

HETEROGENEITY AND COLLECTIVE ACTION FOR EFFORT REGULATION : LESSONS FROM THE SENEGALESE SMALL-SCALE FISHERIES

by

Frederic Gaspart and Jean-Philippe Platteau*

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**Centre de Recherche en Economie du Développement (CRED)
Department of Economics, University of Namur
Rempart de la Vierge, 8 B-5000 Namur Belgium
Email : jean-philippe.platteau@fundp.ac.be**

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Much attention has recently been paid to the potential influence of inequality or heterogeneity on people's ability to organize collectively, particularly with respect to management of local-level natural resources. Speaking generally about this issue makes little sense in so far as heterogeneity or inequality is obviously a multidimensional phenomenon the different facets of which may carry varying implications for collective action capacities. Important among these different facets are : income or wealth (or productive capital) inequality, inequality in access to alternative income opportunities, social stratification or differential positions in the local power structure, skill disparity, ethnic and cultural heterogeneity, and diversity in techniques employed or in patterns of resource use.

The existing literature tends to suggest that all these dimensions except the first one have an unambiguously negative effect on collective action. As for income or wealth inequality, economic analysis can be harnessed to show that in certain circumstances or at certain levels collective action is encouraged rather than hindered by inequality. In particular, inequality is more likely to prompt collective action when it facilitates the establishment of a regulatory authority, and, in appropriation problems, when it places constraints on the individual harvesting efforts of the smaller users. In contrast, if regulatory instruments are limited in a way that emphasizes uniform treatment of all participants, inequality between them tends to make collective agreement and effective enforcement of such instruments more difficult. When a decentralized setup of voluntary contributions to a common good is considered, the impