moreover, as pointed out above, not all fisheries in the last three sites have been subject to limitations of some sort. While in Kayar purse seines and lines are regulated (bottom-set nets are subject to loosely applied access rules), this is true only of purse seines in Saint-Louis and of lines in Yoff (and Soumbedioune). In other words, the available sample contains data about attitudes of two categories of fishermen, those who have gone through a (sustained) experience of effort control and those who have not. Adopting a restrictive definition of what constitutes a regulatory experience, we count 127 fishermen in the former category –corresponding to the sum total of owners and crew labourers operating purse seines in Kayar and Saint-Louis or lines (without ice) in Kayar and Yoff (see the figures in bold characters in Table 1)– and 193 fishermen in the latter. If a broader definition is retained, so that practitioners of line fishing in Soumbedioune are considered as having experienced regulation in spite of its short-lived character, the division of sample fishermen between the two above categories is according to the ratio 152-168 instead of 127-193.

Opinions of local fishmerchants regarding regulatory schemes have been solicited in various sites. The sample comprises 20 fishmerchants from Kayar, 13 from Saint-Louis, 20 from Yoff, and 20 from Hann. Results of these interviews have been disappointing and will therefore not be commented upon in this study.

2. COLLECTIVE MANAGEMENT OF SEA RESOURCES IN SENEGALESE COASTAL COMMUNITIES

2.1 A brief historical sketch of effort-limiting schemes

The first attempt by small-scale fishermen to regulate their harvesting efforts has been made in 1992 in the village of Kayar. Interestingly, this initiative has been launched by the *Comité de solidarité Kayar-Guet Ndar* which the fishermen established in 1990 with the support of some outstanding public authorities (such as the governors of Saint-Louis and Thies, and the General Khalife of the Muslim brotherhood of the *Layènes* in Yoff) in order to bring to an end the bitter conflicts that opposed resident fishermen from Kayar to immigrant fishermen from Saint-Louis. In the wake of this emerging collective action movement encompassing fishermen of all origins, it was decided that canoes equipped with purse seines would be allowed to make a single trip per day during the season suitable for this type of fishing. A special committee named *comité des sennes tournantes* (committee for purse seines) has been created towards the purpose of enforcing the above rule which

was apparently motivated by the desire to increase producer prices for the pelagic species targeted by purse seines and to reduce the market power wielded by local fishmerchants (known as *mareyeurs* in Senegal). The scheme has persisted to this date.

Two years after the creation of the *comité des sennes tournantes*, the so-called *comité des pêches* (committee of the fisheries) has been set up by the fishermen of Kayar to extend the experience of purse seines to the domain of line fishing which targets demersal species destined for export markets. This step was taken soon after the devaluation of the CFA when fishermen started fearing a severe contraction of their profit margins owing to a rapid rise of their production costs (especially, the costs of fuel and the prices of imported fishing equipments). Output prices did not rise significantly either because the species concerned were not of an exportable variety or because fish intermediaries succeeded in pre-empting a large share of the gains from devaluation.

The existence of the latter phenomenon was actually confirmed in the course of interviews conducted with some management staff of fish-processing factories in Dakar. According to them, indeed, commission agents in charge of purchasing raw fish on the landing sites on behalf of export companies did not hesitate to collude with the purpose of preventing producer's prices from increasing after devaluation. The system of payment applied by these companies actually encouraged trade malpractices since they used to pay a predetermined price per unit weight (based on world market prices) to their commission agents, leaving them free to appropriate any residual gain obtained by underpaying fishermen. In other words, fishmerchants were able to deprive fishermen of the beneficial effects of devaluation. It is in reaction to this glaring manipulation of market prices that the fishermen started to demonstrate, first in Yoff (near Dakar) and soon thereafter in Kayar where the protest movement took on the form of a strike stretching over three consecutive days during which fishmerchants were starved of fish. Fishermen of Kayar demanded prices five to ten times higher than those offered them by the *mareyeurs* !

Given that merchants refused to raise their prices substantially after fishermen went back fishing, the latter decided to sell the fish themselves to the factories by renting in refrigerated vans and transporting the raw produce to Dakar. This was nevertheless a temporary solution soon succeeded by a systematic attempt to limit catches of demersal species through the fixing of a maximum number of boxes of fish that a canoe is allowed to unload on the beach for disposal. Most of the time, the number of boxes is set at three, yet the *comité des pêches* can increase or decrease the quota depending on prevailing demand and supply conditions. In actual practice, the quota per canoe never falls below two boxes of fish because fishermen consider that line fishing cannot be profitable if catches are smaller than this quantity. Yet, when catch limitation prove insufficient to prevent an abrupt fall in fish prices, the bureau of the *comité des pêches* (composed of a president, three vice-presidents, one secretary general and his two associates, plus a president in charge of a subcommittee dealing specifically with problems of fish marketing) organises a joint meeting with the fishmerchants' representatives in order to determine a floor price for the day.

The scheme was still in force at the time of writing, attesting to its viability compared with lock-out movements –which are unsustainable given the lack of intertemporal markets to smoothen temporary disruptions of economic activity– and with direct sales of fish to export companies –which confront fishermen with considerable costs due to their lack of experience and skills in marketing.

Migrant fishermen from Saint-Louis operating in Kayar during part of the year have played a critical role in diffusing in their native area the institutional innovation adopted by purse seine operators in Kayar. To regulate fishing trips by canoes operating purse seines as well as to achieve some other collective ends (particularly, to encourage mutual help groups for sea rescue operations and insurance against damages to nets, engines and canoes), a special organisation known as the *Union des Professionnels de la Pêche Artisanale de Guet-Ndar* (U.P.P.A.G.) has been created as early

as in November 1992³. A first attempt to limit trips by purse seines has been made in October 1993 when 55 canoes operating this gear participated in a scheme allowing for only one trip every two days. In order to implement the rotating scheme, the canoes concerned were divided into two groups (one of 22 and the other of 23 units) according to the quarter of residence of their owners : the first group comprised all the purse seines belonging to the quarters of Dack and Pont de Kholé (both in Guet-Ndar itself) while the second one included those of Lodo (also in Guet Ndar), Senthiaaba, and Gokhou Mbathie. During the year 1994, the experience was repeated with a total of 58 participating canoes, and again in 1995. Yet, around the middle of December 1995, the scheme was brought to an end due to internal tensions leading to a large incidence of violations. On the other hand, no regulation of fishing effort among line fishermen has ever been attempted in Saint-Louis.

Yoff, as we have pointed out above, was actually the place where the idea of fixing quotas of fish landings for line-fishing canoes was initially experimented before being emulated in Kayar. Unlike what is observed in the latter fishing site, however, regulation in Yoff is implemented only during the period running from January to May when landings are particularly abundant. A special committee composed of twelve members chosen among the seven quarters (called *penthies*) of the village is in charge of monitoring the regulatory measure during the above period. Recently, however, serious tensions have appeared in the village that led to the discontinuance of the scheme (in February 1997). Opposition to the measures by an important leader eager to recoup considerable investment expenditures in fishing assets (purchase of three canoes equipped with echo-sounders) has been frequently mentioned as the trigger of the crisis. Yet, at the same time, there seems to be a widespread belief that the members of the committee are not up to their task and should be replaced by more dynamic leaders. We cannot exclude the possibility that personal antagonisms and leadership rivalries have contributed to erode the credibility and diminish the authority of the committee.

In trying to emulate their colleagues from Yoff, fishermen of Soumbédioune have been much less successful than those of Kayar. In August 1994, they decided to enforce a scheme limiting to three boxes the quantity of valuable demersal export species (the sea bream and the dentex) that line fishermen were allowed to land per day. Towards that purpose, they set up a special committee made up of six members. After a short period of barely three months, the experience had nevertheless to be ended amidst a lot of disillusionment.

Enforcement of regulatory measures is supported by sanction systems that are essentially similar between the fishing sites. In Kayar, when a canoe equipped with a purse seine is found exceeding the limit of one fishing trip per day, the rule provides that a fine of 100,000 CFA is imposed on the owner. If he refuses to comply, the canoe and the net are confiscated till he pays the fine, and they can be ultimately sold in case of prolonged default. The same system applies to canoes equipped with lines : concealment of fish boxes exceeding the allowed quota is punished by a fine which was gradually revised upwards (from 15,000 to 30,000 and then to 50,000 CFA) when it appeared that it was not dissuasive enough. As a matter of fact, since excess catches are not confiscated, it may make perfectly good sense to run the risk of being detected and to pay the fine in the event of detection. Such payment, it may be further noted, is required under the threat of seizure of the fishing equipment involved. Delays allowed to pay the fine can extend to 10-15 days if the rule-breaker is a well-known fisherman with solvency problems. According to several informants, flexibility in meting out punishment was gradually introduced as the rigid procedures that were initially devised aroused too much resistance. Following this account, frustrated fishermen started criticising the members of the relevant committees for behaving like policemen vis-à-vis their own brethren.

In Saint-Louis, the amount of the fine imposed on rule-violators is 50,000 CFA and, as a matter of principle, the owner of the purse seine at fault is not permitted to go back to sea unless he has paid

³ This organisation is run by a bureau composed of seven members : the president, the vice-president, the general secretary, the general treasurer and his associate, the head of the economic commission and the head of the social commission.

the fine. In Yoff, the amount of the fine is 30,000 CFA for line fishermen exceeding their quota (compared to 50,000 CFA in Kayar). That all these rules are not necessarily enforced with a minimum amount of rigour will soon become evident from the analysis of household survey data.

2.2 Measures aimed at the allocation of fishing space

In a few cases, measures are aimed at allocating fishing space among competing fishing units rather than at limiting fishing effort. Thus, in Yoff, there is a prohibition that forbids canoes with purse seines to operate within a certain distance of the beach during the February-May period. This is with a view to reserving access to in-shore waters for beach seines, that are bell-shaped nets operated directly from the beach. These gears have the advantage of creating a lot of employment (the hauling of a beach seine absorbs between 30 and 100 fishermen, among whom many are unskilled workers).

In Kayar, competition for access to in-shore waters has been a constant source of tensions between migrant fishermen (from Saint-Louis) operating bottom-set nets and resident fishermen. Such tensions may easily erupt into acts of physical violence as witnessed by the occurrence of several death casualties following a violent confrontation in 1985. The conflict is especially severe because it takes on an ethnic dimension. Indeed, it opposes fishermen using passive gears (like bottom-set nets) to those using active gears (such as lines and purse seines), and it turns out to be the case that resident fishermen are entirely specialised in active fishing techniques while a category of fishermen from Saint-Louis operate bottom-set nets to the exclusion of any other technique. It must be borne in mind that fishermen from Saint-Louis have a long tradition of mobility along the West African coast, a result of the fact that the fishing zone of Guet-Ndar is not sheltered from the strong winds of the Atlantic Ocean and is therefore accessible only during a limited part of the year. As a consequence of deep-rooted migration habits, the Saint-Louisiens tend to consider the sea as an open access resource that does not belong to any community in particular. People from Kayar have an almost opposite conception of sea tenure: being originally an agricultural community with lands located not far from the sea, they are inclined to view the adjacent water space as their own territory, much in the same way as they see their agricultural lands.

To the extent that conflicting territorial claims between the two fishermen communities are likely to affect their ability to initiate and sustain effort-limiting schemes, it is appropriate to say a few words about the manner in which this problem was tackled and the extent of success or failure achieved. In February 1986, the government of Senegal set up a special commission charged with the task of defining and monitoring an exclusive fishing zone, marked by buoys, in which bottom-set nets were to be prohibited from operating. This commission is composed of four members, namely the chief of the local fisheries administration, the head of the local gendarmerie squad, and one representative of each fishing community (resident and migrant fishermen). The overwhelming majority of fishermen consider that the commission has largely failed in its mission. Conflicts between bottom-set net operators and other fishermen remain pervasive as illegal encroachments upon the exclusive zone are quite frequent. In most cases, however, they are not dealt with by the commission for lack of monitoring equipment (the commission has received a canoe equipped with an outboard engine for surveillance operations, yet the boat cannot be operated because of a lack of working capital for fuel expenses and maintenance of the equipment).

In these circumstances, fishermen who consider that their rights have been infringed upon tend to punish the alleged culprits without informing the commission (typically, bottom-set nets are seized and re-sold by resident fishermen without the intervention of the commission), thereby creating a suspicious atmosphere where reference to justice easily conceals unallowable motives and obscure settlements of private accounts. According to some knowledgeable people in Kayar, threats of punishment are still insufficient to deter bottom-set net operators from trespassing the boundaries of the exclusive fishing zone because the gains from placing these nets in the prohibited area are quite substantial compared to the expected losses from their seizure or destruction.

2.3 The rationales of the methods used to limit fishing effort

As pointed out above, for purse seines reduction of fishing effort is achieved through limitation of the number of sea trips allowed per unit of time while, for line fishermen, catches per canoe may not exceed a certain number of weight units (measured by boxes of fish). From the viewpoint of efficiency, neither method is ideal in theory. The former method encourages fishermen to make up for the limitation of fishing trips by increasing the productivity of each permitted trip, through the lengthening of fishing time or the introduction of appropriate technical innovations (e.g., using more performing nets, more powerful engines, etc). In a converse way, the latter method induces fishermen to multiply their fishing trips with a view to compensating for the limited catches allowed per trip. Waste of capital and labour resources tends to result from such attempts to circumvent effort-limiting rules. Moreover, new entrants should be prevented from operating which is obviously not the case as attested by the rapid increase in the number of artisanal boats along the Senegalese coast (see supra, Section 1).

One may wonder why schemes devised for purse seines do not comprise limitations of landings of the sort applied to line fishermen and, in the other way around, why limitations of fishing trips as conceived for purse seines are not adopted in the case of line fishing canoes. In other words, what are the possible reasons underlying the selection of different systems of effort regulation, both apparently imperfect, depending on the fishing technique employed? To begin with, the very characteristics of purse seine fishing make catch quotas unfeasible. In this type of fishing, indeed, huge quantities of schooling fishes may be caught with a single sweep of the net handled from one or two motorised canoes. There are two distinct reasons why purse seine fishermen resist the idea of having to throw excess produce back to the sea after a successful haul. The first reason lies in the fact that foregoing a catch that has actually been achieved entails a much higher subjective cost than foregoing a potential catch that is not being attempted. This is an interesting application of the prospect theory of Kahneman and Tversky (1979) according to which subjects tend to evaluate prospects in terms of gains and losses relative to some reference point, rather than hypothetical final states (wealth positions) as assumed by expected utility theory. The so-called value function depicted by these authors captures the idea of loss aversion that is critical in the aforementioned fishermen's attitude (the function is steeper for losses than gains). The second reason has to do with insurance considerations. Indeed, since catches may vary widely from one day to the other, imposing a system of catch ceilings means that fishermen would have to forego a windfall catch on a 'lucky' trip while under poor natural conditions their catches are in any way much smaller than the authorised maximum. In other words, a system of catch quotas would prevent fishermen from smoothing bad and good catches as effectively as they can do under a system of free landings. In the case of purse seine fishing, therefore, limitation of fishing trips unaccompanied by catch quotas appears as a second-best solution imposed by technological (a discrete process of fish harvesting) and ecological (ample and largely unpredictable catch variations) constraints.

Since the catching of fish with hooks and lines is a continuous process that can be discontinued almost at will (quantities of fish caught can be 'finely tuned' by the fishermen), fixing catch quotas per trip is a practical proposition for line fishing canoes. Furthermore, imposing limits on the number of fishing trips per day does not appear to be necessary because (i) the average length of a sea trip for these canoes is close to 9 hours (average computed over a sample of 80 fishermen) due to the long distances travelled to reach the fishing grounds, and (ii) landing sites are not lighted, forcing markets to close at 6.00 PM and boats to return before that time. In actual practice, therefore, the system of catch quotas applied to line fishing conforms with the prescription of economic theory. As for canoes equipped with ice boxes, they undertake much longer voyages since they have preserving facilities on board. They travel up to several hundred kilometres, northwards to Mauritania and southwards to Casamance and Guinea Bissau. Their voyages extend over several days and, increasingly, they come to exceed a week's time. For such canoes, the imposition of a catch quota is unacceptable. This is true even allowing for the fact that quotas could be adjusted upwards to take account of the length of each voyage: for example, the quota per canoe could be fixed on a daily basis so as to make the total

allowable quota proportional to the length of the voyage. Yet, given the high fixed costs involved in long journeys to distant fishing grounds, it is doubtful that the fishermen concerned would accept to restrict their catches.

Finally, the aforementioned psychological resistance of fishermen against forfeiting part of a realised catch explains why the punishment imposed on line fishermen who did not comply with catch quotas takes on the form of a lumpsum fine set in money terms and does not involve the confiscation of the excess catches themselves (see *supra*).

From the standpoint of equity, all reported regulatory measures impose an equal effort of catch reduction on each fishing unit. Each purse seine is permitted to operate once every day in Kayar and once every two days in Saint-Louis while each line fishing canoe is allowed a fixed quota in Kayar and Yoff. It is remarkable that, as revealed by our household survey, there exists a total consensus about this manner of sharing the burden of effort reduction in all the fishing villages concerned. Indeed, all the fishermen interviewed hold the opinion that it would be unfair to impose identical quotas (whether in terms of landings or fishing trips allowed) on all equipment owners, regardless of the size of their capital stock. As a matter of fact, with such identical quotas, large owners would be suddenly deprived of the possibility to maintain the profitability of part of their fishing assets. In addition, crew working on boats prohibited from operating would become unemployed unless some employment-sharing mechanism is agreed upon within the fishing community. Such outcomes appear unacceptable not only to the big owners and the crew labourers but also to the smaller owners. This is a happy situation since big owners are often influential persons in the village who play an important role in the initiation and enforcement of many collective actions, including regulatory schemes.

Equally interesting to note is the fact that Senegalese small-scale fishermen consider that it would be unfair to award larger quotas to better-skilled operators. In the interviews, many of them actually denied that significant skill differentials exist in their community and they took pains to explain that better performances on the part of some fishermen are only transient phenomena likely to be reversed as soon as luck turns its back on them to favour other fishing units. The prevalence of this standpoint has no doubt influenced the selection of effort-reducing methods in the villages surveyed : quotas or rules regarding fishing trips are uniform or skill-neutral, meaning that they are set independently of the skill levels of the fishing teams subject to regulation.

As the aforementioned interviews indicate, it would be actually impossible for fishermen to reach an agreement about their respective skill levels and skill differentials are no doubt difficult to measure in an impartial manner (even though we do not doubt that fishermen have good clues about skill rankings within their community that they do not want to disclose in public). We know from economic theory that when quotas are thus set in an uniform manner there will probably be an opposition from the better-skilled or better-endowed agents who may lose or gain little from effort regulation (Johnson and Libecap, 1982 ; Libecap and Wiggins, 1984 ; Libecap, 1990 ; Baland and Platteau, 1998, 1999). We can then predict that the rules laid down in the groups considered here are likely to be resisted by the most performing members. Unfortunately, we are unable to test that hypothesis since we have no reliable indicator of the relative skill levels of sample fishermen.

3. RESULTS FROM THE CROSS-SECTION ANALYSIS OF HOUSEHOLD SURVEY DATA

3.1 Awareness of regulatory measures and their initiators

Respondents have been asked whether they were aware of any effort-limiting scheme for fish species targeted by them and, in the affirmative, who took the initiative of the scheme. Tables 1 and 2 show the results of this inquiry. From the first table, it can be seen that almost all fishermen operating purse seines in Kayar and Saint-Louis or working with hooks and lines in Kayar are actually aware of the existence of an effort-reducing scheme in their sector.

Table 2 : Frequencies of fishermen mentioning the existence of regulatory measures, as per village and fishing technique

Technique/site	Did not mention the measure	Did mention the measure	Total
Line fishing Kayar	0 (0%)	27 (100%)	27 (100.0%)
Line fishing Yoff	10 (41.67%)	14 (58.33%)	24 (100.0%)
Line fishing Soumbédioune	25 (100%)	0 (0%)	25 (100.0%)
Purse seine Kayar	2 (5.56%)	34 (94.44%)	36 (100.0%)
Purse seine Saint-Louis	3 (7.50%)	37 (92.50%)	40 (100.0%)

As is evident from the second table, a large majority of the same categories of fishermen have correctly identified the initiators of the measures. This is especially true of line fishermen in Kayar. On the other hand, no line fisherman in Soumbédioune has mentioned the existence of regulatory efforts, a direct consequence of the fact that such efforts have been short-lived in this village (see supra). The situation for Yoff is mixed since hardly 60 percent of line fishermen have mentioned the measures adopted to control fishing effort for demersal species (see Table 1). This rather poor result is to be ascribed to the discontinuance of the scheme in the year 1997 (except for a few days in 1997) rather than to a lack of awareness of these measures: indeed, a significant number of fishermen concerned understood the question as referring to the situation that prevailed at the time of the survey (that is, precisely, in the year 1997) and not to events that occurred in the past, even the recent past. It is interesting to notice that all those who mentioned the existence of a scheme in Yoff also correctly identified the initiators (see Table 2).

Table 3 : Frequencies of fishermen correctly identifying the initiators of regulatory measures, as per village and fishing technique

Technique/site	Did not correctly identify initiators	Did correctly identify initiators	Total
Line fishing Kayar	3 (11.11%)	24 (88.89%)	27 (100.0%)
Line fishing Yoff	10 (41.67%)	14 (58.33%)	24 (100.0%)
Purse seine Kayar	10 (27.78%)	26 (72.22%)	36 (100.0%)
Purse seine Saint-Louis	8 (20.00%)	32 (80.00%)	40 (100.0%)

3.2 Perceived incidence of rule infractions

An obvious way of assessing whether a collective scheme works well is by determining the rate of infraction of the rules adopted. Since no objective measure of this indicator is available to us, we have to rely on the subjective assessments of the people concerned. In fact, fishermen's beliefs

regarding the prevailing extent of rule violations are an important yardstick of the scheme's effectiveness: it indeed tells us whether sufficient trust exists to make the scheme viable in the medium or long run⁴. Table 3 summarises such beliefs as they could be inferred from the household survey.

There are several interesting features emerging from this table. First, the perceived incidence of rule violations is quite large: on the whole, more than 40 percent of the sample fishermen consider that there are many rule violations under the effort-limiting schemes. As conversations with them reveal, a high perceived rate of rule infractions points to a belief that too many operators go on violating the limits without being sanctioned: enforcement of the scheme's prescriptions is low with all the attendant consequences in terms of demotivation of participants. It bears noting that such a conclusion runs counter to the views of many leaders of the effort-limiting schemes: according to them, indeed, rules are well enforced and, when asked to describe cases of sanctioning by the committee in charge, they typically argue that punishing is rarely meted out because there are few rule-breakers. Following their account, only once has a fisherman been threatened with confiscation of his equipment and the threat did not have to be executed because the culprit paid the fine on the eve of the announced seizure. In game-theoretical terms, a co-operative equilibrium outcome is achieved and the threat of sanctions is effective in deterring participants from cheating. As attested by Table 3, however, such is obviously not the opinion prevailing among all the fishermen concerned. If we believe them, the temptation to free ride on others' efforts to reduce landings is frequently indulged in by fishermen. Therefore, what leaders tend to describe as flexible practices (see *supra*, Section 2) too often seem to verge on laxity and condonement.

Table 4: Frequencies of fishermen considering that rule violations are frequent, as per village and fishing technique

Technique/site	Low incidence of rule violations	Large incidence of rule violations	Total
Line fishing Kayar	12 (44.44%)	15 (55.56%)	27 (100.0%)
Line fishing Yoff	11 (45.83%)	13 (54.17%)	24 (100.0%)
Purse seine Kayar	27 (75.00%)	9 (25.00%)	36 (100.0%)
Purse seine Saint-Louis	24 (60.00%)	16 (40.00%)	40 (100.0%)
Total	74 (58.27%)	53 (41.73%)	127 (100.0%)

Second, there are significant variations across effort-limiting schemes of the perceived incidence of rule-breaking. Thus, this incidence is noticeably large among line fishermen (around 55 percent of them believe that there are many rule violations), whether in Kayar or in Yoff, and it is significantly larger than that obtaining for purse seine fishermen (in Kayar and Saint-Louis)⁵. The fact that cheating is easier with lines than with purse seines largely accounts for this statistically significant difference. As a matter of fact, it is obviously easier to conceal a box of fish that has been caught in excess of the prescribed quota, and to dispose of it in a secret manner, than to make an additional, illegal sea trip without being noticed (here, mutual monitoring is typically sufficient to detect violations). The fact that sale transactions may take place out at sea or on the beach itself but amidst crowds of people gathering at peak landing times greatly facilitates the discreet disposal of excess

⁴ Note that we have also asked fishermen whether they have themselves violated the rules, yet the answers are unreliable and will therefore be ignored (only 9 out of 127 fishermen in the restricted sample confessed to have done so).

⁵ According to the Fisher test, the difference between line and purse seine fishermen is statistically significant at 2 percent level of confidence.

catches under a system of catch quotas. We are now in a position to qualify an earlier statement (see *supra*, Section 2) according to which schemes based on catch quotas, as they are applied to line fishermen, are more efficient than those based on limitations of fishing trips, as they are applied to purse seine fishermen. The fact of the matter is that the former effort-reducing method is fraught with more supervision problems than the latter so that, allowing for enforcement costs, it may well be more efficient to limit sea trips than landings in order to control output.

Third, the perceived incidence of rule-breaking among purse seine fishermen is larger in Saint-Louis than in Kayar. This result is to be directly related to the eventual failure of the scheme in the former fishing site (by the end of the year 1995). A crucial difference between the effort-limiting schemes implemented in the two villages seems to largely explain the poorer achievements of Saint-Louis compared with Kayar in terms of enforcement effectiveness. To recall, while purse seines may be operated one time per day in Kayar, they are allowed to work only once every two days in Saint-Louis. This feature determines a comparatively strong reluctance to abide by the rule in the latter area. In point of fact, fishermen are eager to work every day because ecological conditions may vary significantly from day to day. They always worry that they may miss a bumper catch that will not happen again, or they are deeply frustrated if the day they are allowed to operate turns out to be a bad day that they will not be able to make up for till after two days or more. Frustration is especially great when the sea is too rough to ride on their day of fishing since they then consider that they have been robbed of effective fishing time.

Moreover, well-to-do fishermen from Saint-Louis are used to lend their fishing equipment to poorer relatives or friends when they themselves want to rest or make a pause. Following the effort-limiting regulation, however, such loans of equipment may only take place on days during which the fishing unit concerned is allowed to operate. This prescription is deemed unfair by both lenders and borrowers of fishing equipment since the custom is interpreted as a way to assist the poor that should not be subject to the regulation. Being permitted to go out at sea only once every two days, well-to-do fishermen feel less inclined to forego the use of their equipment to the benefit of poorer fellow fishermen. The latter resent the new situation which their previous benefactors blame on the regulatory scheme.

Finally, there is in Saint-Louis a strong tradition of so-called ‘special sea trips’ (*ndiaylou*) whereby different members of an extended family join together to earn incomes required for a collective purpose, say, financing a wedding, a baptism, or helping a relative who has suffered from an accident or illness. In so far as these sea trips are meant to serve the interests of a limited fraction of the community, they were supposed to fall under the scope of the effort-limiting scheme. Fishermen nevertheless find it hard to comply with such a requirement since they do not privately benefit from the income thus earned. Hence the frequent practice consisting of eschewing the commission’s approval for these special sea trips and the consequent suspicion that some fishermen use the pretext of a *ndiaylou* to increase their allowed time of fishing. The problem is less acute in Kayar where the practice of special sea trips is rapidly vanishing.

3.3 Identification of fishermen with a negative assessment of rule abidance

Can we say something about the characteristics of the fishermen who believe that the incidence of rule-breaking is large? In order to answer that question, we estimate a logit model in which the dependent variable, designated as *infrac*, is a dummy that takes on the value one when the incidence of violations is deemed to be large and zero when it is deemed to be low. Various explanatory variables have been tried, controlling for the aforementioned geographical and technological factors. In particular, we want to test whether ownership, wealth, and migrant status, age and education level, as well as possible relationships of fishermen with fishmerchants bear upon their assessment of the effectiveness of regulatory schemes in the sites where they have been attempted for a prolonged period (Soumbédioune is therefore excluded).

Ownership status (designated as *owner*) is simply measured by a dummy with the unit value when the fisherman is an owner of fishing equipment and with zero value when he is a crew labourer under the fishing technique considered. Wealth status (designated as *wives*) could not be measured directly and is here approached with the help of a proxy, namely the number of wives presently belonging to the fisherman's household. (Note that the number of wives is strongly correlated with the amount of fishing assets owned by the fishermen). The variable *migrkay* is another dummy which takes on the value one when the fisherman is a migrant from Saint-Louis operating in Kayar, and the value zero otherwise. Age and education are designated by *age* and *educ*, respectively. While *age* is a continuous variable, *educ* is a dummy with value one when the fisherman has more than either six years of coranic schooling or six years of primary school in French language, and with zero value otherwise. Finally, we have the two control variables, namely the fishing technique used and the location of the village. Designated by *purseuse*, the technological variable takes on the value one when the fisherman operates a purse seine and zero when he works with hooks and lines. Note incidentally that there is no much meaning in introducing location variables because there is perfect correlation between technique and fishing site in two of the three villages (only purse seines are regulated in Saint-Louis and only lines in Yoff).

Finally, *exclus* is a dummy with value one when the fisherman has an exclusive sale agreement with a particular fishmerchant, and zero if he is free to sell his catches to whomever he wants. Exclusive sale agreements in fishing always accompany credit relationships. Thus, when a fisherman takes a loan from a lender-merchant to finance either fixed or working capital expenditures, he ties himself to the merchant in the sense that he promises to deliver his future catches to him on a priority basis : in other words, as long as the loan is outstanding, the indebted fisherman is not entitled to sell his catch to anyone else, unless the merchant explicitly allows him to do so. The implied logic is that the latter does not insist that the former repays the loan principal if he is satisfied with his catch performances (interests on the loan are regularly paid under the form of lower fish prices offered by the merchant acting as a monopolist). Results are presented in Table 4 below.

Table 5 : Logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking

Logit Estimates		Number of obs = 127				
Log Likelihood = -76.883164		chi2(7) = 18.80				
		Prob > chi2 = 0.0088				
		Pseudo R2 = 0.1090				
infrac	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
owner	-.1421856	.5423711	-0.262	0.793	-1.205213	.9208421
migrkay	-.4854577	.6086912	-0.798	0.425	-1.67847	.7075551
educ	.7311907	.4189728	1.745	0.081	-.0899809	1.552362
age	.0269207	.0195801	1.375	0.169	-.0114556	.0652971
wives	-.6393262	.3257245	-1.963	0.050	-1.277735	-.0009178
purseuse	-.8468396	.4076245	-2.077	0.038	-1.645769	-.0479103
exclus	.9533989	.5235918	1.821	0.069	-.0728222	1.97962
cons	-.5938881	.6224267	-0.954	0.340	-1.813822	.6260458

What can we conclude from this table ? First, the coefficient of the technological variable is statistically significant at the 95 percent level of confidence and has the expected negative sign : evasion of effort-limiting prescriptions is deemed less important in the case of purse seines than in the case of lines. Second, other things being equal, rule-breaking is deemed to be more pervasive by comparatively educated fishermen (yet significance is only achieved at the 90 percent level of confidence). Given that we do not measure actual rates of infractions, it is difficult to interpret this result. Competing explanations suggest themselves : for example, it might be the case that educated

fishermen have a better ability to realistically assess the true extent of rule violations, or that they are less reluctant to admit to failure in front of outsiders. Alternatively, they may be more sceptical than other fishermen about the chances of success of complex collective schemes and therefore more prone to exaggerate the problems involved or they may themselves be more inclined to opportunistic behaviour, hence their relative pessimism about the cooperative potential of human groups.

Third, fishermen involved in sales-tying debts with particular merchants have a tendency to perceive a larger incidence of rule violations, presumably because they themselves are more prone to evade catch limitations. Indeed, since rules apply to all fishermen irrespective of whether they have exclusive sale agreements with merchants (at least this is true in Kayar), it is easy to understand why those who are in this situation will be subject to more pressures (from their creditor-merchant) to land as much fish as possible. After all, this is the very objective pursued by fishmerchants when they give loans to fishermen.

Four, controlling for age, fishermen with more wives tend to be relatively optimistic regarding rule violations. Yet, when the age variable is dropped, the coefficient of the wealth variable ceases to be statistically significant. A close look at the data brings out the statistical clue behind this puzzle. There are indeed two specific ways in which age and number of wives interact to produce an effect on the assessment of rule-breaking. (i) For one thing, such assessment is comparatively low among rather old fishermen (more than 47 years) who have three wives (bear in mind that no one in the sample has more than three wives): only 21 percent of them believe that there are many rule violations compared with a proportion of 44 percent for all other categories taken together. A straightforward explanation is that many fishermen exhibiting this specific combination of age and marriage characteristics are well-to-do and influential persons who play a leadership role not only in the effort-limiting scheme but in many other collective initiatives as well (cleaning of the beach, construction and maintenance of the village mosque, assistance in the event of sea accidents, etc). Understandably, they may have special difficulties in seeing the dysfunctionings of an undertaking with which they are strongly identified. Or, it may be that they are more confident in its ability to eventually succeed in spite of what they perceive as minor problems.

Moreover, it bears emphasis that the above-noted difference of attitude is perceptible only in the village of Kayar : when Yoff and Saint-Louis are considered separately from Kayar, there is no effect left of age and number of wives. In other words, the leadership phenomenon is even more marked in Kayar than what the above figures indicate : thus, the proportion of old fishermen with three wives who stated a high incidence of rule infractions in Kayar is only 10 percent compared with 43 percent for all other categories taken together. This result reflects the fact that in Kayar more than in any other fishing village on the Senegalese coast there exists a well-established power structure based on traditional ascriptive criteria (social status is critically dependent on lineage and seniority under a strongly patriarchal system) combined with wealth achievements (translated in fishing assets and wives). The agricultural origin of the village where even today cultivation (of vegetables) remains an important activity for many fishermen's families especially during the lean fishing season largely accounts for the specific social structure of Kayar. It stands in stark contrast to Saint-Louis, for example, where fishing is a completely specialised activity and fishermen therefore migrate to other fishing grounds when fish disappear from the local waters or when the sea is too rough (see supra). Presumably because of lesser needs for collective action, genuine fishing communities are less cohesive but also more democratic than peasant societies.

For another thing, it appears that fishermen who have one or several wives before reaching 36 years of age have a lower propensity to state high rates of rule-breaking than unmarried fishermen belonging to the same age class or than older married fishermen. Thus, 32 percent of married fishermen aged between 24 and 35 years (marriages before 24 years are exceptional) have deemed violations of effort-limiting prescriptions to be pervasive as against 57 percent of those unmarried in the same age bracket and against 50 percent of married fishermen older than 36 years but excluding those older than 47 years with three wives (bear in mind that unmarried fishermen older than 36 years are very few). Again, this relationship vanishes as soon as Kayar is left out of the picture. When this

village is considered separately, differences in the above proportions are quite pronounced : the proportions of Kayar's fishermen reporting a large extent of rule-breaking are 15 percent for those married in the 24-35 age category, 64 percent for those unmarried in the same category, and 44 percent for married fishermen older than 36 years but excluding the presumed leaders (more than 47 years with three wives). Table 5 summarises all these results.

Table 6 : Assessment of extent of rule-breaking according to certain age and marriage characteristics, all villages (Kayar, Yoff, Saint-Louis) and Kayar only (figures between brackets)

Age and marriage characteristics	Proportion of fishermen stating a large incidence of rule-breaking
a. Aged between 24-35 years and unmarried	57 % (64 %)
b. Aged between 24-35 years and married	32 % (15 %)
c. More than 35 years old and married but excluding people of category (e) below	50 % (44 %)
d. More than 35 years old and married	43 % (31 %)
e. More than 47 years and three wives	21 % (10 %)
f. Total average	42 % (38 %)

Why is it that married fishermen (with either one or two wives) who are relatively young (less than 36 years) tend to be optimistic in their statements about rule-breaking, and why is it that this phenomenon is observed in Kayar and not in Saint-Louis or Yoff? We have no ready explanation for such a differentiated phenomenon. Yet, a plausible hypothesis rests on the following scenario. Before reaching their thirties, fishermen are typically bachelors (only 18 percent of the sample fishermen who are less than 29 years old are married)⁶ working and living with their father whose opinions about the effectiveness of the effort-limiting scheme shape their own perceptions to a large extent. Hence the high proportion of them (62 percent in Kayar) who consider the rate of infractions to be high (not shown in the table).

When they enter the 29-35 age category, they usually get married (the marriage rate in this category is 82 percent), which implies that they form their own household and become more independent of their father (even though they may well continue to operate his boat and nets). At that stage, they are inclined to play an active role in a profusion of organisations such as the *Comité Villageois de Développement*, the local branch of the CNPS (*Collectif National des Pêcheurs Sénégalais*) and the Federation of the GIE (*Groupements d'Interêt Economique*) which are particularly active in Kayar and have been jointly involved in initiating and monitoring the effort-limiting scheme. Participation in these collective ventures has the effect of arousing hope among them that organisational dysfunctions are minimal and problems well under control. Thus, only 9 percent of married fishermen aged between 29 and 35 years in Kayar have expressed pessimistic beliefs about enforcement of the effort-limiting scheme in particular.

After a few years of experience, however, fishermen begin to realise that collective mechanisms are plagued with the opportunistic acts of a significant number of them and they come to a more realistic assessment of their effectiveness. In this, they exhibit more flexibility than the old elite whose identification with the regulatory measures is stronger (see supra). In Yoff and Saint-Louis, such a turnaround in beliefs is not observed presumably because there are fewer local organisations through which young married people can make their own direct experience of collective action.

In the light of the preceding discussion, it is now possible to improve upon the above econometric model by giving up the rather rough explanatory variables measuring the fishermen's age and number of wives and replacing them by the two following dummies : *leadkay*, which takes on the value one when the fisherman is presumably a local leader in Kayar, that is, when he is more than 47

⁶ Fishermen of Hann and Soumbédioune have been taken into account to arrive at this proportion.

years old, has three wives and works in Kayar, and the value zero otherwise ; and *ymarkay*, which takes on the value one when the fisherman is a (relatively) young married person (between 24 and 35 years old) working in Kayar, and the value zero otherwise. Results are displayed in Table 6.

One of the expected effects is borne out by the new estimate : the coefficient of the *ymarkay* variable is significant at 95 percent level of confidence. This is not true of the *leadkay* variable which is not even significant at the 90 percent level of confidence. There is, however, a straightforward statistical explanation for this disappointing result, namely that the leadership variable is strongly correlated with all the other variables present in the equation, except, of course, the *ymarkay* variable : leaders tend to have higher education, to own fishing assets and to operate purse seines. It is therefore possible to make the *leadkay* variable become statistically significant by reducing multicollinearity through removal of some correlated variable(s). This is done in Table 7 below. Before offering comments, let us note that collinearity also explains why the significance of the coefficient of the *educ* variable has been somewhat reduced compared with the previous estimate. In the other way around, significance of the technological variable's coefficient has improved since it is now significant at 99 percent level of confidence.

Table 7 : Adjusted logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking

Logit Estimates						Number of obs = 127	
						chi2(7) = 21.90	
						Prob > chi2 = 0.0026	
Log Likelihood = -75.335438						Pseudo R2 = 0.1269	
Infrac	Coef.	Std. Err.	z	P>.z	(95% Conf. Interval)		
Owner	-.4069745	.414509	-0.982	0.326	-1.219397	.4054481	
migrkay	-.3085531	.60945	-0.506	0.613	-1.503053	.8859469	
educ	.6617543	.4264266	1.552	0.121	-.1740264	1.497535	
leadkay	-1.686125	1.131319	-1.490	0.136	-3.90347	.5312191	
ymarkay	-1.696	.8687579	-1.952	0.051	-3.398734	.0067345	
purse	-1.025698	.4266358	-2.404	0.016	-1.861889	-.189507	
exclus	1.002479	.5381882	1.863	0.063	-.0523505	2.057309	
cons	.1627518	.4070024	0.400	0.689	-.6349582	.9604618	

In Table 7, the logit estimate of a new model is presented in which the leadership variable has become significant at the 90 percent level of confidence at the price of eliminating the ownership variable and making the coefficient of the education variable nonsignificant. Throwing out the education variable in addition to the ownership variable would only slightly increase the confidence level associated with the leadership variable. This is because technology, which is kept in the regression owing to its critical influence on the assessment of rule-breaking, is the variable most strongly correlated with *leadkay* (only 10 percent of Kayar's fishermen older than 47 years and with three wives do not own at least a purse seine).

Table 8 : Adjusted logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking (ownership variable omitted)

Logit Estimates					Number of obs = 127	
Log Likelihood = -75.822999					chi2(6) = 20.92	
					Prob > chi2 = 0.0019	
					Pseudo R2 = 0.1213	
infrac	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
migrkay	-.3441515	.6098426	-0.564	0.573	-1.539421	.8511181
educ	.5771422	.4131097	1.397	0.162	-.232538	1.386822
leadkay	-1.896944	1.106175	-1.715	0.086	-4.065007	.271119
ymarkay	-1.699002	.8667965	-1.960	0.050	-3.397892	-.0001124
pursese	-.9869905	.4222457	-2.337	0.019	-1.814577	-.1594042
exclus	.9430304	.5326338	1.771	0.077	-1.1009126	1.986973
cons	.0151894	.3768604	0.040	0.968	-.7234434	.7538221

3.4 Proportion and identification of fishermen holding various beliefs about the effects of regulatory measures (Kayar, Saint-Louis, Yoff)

Fishermen were explicitly asked whether, according to them, the effort-limiting measures have the intended effects, both on the economic and environmental levels. As far as the first level is concerned, the question is about whether limitation of supply has the effect of increasing fish prices while, regarding the second level, the question is whether it can prevent the fish stock from decreasing. The idea is that beliefs about the likely effects of effort-restricting measures have an important influence on the actual behaviour of fishermen vis-à-vis the rules. It is indeed difficult to conceive that someone who deems a rule to be ineffective will be inclined to follow it at a private cost to himself. Table 8 below shows, for Kayar, Yoff and Saint-Louis, the frequencies and proportions of fishermen associated with each of the four possible combinations of beliefs. In addition, it exhibits the corresponding proportions of fishermen believing that rule violations are frequent (shown between brackets).

Table 9 : Frequencies (absolute and relative) of fishermen and perceptions of rule-breaking according to beliefs in effects of effort-limiting measures

	Biological effect is denied	Biological effect is signalled	Total
Economic effect is denied	20 15.8 % (20.0 %)	29 22.8 % (75.9 %)	49 38.6 % (53.1 %)
Economic effect is signalled	23 18.1 % (21.7 %)	55 43.3 % (40.0 %)	78 61.4 % (34.6 %)
Total	43 33.9 % (20.9 %)	84 66.1 % (52.3 %)	127 100.0 % (41.7 %)

Three facts deserve to be emphasised. First, in villages where prolonged attempts have been made to control fishing effort, more than 43 percent of the fishermen reckon that such measures produce both biological and economic effects whereas at the other extreme only 16 percent of them deny the two types of effects. Second, there are slightly more fishermen pointing to the biological effect (about two-thirds) than fishermen pointing to the economic effect (about 61 %) while we would have expected the opposite result given the presumably more direct visibility of the latter effect. To put it in another way, the probability for people believing in the biological effect to also mention the economic effect is only 0.65 (55/84) while the reverse probability is slightly higher (55/78, or 0.70). However, and this is our third point, there is a definite relationship between beliefs in effects of effort-limiting measures and beliefs regarding the extent of rule-breaking. More exactly, fishermen who exclusively admit to biological or environmental effects often believe that many people bypass these measures (this is the case for more than three-fourths of them).

One interpretation of this finding that immediately springs to mind is the following :while the presence of even a few rule transgressors may be sufficient to destroy the price effect of effort restriction –a marginal free rider on a cartel may seriously undermine its effectiveness– biological depletion of the fish stock may be slowed down even though rule violations occur on a significant scale. This said, as the above-sketched history shows, initiation of collective efforts to limit fish landings has been clearly motivated by the desire to counter the market power of fishmerchants and not by any concern about resource degradation. It is also revealing that leaders often express the view that output regulation for economic purposes can be a crucial step towards bringing awareness among fishermen of the need to manage the resource for the sake of its conservation.

Given these facts, we believe that biological concerns are often voiced in a rather perfunctory manner : when mentioning biological effects, most of the time fishermen are not really thoughtful about what they say. They do not seriously consider the possibility of their being partly responsible for overfishing and, therefore, the idea that they could combat environmental degradation by restricting their own fishing effort seems alien to most of them. Revealingly, there is a clear tendency among Senegalese fishermen to externalise the problem by blaming industrial fishing vessels for the destruction of fish resources. There is no denying that industrial fishing can wreak havoc in maritime fisheries as the history of recent decades amply testifies across the world. This said, small-scale fishermen often take too much comfort from this fact to conceal from themselves the painful truth that they can also have their share of the blame owing to the rapid expansion of the artisanal fishing fleet and the tremendous improvements in the artisanal fishing technology (see supra, Section 1).

When only fishermen who believe in a low incidence of rule violations are taken into account, we obtain the distribution presented in Table 9. Figures are now much more congruent with our expectation. Indeed, almost 70 percent of the fishermen signal the economic effect while only 54 percent of them mention the biological effect. Moreover, the probability for fishermen believing in the biological effect to also mention the economic effect increases noticeably to 0.83 while the reverse probability goes down to 0.65.

Table 10 : Frequencies (absolute and relative) of fishermen according to beliefs in effects of effort-limiting measures (fishermen believing in low incidence of rule violations only)

	Biological effect is denied	Biological effect is signalled	Total
Economic effect is denied	16 (21.6 %)	7 (9.5 %)	23 (31.1 %)
Economic effect is signalled	18 (24.3 %)	33 (44.6 %)	51 (68.9 %)
Total	34 (45.9 %)	40 (54.1 %)	74 (100.0 %)

We are now in a position to inquire into the determinants of the various beliefs held by the fishermen of Kayar, Yoff, and Saint-Louis regarding the likely effects of effort-limiting measures. Towards that purpose, we have opted for the multinomial logit regression method. We consider that fishermen who did not mention either effect is the reference group and we aim at identifying factors explaining adherence to the other three groups. Three regressions have therefore been tried the most performing of which are given in Table 10. In the first regression, the dependent variable is the dummy *econly*, which takes on the value one when the fisherman has mentioned the economic but not the biological effect, and zero otherwise. In the second regression, conversely, the dependent variable is the dummy *bionly*, which takes on the value one when the fisherman has mentioned the biological but not the economic effect, and the value zero otherwise. And, finally, the third regression attempts to explain *ecobio*, a dummy variable which takes on the value one when the fisherman has mentioned the two effects simultaneously, and the value zero otherwise.

Two explanatory variables are taken into account that have not been defined yet. These are the *collus* and *altinc* variables. *Collus* is a dummy taking the unit value when the fisherman has explicitly mentioned the existence of collusive practices among fishmerchants, and zero otherwise. As for *altinc*, it is a dummy variable indicating the possible presence of alternative income sources within the household. It takes on the value one when there is in the household of the fisherman concerned at least one member earning incomes from an activity other than fishing (and this includes activities centred on the marketing of fish, or organisational activities that bring incomes), and/or when the household owns some agricultural land or more than one house (from which rental incomes can possibly be earned), and it is set to zero in all the other cases.

The first regression is not very successful. If we except the fact that the leadership variable perfectly predicts the *econly* variable (no fisherman more than 47 years and with three wives in Kayar has pointed to the economic effect alone), –which explains why *leadkay* had to be dropped from the equation–, the only significant coefficient is that associated with the *migrant* variable (at the 90 percent level of confidence). Since the coefficient is negative, it indicates that migrant fishermen native of Saint-Louis and operating in Kayar have a tendency to avoid mentioning the economic effect compared with the alternative of not mentioning any effect at all.

Fortunately, the other two regressions yield richer results. First, the coefficient of the *educ* variable has the expected positive sign and is significant at the 99 percent level of confidence in the second regression and at the 95 percent level in the third one. In other words, fishermen who are relatively educated (they have more than six years of French or Coranic school) tend to mention more often the simultaneous presence of biological and economic effects, or the presence of the biological effect alone as against the alternative of not mentioning any effect at all. The fact that environmental problems are nowadays a widely publicised issue, in the media, at school, and in the meetings of various fishermen’s organisations (more particularly, in the CNPS and the Federation of GIE) probably explains why many relatively educated fishermen refer to the biological dimension of fish resource management. Furthermore, a general effect of education is to combat fatalistic attitudes and to instil confidence in people’s ability to influence their living conditions through various forms of purposeful collective action. This applies not only to environmental but also to social, political and economic problems. In particular, educated people may better learn that producers can sometimes change market conditions through organising collectively in order to reduce the power of merchants.

Table 11 : Multinomial logit estimates of the determinants of fishermen's beliefs in economic and biological effects of effort-limiting measures (Kayar, Saint-Louis and Yoff)

Multinomial regression						Number of obs = 127	
Log Likelihood = -128.13811						chi2(29) = 73.98	
						Prob > chi2 = 0.0000	
						Pseudo R2 = 0.2240	
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]		
1. econly							
owner	9183656	.7140784	1.286	0.198	-.4812023	2.317934	
educ	.5887418	.7142158	0.824	0.410	-.8110955	1.988579	
migrkay	-1.533036	.8734431	-1.755	0.079	-3.244953	.1788813	
infrac	.3324081	.8381308	0.397	0.692	-1.310298	1.975114	
leadkay	(dropped)						
ymarkay	-.7885451	1.306074	-0.604	0.546	-3.348402	1.771312	
techn	.308619	.736175	0.419	0.675	-1.134257	1.751495	
altinc	-1.904582	1.401945	-1.359	0.174	-4.652345	.8431798	
exclus	-.3325192	.705728	-0.471	0.638	-1.715721	1.050682	
collus	.198917	.6799186	0.293	0.770	-1.133699	1.531533	
cons	-.1472421	.7656247	-0.192	0.847	-1.647839	1.353355	
2. bionly							
owner	.0810431	.7996471	0.101	0.919	-1.486236	1.648323	
educ	2.396745	.8109191	2.956	0.003	.8073726	3.986117	
migrkay	-3.112952	1.100201	-2.829	0.005	-5.269305	-.9565982	
infrac	3.063997	.8696592	3.523	0.000	1.359497	4.768498	
leadkay	4.460675	1.873074	2.381	0.017	.7895171	8.131833	
ymarkay	.1101003	1.51558	0.073	0.942	-2.860382	3.080583	
techn	.5525091	.7777238	0.710	0.477	-.9718015	2.07682	
altinc	-2.14038	1.375992	-1.556	0.120	-4.837275	.5565149	
exclus	.0700108	.391456	0.179	0.858	-.6972289	.8372504	
collus	-.4294194	.7370731	-0.583	0.560	-1.874056	1.015217	
cons	-1.809203	.9301536	-1.945	0.052	-3.63227	.0138646	
3. ecobio							
owner	.3948633	.707286	0.558	0.577	-.9913919	1.781118	
educ	1.495693	.6878276	2.175	0.030	.1475759	2.84381	
migrkay	-3.992373	1.079191	-3.699	0.000	-6.107549	-1.877197	
infrac	1.639492	.7831023	2.094	0.036	.1046398	3.174344	
leadkay	2.715988	1.671438	1.625	0.104	-.5599707	5.991946	
ymarkay	1.367391	1.102267	1.241	0.215	-.7930125	3.527796	
techn	.8664236	.6955223	1.246	0.213	-.4967752	2.229622	
altinc	-.459705	1.054752	-0.436	0.663	-2.526981	1.607571	
exclus	.0662535	.2802763	0.236	0.813	-.4830781	.615585	
collus	-.4073856	.6486115	-0.628	0.530	-1.678641	.8638695	
cons	-.2237685	.7441414	-0.301	0.764	-1.682259	1.234722	

Second, a major result from Table 10 is that inter-community tensions tend to reduce people's ability to collectively organise. It is indeed striking that the coefficient of the *migrkay* variable is significant at (close to) 100 percent level of confidence in both the second and third regressions, and that it has a negative sign (moreover, its size is big). In other words, migrant fishermen native of Saint-Louis and operating in Kayar have a marked tendency to deny the existence of economic and biological effects. Their sceptical attitude vis-à-vis the effort-limiting scheme seems to be greatly determined by a traumatic experience of tense inter-community relations and what they consider to be an unsatisfactory solution to gear conflicts involving bottom-set nets (see supra, Section 2). It bears emphasis that the above result is maintained if we club together permanent residents of Kayar who are native of Saint-Louis and temporary migrants from Saint-Louis who were working in Kayar at the time of the survey (and come back every year during what corresponds to the off-season in Saint-Louis) instead of considering only the latter category. This suggests that the problem is more a problem of inter-community relations than one of migrant-resident opposition.

Third, in both the second and third regressions, the coefficient of the *leadkay* variable is significant (at 99 percent level of confidence in the second regression and at 90 percent level in the third one) and has the expected positive sign (moreover, it is quite big). If the *altinc* variable with which *leadkay* is strongly correlated is removed from the equation, the level of significance of the coefficient associated with *leadkay* improves perceptibly, particularly in the third equation where significance is now achieved at 95 percent level of confidence. Fishermen older than 47 years and with three wives in Kayar are thus inclined to mention the biological effect alone or together with the economic effect compared to the alternative possibility of not mentioning any effect at all. We also know that in their statements about rule violations these fishermen tend to minimise the problems arising from enforcement of the effort-limiting scheme. All these attitudes are typical of leaders deeply involved in the initiation and monitoring of the scheme (particularly, through participation in the local fishing committees – *comité des sennes tournantes* and *comité de pêche*).

Four, the coefficient of the *infrac* variable now considered as an explanatory factor is significant at 100 percent level of confidence in the second regression and at the 95 percent level in the third regression. In both cases, it has a positive sign, indicating that fishermen who believe the incidence of rule violations to be large have a tendency to either mention the biological effect alone or the two types of effects simultaneously. On the other hand, they do not seem to prefer mentioning the economic effect alone to abstaining from mentioning any effect (the coefficient of *infrac* in the first regression is non-significant). Results in Table 8 are thus neatly confirmed.

Let us now say a few words about factors that apparently fail to influence fishermen's beliefs regarding the effectiveness of effort regulation. As is evident from Table 10, such beliefs are not significantly influenced by the fishing technology used. While the mode of restricting effort with line-operating canoes gives rise to more monitoring difficulties than the mode used for purse seines (see supra), the effects of the former are not reckoned to be weaker than the effects of the latter by Senegalese fishermen. Moreover, there is no difference of opinion between owners and crew labourers : the coefficients of the *owner* variable are consistently non-significant. Bear in mind that the latter also benefit from effort-restraining schemes if successful, since labour incomes are calculated as a fixed percentage of the catch proceeds. In addition, beliefs in the economic effect of the measures considered do not seem to be affected by awareness of existence of collusive practices among fishmerchants. Fishermen who have explicitly pointed to such practices do not believe more than others that limiting fishing effort can succeed in increasing fish prices (the coefficient of the *collus* dummy variable is not significant in the first and third regressions). Likewise, involvement of fishermen in interlinked credit-cum-marketing ties with merchants does not appear either to prompt them to signal the economic effect of effort-restraining rules (the coefficient of *exclus* is non-significant in all the regressions).

Finally, the availability of alternative income sources within the household does not encourage fishermen to mention the positive effects of such rules. Yet, it must be borne in mind that the *altinc* variable is strongly correlated with the *leadkay* variable (see supra). As the econometric results

nevertheless show, the effect of *altinc* seems to be dominated by that of *leadkay*⁷. There is thus not much support in favour of the following hypothesis : when they can rely on complementary sources of income, fishermen are more prone to vindicate effort regulation because they are better able to endure the loss of fishing incomes in the short or medium term so as to benefit from higher incomes in the long term, whether through gaining increased market power or ensuring conservation of fish resources. The fact of the matter is that there is another effect running into the opposite direction, namely that fishermen with greater alternative income opportunities may pay less attention to their fishing incomes and feel less ready to incur sacrifices to make them grow. This is all the more so if alternative incomes originate in fish marketing (usually by the fishermen's wives), since gains accruing to fishermen under the form of increased unit prices must then be weighed against the losses suffered by fishmongers in the household.

As we know, fishermen who think that effort-limiting rules are often violated have a tendency to simultaneously profess a belief in the biological effect of such rules, whether alone or accompanied by the economic effect. This may seem a strange, even perhaps contradictory combination of beliefs. To allow for possible inconsistencies in answers regarding the biological effect, let us now estimate a standard logit model in which attention is focused on the economic effect. A binary dependent variable labelled *eco* simply distinguishes between fishermen who mentioned the economic effect (alone or together with the biological effect), in which case *eco* = 1, and those who did not, in which case *eco* = 0. Results are presented in Table 11.

Table 12 : A logit estimate of the determinants of fishermen's beliefs in the economic effect of effort-limiting measures (Kayar, Saint-Louis and Yoff)

Logit Estimates		Number of obs = 127				
Log Likelihood = -77.292747		chi2(10) = 14.79		Prob > chi2 = 0.1398		
				Pseudo R2 = 0.0873		
eco	Coef.	Std. Err.	z	p> z	[95% Conf. Interval]	
educ	-.2276006	.4145658	-0.549	0.583	-1.040135	.5849334
migrkay	-1.249287	.5945059	-2.101	0.036	-2.414497	-.0840765
infrac	-.7002499	.4201872	-1.667	0.096	-1.523802	.1233019
techn	.246533	.4273818	0.577	0.564	.5911199	1.084186
owner	.4156334	.4241923	0.980	0.327	-.4157682	1.247035
leadkay	-.871089	1.009327	-0.863	0.388	-2.849333	1.107155
ymarkay	.1622241	.7646928	0.212	0.832	-1.336546	1.660994
exclus	-.6977554	.5188517	-1.345	0.179	-1.714686	.3191753
collus	.0428501	.4070053	0.105	0.916	-.7548657	.8405659
altinc	.9028507	.7451801	1.212	0.226	-.5576755	2.363377
cons	.7588842	.5060493	1.500	0.134	-.2329542	1.750723

The above regression is not globally significant even at 90 percent level of confidence (see the chi-square value), yet its significance can be improved to a 100 percent level by a stepwise elimination procedure. The variables that are significant in Table 11 remain significant in the course of this proce-

⁷ Thus, if *leadkay* is removed from the second regression, the coefficient of *altinc* becomes statistically significant.

dure. This is particularly true of the *migrkay* variable whose coefficient is significant at 95 percent level of confidence and has the expected negative sign (this result continues to hold if migrants are clubbed together with residents native of Saint-Louis). The *infrac* variable does also affect beliefs in the economic effect (yet, significance is achieved only at the 90 percent level) and the coefficient has again the expected negative sign : when a fisherman thinks that rule-breaking is pervasive, he also tends to be sceptical about the economic effect of an effort-limiting scheme. This is expected because free riders can easily destroy the price effect of such a scheme by severely competing at the margin. Such is not the case with the biological effect, however, since the presence of free riders does not prevent total catches from decreasing. The coefficient of the *educ* variable is no more significant, bearing out the hypothesis that only biological awareness is stimulated by better education (see supra). The same is true of the coefficient of *leadkay*. This result is to be related to the fact that almost all the leaders of Kayar have stated the economic and biological effects together, while none among them has signalled the economic effect alone (see supra).

3.5 Fishermen's opinion regarding the likely effects of effort regulation (all villages and all fisheries)

It is interesting to repeat the same econometric exercise as that undertaken above but for the whole sample of villages and fisheries, whether they have experienced effort-limiting measures or not. This might enable us to identify factors susceptible of explaining why some villages (represented here by Hann and Soumbédioune) or some fisheries (represented by bottom-set nets in Kayar, lines in Saint-Louis, purse and beach seines in Yoff) have failed to adopt such measures. Towards that aim we have introduced a series of new variables into the multinomial logit regressions. The first of these is a dummy labelled *exper*, with value one if the fisherman has gone through a prolonged experience of regulation (lines in Kayar and Yoff, purse seines in Kayar and Saint-Louis), and zero otherwise. The second new variable is *migrsou*, a dummy with value one when the fisherman is a migrant from Saint-Louis operating in Soumbédioune, and zero otherwise.

A third variable is the dummy *dist*, which takes on the value one if the fisherman has stated that he goes farther and farther into the sea to target valuable species of exportable value (such as the rose sea bream known as the dentex), and zero otherwise. This variable could not be used in the previous regressions because too few fishermen belonging to the restricted sample mentioned the aforementioned phenomenon : in actual fact, the majority of those who did mention it are line fishermen belonging to Hann and Soumbédioune in the Dakar area. More exactly, while their overall proportion is 11 percent in the whole sample⁸, they form more than one-third of line fishermen operating canoes equipped with ice boxes in Hann and Soumbédioune ; about one-fifth of line fishermen operating simple canoes in Kayar, Hann and Soumbédioune ; and one-fifth of purse seine fishermen in Hann.

Lastly, two dummy variables will now be used to distinguish between three fishing techniques : *purse* and *icebox*. The latter dummy takes on the unit value for line-operating canoes equipped with ice boxes, and zero otherwise. When the two technological dummies have zero value, it therefore means that the technique used by the fisherman is simple lines, bottom-set nets, or a beach seine (fishermen using the latter two techniques are not numerous enough to make up a separate category). Results are displayed in Table 12.

⁸ Of course, the proportion of fishermen who mentioned in a general way that they have to go farther into the sea is much higher than this proportion of 11 percent and reflects the increasing perception of resource scarcity in the Senegalese waters.

Table 13 : Multinomial logit estimates of the determinants of fishermen's beliefs in economic and biological effects of effort regulation (all villages and all fisheries)

Multinomial regression					Number of obs = 320	
Log Likelihood = -348.58337					chi2(39) = 154.48	
					Prob > chi2 = 0.0000	
					Pseudo R2 = 0.1814	
					[95% Conf. Interval]	
	Coef.	Std. Err.	z	P> z		
1. econly						
exper	1.299116	.5075321	2.560	0.010	.3043711	2.29386
educ	.0890896	.3457277	0.258	0.797	-.5885242	.7667034
migrkay	-.4880116	.5631902	-0.867	0.386	-1.591844	.615821
infrac	-.9087412	.6939173	-1.310	0.190	-2.268794	.4513118
purse	-.4855144	.4437077	-1.094	0.274	-1.355166	.3841367
icebox	-.7735517	.5019008	-1.541	0.123	-1.757259	.2101558
altinc	-1.831245	.7990108	-2.292	0.022	-3.397278	-.2652129
dist	2.543566	.8186858	3.107	0.002	.9389717	4.148161
owner	1.301621	.3495983	0.372	0.710	-.555038	.8153623
leadkay (dropped)						
ymarkay	-1.541686	1.302236	-1.184	0.236	-4.094023	1.01065
exclus	.7595049	.3990512	1.903	0.057	-.0226211	1.541631
collus	.518986	.3608229	1.438	0.150	-1.882139	1.226186
migrsou (dropped)						
cons	-.6354918	.3918712	-1.622	0.105	-1.403545	.1325617
2. bionly						
exper	1.682911	.6473854	2.600	0.009	.4140589	2.951763
educ	.9996363	.4638075	2.155	0.031	.0905903	1.908682
migrkay	-2.082995	.9093227	-2.291	0.022	-3.865234	-3007547
infrac	2.068237	.6436474	3.213	0.001	.8067109	3.329762
purse	-.0235833	.5196588	-0.045	0.964	-1.042096	.9949293
icebox	-.0041546	.787993	-0.005	0.996	-1.548593	1.540283
altinc	-.1295586	.6558398	-0.198	0.843	-1.414981	1.155864
dist	2.576811	.9921724	2.597	0.009	.6321889	4.521433
owner	.0689103	.4613471	0.149	0.881	-.8353133	.9731339
leadkay	2.066681	1.603032	1.289	0.197	-1.075203	5.208565
ymarkay	-.2230906	1.442717	-0.155	0.877	-3.050764	2.604583
exclus	-.0020832	.5459322	-0.004	0.997	-1.072091	1.067924
collus	1.698155	.4563487	0.372	0.710	-.7246116	1.064243
migrsou (dropped)						
cons	-2.699395	.59787	-4.515	0.000	-3.871199	-1.527591
3. ecobio						
exper	1.633759	.4713625	3.466	0.001	.7099051	2.557612
educ	.7111716	.3374699	2.107	0.035	.0497427	1.372601
migrkay	-3.07171	.8960977	-3.428	0.001	-4.82803	-1.315391
infrac	.4000893	.5747974	0.696	0.486	-.7264929	1.526671
purse	-.755428	.4028428	-1.875	0.061	-1.544985	.0341294
icebox	-1.741813	.5801645	-3.002	0.003	-2.878914	-.6047114
altinc	.0006823	.4556902	0.001	0.999	-.892454	.8938186
dist	2.943645	.8348808	3.526	0.000	1.307309	4.579981
owner	.1595337	.3440594	0.464	0.643	.5148104	8338777
leadkay	2.096566	1.376379	1.523	0.128	-.6010878	4.79422
ymarkay	.392324	1.08429	0.362	0.717	-1.732845	2.517494
exclus	-.0562446	.4087139	-0.138	0.891	-.8573092	.7448199
collus	.3771833	.3467788	1.088	0.277	-.3024908	1.056857
migrsou	1.727549	.8214984	2.103	0.035	.1174419	3.337656
cons	-.6191525	.3774321	-1.640	0.101	-1.358906	.1206007

There are a number of interesting results emerging from this table. Let us start with the two new best-established relationships. For one thing, a prolonged, relatively positive experience with effort regulation has the clear effect of prompting beliefs in its economic and biological impact (the coefficient of *exper* is significant at 99 percent level of confidence in all three regressions, and it is positive). For another thing, fishermen who target exportable species and are ready to travel longer distances than before in order to reach them have a neat tendency to reckon the effects of effort regulation as against the alternative of denying them (the coefficient of *dist* is again significant at 99 percent level of confidence in all three regressions and it is positive). In other words, progressive fishermen eager to seize on new economic opportunities and bent on catching valuable species do not hesitate to stress the importance and effectiveness of regulation⁹. This may directly follow from the fact that profitability of effort control resulting in increases of unit producer prices is likely to increase with the initial level of these prices.

Some other results confirm previously reported findings (see Table 10), such as the negative influence of community divisions in Kayar¹⁰—again, the result holds if all fishermen from Saint-Louis are put together whether they are permanent residents or temporary migrants—, or the positive influence of education on ecological awareness (see the second and third regressions). If, like in the previous multinomial logit regressions, the *leadkay* variable is perfectly predicted in the first regression (it had hence to be removed), its coefficient is no more significant at the 90 percent level in the two following regressions. Yet, this disappointing result is due to a large extent to multicollinearity: when *altinc* is dropped, the coefficient of *leadkay* becomes significant at the 90 percent level in the second regression and at the 95 percent level in the third one.

Unlike what was observed in Table 10, *exclus* has a significant coefficient (at 95 percent level of confidence) with positive sign in the first regression, yet continues to perform very badly in the other two regressions. The positive sign indicates that fishermen involved in sales-tying debt relationships are more aware of the economic advantage of effort regulation. This is not surprising given that they usually get lower prices for the fish they are committed to dispose through their lender-merchant. They are therefore more sensitive to the potential gains that can be earned through collective organisation. On the other hand, since there is no reason why such fishermen should be more alert to the environmental benefits of collective action, the absence of significant relationships between *exclus* and either *bio* or *ecobio* (see the second and third regressions) is perfectly understandable.

It bears emphasis that some categories of fishermen in some villages have a higher propensity to accept exclusive sale agreements with merchants than others (see Table 13). While about one-fourth of the total sample of Senegalese fishermen are in this situation, the proportion shoots up to much higher figures for operators of bottom-set nets (59 percent in Kayar and 76 percent in Saint-Louis), and for line fishermen in Hann (71 percent) and Saint-Louis (41 percent). Here lies a powerful factor accounting for the lack of effort-restraining mechanism in all these fisheries, since it is hard to see how such a collective mechanism could take root when a large number of the fishermen concerned are entangled in private exclusive relationships with particular merchants. The fact that in Kayar and Yoff, where effort regulation has occurred, only 22 and 17 percent, respectively, of the fishermen are engaged in this type of relationships deserves to be strongly emphasised. The presence of an endogeneity bias—exclusive commercial relationships with merchant-creditors tend to disappear when effort regulation is adopted—is rather unlikely in so far as owners of fishing assets cannot easily terminate such relationships.

⁹ It bears emphasis that progressivity is measured with respect to the fishing technique and, even more, to the site concerned. Thus, a line fisherman of Hann for whom *dist* = 1 is not necessarily more progressive than a line fisherman from Saint-Louis where opportunities are less favourable.

¹⁰ Note however that the coefficient of *migrkay* is no more significant in the first regression.

Table 14 : Proportions of fishermen engaged in exclusive sale relationships with merchants, according to fishing techniques and sites

Technique/Site	Kayar	St-Louis	Yoff	Hann	Soumbedi.	Total
Line	22.2 %	40.9 %	16.7 %	71.4 %	24.0 %	31.2 %
Line + ice box	-	-	0.0 %	15.0 %	24.0 %	19.6 %
Purse seine	13.9 %	15.0 %	0.0 %	26.7 %	-	13.3 %
Beach seine	-	-	0.0 %	-	-	0.0 %
Bottom-set net	58.8 %	76.5 %	-	-	-	67.6 %
Total	26.3 %	35.4 %	6.4 %	34.7 %	24.0 %	25.6 %

The two technological dummies (*purses* and *icebox*) figuring out in the third regression have a significant influence on the dependent variable : since the coefficients are both negative, the implication is that simple line fishermen have a higher propensity to state the economic and biological advantages of effort regulation simultaneously. It also bears noticing that in the first regression the coefficient of *icebox* becomes significant at 95 percent level of confidence (and it is negative) when the variable *exclus* with which it is correlated is being left out. The most solid result regarding the role of technology is therefore that line fishermen operating canoes equipped with ice boxes are comparatively reluctant to recognise the economic effect of effort limitation (whether in conjunction with the biological effort or not). This probably reflects the fact that these fishermen operate in conditions (long journeys out at sea) that make a collective scheme of effort regulation especially hard to put into practice (see supra, Section 2).

Finally, migrants from Saint-Louis operating in Soumbédioune exhibit a stronger tendency than residents to declare the economic and biological effects of effort regulation (significance at the 5 percent level in the third regression). Moreover, they never mention either effect exclusively (*migrsou* is perfectly predicted in the first and second equations). The coefficient of *migrlou* in the third regression ceases to be significant if migrants from Saint-Louis are clubbed together with permanent residents native of Saint-Louis, pointing to different opinions among the Saint-Louisiens depending on whether they are migrants or residents. Here, unlike what we observed for Kayar, the migrant-resident difference seems to be more relevant than the ethnic dimension as such.

Since *infrac* significantly and positively affects the *bioonly* variable (see the second regression), it is worthwhile repeating the kind of econometric experiment carried out in Table 11, that is, estimating a standard logit model in which the dependent variable is the binary dummy *eco*. Results are shown in Table 14.

Table 15 : A logit estimate of the determinants of fishermen's beliefs in the economic effect of effort-limiting measures (all villages and all fisheries)

Logit Estimates					Number of obs = 320	
Log Likelihood = -196.27235					chi2(14) = 39.75	
					Prob > chi2 = 0.0003	
					Pseudo R2 = 0.0920	
eco	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
exper	1.019205	.3698983	2.755	0.006	.2942176	1.744192
educ	.0937508	.2533603	0.370	0.711	-.4028262	.5903278
migrkay	-.8964948	.4720718	-1.899	0.058	-1.821739	.028749
infrac	-1.239734	.3911285	-3.170	0.002	-2.006332	-.4731364
purse	-.6519487	.3033652	-2.149	0.032	-1.246533	-.0573638
icebox	-1.102867	.4149233	-2.658	0.008	-1.916102	-.2896326
dist	1.731236	.5059418	3.422	0.001	.7396079	2.722863
owner	.1241633	.2640678	0.470	0.638	-.3934	.6417266
leadkay	.1860784	.8362991	0.223	0.824	-1.453038	1.825194
ymarkay	-.3800427	.74514	-0.510	0.610	-1.84049	1.080405
exclus	.2534723	.3002832	0.844	0.399	-.335072	.8420165
collus	.4436479	.2631905	1.686	0.092	-.072196	.9594918
altinc	-.3260308	.375968	-0.867	0.386	-1.062915	.410853
migrsou	-.0977062	.783761	-0.125	0.901	-1.63385	1.438437
cons	.2034727	.2928779	0.695	0.487	-.3705575	.7775028

The main findings of this more condensed estimate centred on the economic effect are the following. (i) as expected, the role of education vanishes ; (ii) a prolonged and serious experience positively influences expectations regarding the economic impact of effort regulation (significance is achieved at the 1 percent confidence level) ; (iii) migrant fishermen in Kayar are sceptical about this impact (significance at the 95 percent level), yet do not behave in a specific manner in Soumbédioune¹¹ ; (iv) understandably, a high perceived rate of infractions tends to destroy the belief that limiting effort is likely to cause an increase in fish prices (significance almost at the 100 percent level) ; (v) fishing technology has a decisive bearing upon the latter belief : line fishermen working with simple canoes are the most prone to trust economic regulation ; (vi) dynamic fishermen targeting exportable species are highly confident that the economic effect can materialise (significance at almost 100 percent confidence level) ; (vii) the impact of leadership in Kayar has vanished¹², not a surprising fact given that what mostly characterises leaders from Kayar is their (very) strong proclivity to mention both the economic and the biological effects of regulation ; (viii) the above-substantiated effect of credit-cum-marketing relationships has disappeared to the benefit of a timid (positive) effect (at only 90 percent confidence level) of concerns about collusive practices among fishmerchants. The vanishing of the *exclus* effect is not surprising either since an exclusive sale relationship with a fishmerchant affects the prices obtained for the fish landings but not the biology of fish resources. Therefore, we may expect that fishermen entangled in such exclusive relationships hold particularly strong views regarding the price effect of output regulation yet do not mention that effect in combination with biological impacts.

¹¹ This is due to the fact that, if migrant fishermen in Soumbédioune have a strong proclivity to mention the economic effect together with the biological effect, they never mention it alone.

¹² In this case, removing the *altinc* variable would not help establish a significant relationship between *leadkay* and *eco*.

3.6 Support for effort regulation among line fishermen without relevant experience

Line fishermen who did not really have the experience of effort regulation have been asked if, according to them, it was a good idea to limit the number of fish boxes allowed to be landed by each canoe. In case they have answered yes to that question, a new dummy labelled *linesupp* is set to one, while it is set to zero otherwise. We now attempt to identify the characteristics of these fishermen that are susceptible of explaining their attitude vis-à-vis the imposition of landing quotas. The sample size is 107 units comprising line fishermen operating simple canoes in Saint-Louis, Soumbédioune and Hann, and canoes equipped with ice boxes in Soumbédioune, Yoff, and Hann. Two new explanatory variables have been introduced to distinguish between three different locations. These are the location dummies, *soumb* and *slouis*, where *soumb* = 1 if the fisherman operates in Soumbédioune, and zero otherwise, while *slouis* = 1 if he operates in Saint-Louis, and zero otherwise (when *soumb* = *slouis* = 0, the fisherman operates in Hann or in Yoff for which we have only one observation). Results are presented in Table 15.

The most significant result is that, as expected, line fishermen operating canoes with ice boxes have a strong proclivity to believe that catch quotas are detrimental to their interests (the negative coefficient of *icebox* is significant at 100 percent level of confidence). Another striking result emerging from the table is that, other things being equal, fishermen from Soumbédioune show more support for regulation than fishermen from the other villages. This may appear surprising since an attempt at limiting landings in Soumbédioune ended in quick failure (see supra, Section 2). It bears noticing that (simple) line fishermen from this village have frequently complained (in the preliminary interviews conducted during the first phase of the fieldwork) that, owing to oversupply, they are not able to sell all the fish harvested or are compelled to dispose of it at unprofitable prices through small merchants or women buyers. Priority is apparently given by bigger merchants to line fishermen operating canoes with ice boxes. The other line fishermen seem to believe that restriction of their fishing effort is the best way available to restore their bargaining power vis-à-vis these sizeable merchants. Still, the question remains as to why the same phenomenon is not observed in Hann, a village also located in the market area of Dakar.

Table 16 : Support for effort regulation among line fishermen in the sample villages

Logit Estimates				Number of obs = 107 chi2(12) = 47.91 Prob > chi2 = 0.0000 Pseudo R2 = 0.3306		
Log Likelihood = -48.51		4053				
linesupp	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
educ	.207576	.5370808	0.386	0.699	-.845083	1.260235
icebox	-3.202455	.766837	-4.176	0.000	-4.705428	-1.699482
altinc	3.310454	1.502303	2.204	0.028	.3659935	6.254914
dist	1.951435	.851312	2.292	0.022	.2828941	3.619976
yarkay	.3827632	.7028755	0.545	0.586	-.9948475	1.760374
leadkay	-.5202497	1.638609	-0.317	0.751	-3.731864	2.691365
owner	.1527361	.5549993	0.275	0.783	-.9350426	1.240515
soumb	1.742825	.7071045	2.465	0.014	.3569259	3.128725
slouis	.5519409	.7398247	0.746	0.456	-.8980888	2.001971
exclus	-.2274208	.5664152	-0.402	0.688	-1.337574	.8827326
collus	-.035761	.5649404	-0.063	0.950	-1.143024	1.071502
migrsou	-2.852191	1.459997	-1.954	0.051	-5.713734	.0093513
cons	-.7140407	.7971001	-0.896	0.370	-2.276328	.8482468

Also worth noticing is the fact that migrants from Saint-Louis operating in Soumbédioune are less in favour of effort regulation than other fishermen. This is typical of migrants only since, if we club together migrants with residents from Saint-Louis operating in Soumbédioune, the effect vanishes.

Two last results come out with a high level of significance. For one thing, progressive line fishermen (those who go far into the sea in order to catch the most valuable species) are more supportive of effort-limiting measures than others. This confirms previous findings for which an explanation has been advanced : profitability of effort control is likely to be higher for this category of fishermen. For another thing, those fishermen who have alternative income opportunities also seem to be more in favour of catch quotas, even though we did not previously find evidence of their better awareness of the potential advantages of regulation. Thanks to their complementary incomes, such fishermen can more easily tide over a waiting period till the results of effort limitation materialise, which may well explain their stronger support for it.

3.7 Support for a centralised marketing organisation

Finally, all the sample fishermen have been asked the following question : do you think that you could personally benefit from the setting up in your village of an association intended for the centralised sale of fish catches (in the way it is done in Joal for the octopus) ? In case they have answered yes to that question, a new dummy labelled *saleorg* is set to one, while it is set to zero otherwise. In attempting to uncover factors susceptible of explaining fishermen's assessment of a marketing organisation run by themselves, we have used another standard logit model now estimated over the whole sample. The results, shown in Table 16, are good since quite a few explanatory variables tried in this model turn out to be associated with (sometimes highly) significant coefficients.

Table 17 : Determinants of fishermen's support for a centralised marketing organisation

Logit Estimates		Number of obs = 320				
Log Likelihood = -184.83454		chi2(14) = 44.70				
		Prob > chi2 = 0.0000				
		Pseudo R2 = 0.1079				
	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
exper	.4162337	.3595115	1.158	0.247	-.2883959	1.120863
educ	.334932	.2624046	1.276	0.202	-.1793715	.8492355
migrkay	-.8093489	.4872589	-1.661	0.097	-1.764359	.1456609
infrac	.6202775	.413215	1.501	0.133	-.1896091	1.430164
purseuse	-.5653727	.315153	-1.794	0.073	-1.183061	.0523157
icebox	.395253	.4307179	0.918	0.359	-.4489387	1.239445
altinc	-.9425862	.3830878	-2.460	0.014	-1.693425	-.1917479
dist	-.8921823	.4165472	-2.142	0.032	-1.7086	-.0757648
leadkay	2.014534	1.14858	1.754	0.079	-.2366404	4.265709
ymarkay	-.7597875	.7100298	-1.070	0.285	-2.15142	.6318454
owner	.8116015	.274771	2.954	0.003	.2730602	1.350143
exclus	.1535129	.3171832	0.484	0.628	-.4681548	.7751806
collus	.1626724	.2741367	0.593	0.553	-.3746257	.6999704
migrsou	-1.274166	.7779488	-1.638	0.101	-2.798918	.2505855
cons	.1771256	.298632	0.593	0.553	-.4081824	.7624335

First, in Kayar, if migrant fishermen from Saint-Louis tend to oppose the creation of a centralised marketing organisation (see the effect of *migrkay*), the core leadership of native fishermen takes up a favourable stance (see the effect of *leadkay*). In actual fact, some of the latter have actually made a trial in that direction by acquiring a second-hand truck in order to transport the collected fish to Dakar and sell it directly to the fish-processing factories. This experience was far from successful, however, since the leaders concerned were eventually obliged to rent the truck out to local fishmerchants in order to be able to repay the debts incurred. In Soumbédioune, opposition from migrant fishermen native of Saint-Louis is also observed and the effect is again significant only at 90 percent level of confidence. Yet, if residents native of Saint-Louis are clubbed together with the migrants, the (negative) effect becomes significant at 95 percent level. The difference of opinion regarding the creation of a commercial association has more to do with community feelings than with a migrant-resident division¹³.

Second, owners of fishing assets turn out to be much more supportive of a centralised marketing organisation than ordinary crew labourers (significance at almost 100 percent confidence level). A plausible reason for the latter's reservations lies in the fact that a sales organisation might create opportunities for asset owners, in collusion with managers, to underreport the prices obtained to their crew labourers and thereby rob them of part of their due share of the catch proceeds. Open sales carried out on the beach are much more transparent than those which would be run through a centralised organisation.

Third, dynamic fishermen bent on catching valuable species in distant fishing grounds are opposed to the marketing organisation. This contrasts with their positive attitude vis-à-vis catch quotas. There is, of course, no contradiction here since the two methods to achieve higher producer prices are entirely different and there are solid reasons to believe that implementing an effort-restraining scheme is a much less arduous task than building up a viable sale organisation. Fourth, fishermen operating purse seines have a negative opinion about the role of such an organisation compared to other fishermen. The explanation behind this differential attitude lies in the characteristics of the produce. Indeed, the demersal species caught by fishermen operating lines and bottom-set nets are luxury products that can be sold directly by a fisherman's organisation to specialised export companies. The same cannot be said of the pelagic species harvested by purse seines which are mainly destined for domestic markets (and other African countries) and necessitate a complex and decentralised network of fishmerchants operating at wholesale and retail levels.

Finally, fishermen with alternative income opportunities appear to be opposed to centralised marketing organisations in the hands of the fishermen themselves (the coefficient associated with *altinc* is highly significant). Our presumption is that, when some household members have a business experience in fishmarketing or in another sector, they have a more realistic appraisal of the difficulties involved in the running of this kind of organisation and they tend to communicate their scepticism to their relatives specialised in fishing activities.

4. RESULTS FROM TIME-SERIES ANALYSIS OF PRICE AND OUTPUT DATA

So far, in our discussion centred on the incentive aspects of effort-limiting schemes, we have implicitly assumed that effort regulation is effective in achieving its economic objective of increasing producer prices. This is not necessarily the case, however. In order to assess the fishermen's ability to exert market power in a sustainable way, we must establish whether demand elasticity is greater or lower than -1 for every regulated product. In other words, there is obviously a demand side to our story that we address in this final section. A value below -1 for demand elasticity would insure that a monopoly can find one positive level of output that maximises profit and, therefore, that the fishermen's cartel can precisely define the target level of aggregate output.

¹³ The opposite result is observed in Kayar where the effect vanishes when residents from Saint-Louis are added to the migrants.

Estimating demand elasticity is usually a tricky operation because prices and quantities are simultaneously determined by supply and demand. Fishing is nevertheless a special activity in this regard : when sellers meet buyers on the shore, it is too late to adjust the quantity. On the other hand, the possibility of conserving fish in freezing facilities enables speculation although it does not leave the quality of the product unaffected. Expected future prices must clearly enter the determinants of demand if this effect is to be taken seriously. This reintroduces a simultaneity problem in the demand curve, in so far as future prices may be a function of current prices. Fortunately, past prices and seasonal dummies provide good exogenous variables to instrument for expected future prices. Besides quantity and expected future prices, prices of substitute goods also affect demand. These are of course endogenous (since a good is a substitute of its substitutes) and can be instrumented for on the basis of past values and seasonal dummies as well.

On the basis of these considerations, we assume that market data are generated by a three-step process. First, fishermen form an expectation of the day-price on the basis of past prices and of the season. Second, quantities are determined by the joint effect of the fishermen's willingness-to-sell at the expected price and of a random shock. And, third, actual prices are fixed by the demand curve. Two points deserve to be made at the present stage. On the one hand, we have no special hypothesis to test about step 2 in this process. Indeed, supply curves may well be positively sloped or backward bending since they involve choices between labour and leisure that are known to exhibit a wide variety of possible patterns. On the other hand, besides our main hypothesis that demand curves have an elasticity below -1 , we want to test whether expectations may be formed with a high degree of accuracy in step 1. This is actually a condition for an efficient computation of the target level of aggregate output : if prices are not correctly anticipated, a cartel is bound to fail because day-to-day losses are not likely to be compensated by gains on the average if fishermen are not perfectly patient.

Mathematically speaking, we are estimating the following system of equations :

$$\text{(expectations)} \quad P_t = \alpha + \beta*s + \gamma*B(P) + u_t \quad , \quad \text{with } P_t^c = P_t - u_t$$

$$\text{(supply)} \quad \log Q_t = \delta + \varepsilon * \log P_t^c + v_t$$

$$\text{(inverse demand)} \quad \log P_t = \phi + \rho * \log Q_t + \sigma * \log P_{t+1}^c + \theta * \log P_t^{\text{subst}} + w_t$$

Where P_t is the price at time t , s is a vector of eleven dummy variables representing the month of the year, $B(P)$ is a vector of lagged prices (the number of lags is chosen through a standard ARIMA procedure, i.e. by inspecting correlograms ; typically, zero or one lag is used), Q_t is the quantity at time t ; u , v and w are normally distributed residuals (with seasonal heteroscedasticity) ; parameters to be estimated include β and γ , which are real vectors, and α , δ , ε , ϕ and ρ , which are real numbers.

An inverse demand curve is estimated because observation errors occur frequently in prices and rather infrequently in quantities ; it is safer to let those errors appear in the residuals of an inverse demand function than to estimate a demand curve with a stochastic regressor (remember that expected future prices and prices of substitute goods are replaced by an instrumental variable in this equation).

If fishermen are right in reporting commercial effects wherever fishing effort is controlled, these effects ought to appear in our estimations of demand curves. It is evident that in markets where prices are insensitive to supplied quantities it cannot be instantly profitable to regulate fishing effort, even though in this case it may make sense to prevent the overexploitation of fish resources in order to keep down current cost levels. We should therefore not expect a one-to-one correspondence between poorly elastic demand curves and the existence of catch quotas in fishing villages. This said, it is worth bearing in mind that a significant result of our household survey is the following: fishermen who believe that regulation has a desirable effect on the preservation of natural resources also tend to

expect a beneficial commercial impact, except when they also report high rates of rule violations (see supra). Since it is rather unlikely that regulation is adopted for the sake of the biological effect only, there is a strong case for the *a priori* claim that regulation should be observed only where demand is relatively inelastic.

Unfortunately, due to difficult logistical problems, we could only obtain from the CRODT (Centre de Recherches Océanographiques de Dakar-Thiaroye) monthly price and landing data pertaining to the years prior to devaluation (in 1994). Moreover, as many price series are incomplete, we have to confine our attention to three fishing sites (Kayar, Hann, and Saint-Louis) and to a restricted number of seven fish species (the flat sardine; the round sardine; the white grouper known locally as thiof; a thread fin called capitaine in the French-speaking and cassava fish in the English-speaking part of West Africa; and three fish species belonging to the sea bream family, the rose sea bream, and the so-called pagre and dentex). The conclusions below must therefore be taken with the required caution.

In Table 17, we present the result of our econometric estimates for the two types of sardines, the only pelagic species for which data are available.

Table 18 : Econometric estimates of inverse demand functions for sardines (based on price and output data pertaining to the years 1991-1993)

Inverse Demand Estimations : $\ln P_t = \alpha + \beta \ln Q_t + \gamma \ln P_{\text{subst}} + \delta \ln P_{t+1}^*$				
Site	Sub-species (sardines)	β (inverse demand elasticity)	γ (substitution effect)	δ (speculation effect)
Kayar	Round	-0.01	0.46 **	--
	Flat	-0.20 **	0.97 **	--
St-Louis	Round	-0.07	-0.00	--
	Flat	-0.11 **	1.20 **	--
Hann	Round	-0.03	0.36 *	.60 *
	Flat	-0.08	0.40 *	.19

(†) ** indicates significance at the 95 percent confidence level while * indicates significance at the 90 percent level.

It is evident from the table that it is only for flat sardines in Kayar and Saint-Louis that inverse demand elasticities are significantly different from zero. Elasticities are higher than -1 , which is conform to theory since these are inverse demand elasticities. For round sardines in the three fishing sites and for flat sardines in Hann, one cannot reject the hypothesis of a perfectly elastic demand, which should preclude any regulation effort from causing an increase in prices. These results are not really surprising in the light of the following circumstances. First, in Kayar and St-Louis, sardines are not refrigerated but are sold immediately to artisanal fish processors who condition fishes for local consumption. Second, Hann is a suburb of the capital Dakar and freezing sardines for other markets (such as cities in the hinterland) is much more common there. Moreover, the area of Dakar forms a large integrated market strongly articulated with export outlets, contrary to Kayar and Saint-Louis which are not within easy reach. Third, round sardines are bigger than the flat ones and therefore more convenient for refrigeration.

It is probably not coincidental that purse seines, which target only pelagic species among which flat sardines are important, are regulated in Kayar and Saint-Louis but not in Hann and Yoff (bearing in mind that, like Hann, Yoff is located in the suburb of Dakar). Still, one must not lose sight of the fact that even where demand is perfectly elastic, regulation can be profitable if marginal costs are

(locally) steeply increasing. This condition may be fulfilled if scarcity of fish is sufficiently acute to compel fishermen to reach more distant fishing grounds. Finally, it may be noted that, as expected, all substitution effects are positive, indicating actual substitutability (rather than complementarity) between fish species.

As far as demersal species caught by hooks and lines (or bottom-set nets) are concerned, estimations of inverse demand functions yield complicated results from which Kayar however emerges as the most suitable location for effective attempts at effort regulation. It is indeed apparent that demersal species for which demand is not perfectly elastic are the thiof in Kayar (but not in Saint-Louis and Hann); the capitaine in Kayar; the rose sea bream in Kayar; and the pagre in Saint-Louis and Hann.

5. CONCLUSION

For local-level effort regulation to succeed, it is obviously important that market conditions are such that fish prices respond to supply variations. To put it in another way, if demand is perfectly elastic with respect to prices, such as happens under well-integrated markets approximating perfect competition, restriction of landings by fishermen will not cause any price increase. This said, one cannot rule out the possibility that effort limitation has the effect of reducing harvesting costs since fish scarcity may determine steeply increasing cost functions. Data available to us did not permit to test for the latter eventuality but, to a limited extent, they allowed us to assess market conditions. The main conclusion is that significantly negative price-effort elasticities are not systematically observed and, when observed, they often concern the village of Kayar. Unfortunately, price and output data available date back to the pre-devaluation period (before 1994) and it is therefore quite possible that market conditions have changed in the meantime. It is thus revealing that fishermen of Kayar themselves have recently confessed to us that the impact of their effort-limiting measures seems to have decreased: they have indeed observed that the price of some species continues to fall even though they have tightened the catch quotas. We are nevertheless entitled to assert with sufficient confidence that, historically, market conditions have favoured effort regulation in Kayar compared with the other sites. The fact that precisely this village has been the most successful in its regulation efforts is probably not coincidental.

Assuming away all kinds of incentive problems, we know that imposing catch quotas is theoretically the best way of controlling effort in order to enhance the producers' market power or to conserve the resource. Once labour incentive problems are taken into account, if the adoption of catch quotas appears optimal for line fishermen, limitations of fishing trips seem to be better feasible for purse seine fishermen. And when problems arising from the monitoring of effort restraint are also paid attention to, the system of catch quotas applied to the former category seems less efficient than limitations of fishing trips chosen by the latter category. This goes a long way towards explaining why the extent of rule-breaking is perceived to be larger with respect to catch quotas. In a second-best world pervaded by all kinds of incentive problems, restriction of effort therefore seems to have better chances to succeed in the case of purse seines than in that of line fishing to which limitations of sea trips can hardly be applied.

Line fishermen operating canoes equipped with ice boxes and used to make long journeys out at sea are especially difficult to bring under any effort-limiting scheme due to a combination of incentive problems particularly hard to overcome. It is thus not surprising that nowhere along the Senegalese coast did we find any sign of attempts towards regulating their fishing efforts. Direct competition from this type of sophisticated fishermen (they target the same fish species) may account for the fact that regulation has not been adopted by simple line fishermen in Hann and Soumbédioune where ice boxes are found, yet cannot explain why it could work with simple line fishermen in Kayar but not in Saint-Louis since in both places no ice boxes are used. The presence of more favourable market conditions for demersal species in Kayar than in Saint-Louis (and Yoff where the regulatory scheme has been discontinued) constitutes an important advantage for Kayar's line fishermen. Another

advantage in favour of the latter is the existence of a strong traditional leadership structure. Unfortunately, we are unable to disentangle the respective effects of these two favourable factors.

What we may nevertheless note is that Kayar's leadership, which is apparently rooted in the hierarchical socio-political structure of what was originally an agricultural village, has been able to impose a relatively good measure of discipline and sense of common purpose on people well-known for their inveterate tendencies towards individualism. This factor is all the more important as Kayar suffers from a major weakness arising from severe inter-community tensions between fishermen native of Kayar itself and those native of Saint-Louis. It is noteworthy that the division is not simply a classical opposition between migrants and residents since permanent residents who were born in Saint-Louis do not seem to think and behave differently from temporary migrants from the same area. Differences in attitudes between local fishermen and Saint-Louisiens have also been empirically substantiated for Soumbédioune, yet, in the latter area, differences manifest themselves along the resident-migrant vector rather than along the communal dimension per se.

Inter-community tensions in Kayar have their origin in grave conflicts between operators of bottom-set nets (exclusively people from Saint-Louis) and users of other fishing techniques, especially if they are native of Kayar. In spite of repeated efforts, the vexed problem of how to allocate among these two categories the limited fishing space available close to the shore has never been solved in a satisfactory way. Furthermore, bottom-set net operators have always refused to adopt an effort-limiting scheme even though they target valuable demersal species (such as soles and groupers) that are also harvested by line fishermen (in more distant fishing grounds). A ready explanation for this non-co-operative attitude lies in the fact that a large majority of bottom-set net operators are indebted to fishmerchants with whom they have exclusive sale relationships. Revealingly, the same phenomenon obtains in Saint-Louis. In the latter fishing site as well as in Hann, pervasive sales-tying agreements also characterise relations between simple line fishermen and fishmerchants, which may again account for the absence of regulation for this fishing technique contrary to Kayar where the phenomenon is less widespread.

Lastly, the most dynamic among line fishermen –those who declare that they are going farther into the sea to catch valuable species– have a strong proclivity to support effort regulation presumably because their expected gains are larger owing to the high value of the species targeted.

Many of the above results actually point to the importance of homogeneity of users as a condition for successful collective action. The fact that regulatory schemes are devised on the basis of a particular fishing technique –with regulating methods varying between line fishing and purse seining– shows that fishermen try to reduce heterogeneity whenever possible. Yet, some dimensions of user heterogeneity are not easily reducible, namely the presence of fishing canoes with ice boxes, the pervasive existence of fishermen-fishmerchants exclusive links for some techniques, the co-existence of different ethnic communities using the same harvesting technique and targeting the same species, the availability of alternative income opportunities for some fishermen but not for others.

As one can judge from the above conclusions, our study has to a large extent succeeded in explaining variations in both the incidence and continuity of effort-limiting schemes in communities of Senegalese small-scale fishermen. It is noteworthy that many of the factors shown to have a significant impact are of a rather structural character, namely, market conditions, features of fishing techniques which bear upon enforcement costs of a collective scheme, nature of relationships between fishermen and fishmerchants, and history-determined patterns of authority and leadership. By overlooking such critical parameters, one incurs a high risk of setting up effort control measures that will be short-lived. Moreover, it must be borne in mind that the same parameters are susceptible of evolving and, as a result, measures that worked rather well in a given period may prove difficult to sustain in a different set of circumstances. This dynamic aspect of reality, as we could realise in the course of field interviews, is probably the most difficult to accept by leaders who have played a major role in the initiation and enforcement of local-level regulation of fishing effort.

On the other hand, policy aspects do also matter. Ill-conceived regulation mechanisms can obviously impair their viability and effectiveness. This is illustrated in our study by the rotation scheme for purse seines in Saint-Louis which has given rise to serious incentive problems owing to its ignoring important income-smoothing considerations.

Bearing in mind that effort-limiting schemes have run into difficulties in Saint-Louis and Yoff and that they have not been started in Hann and Soumbédioune, it appears that most of the conditions recalled above must be simultaneously satisfied for decentralised schemes of effort regulation to succeed. The market structure must be such that fishermen can influence prices ; monitoring costs as determined both by technological or marketing conditions and by the design mechanism adopted must not be too high ; most fishermen should be free of exclusive relationships with fishmerchants acting as credit-givers ; good leaders should be available ; heterogeneity of resource users must not be too high (hence the need to devise technique-specific schemes). Note that the first of these conditions must be fulfilled only if effort regulation is motivated by market power rather than by resource management considerations, as has been shown to be the case among Senegalese coastal fishermen.

Support for decentralised measures of effort regulation does not vary between asset owners and crew labourers. This is not surprising given that the share system of payment used in the fishing sector makes crew labourers equally interested in getting better prices. By contrast, crew labourers are opposed to marketing organisations run by fishermen presumably because under the same system of payment there would be ample scope for uncontrollable cheating (mainly through underreporting of true values of sale proceeds) by asset owners.

Relying on regulatory schemes aimed at increasing fish prices in order to gradually build up awareness about resource conservation may prove deceptive. Indeed, market conditions may not be suitable for a cartel operation and, as a result, price may fail to increase following control of fishing effort. Fishermen may then be discouraged and drop out of the scheme before they come to understand the need to manage the resource for conservation purposes.

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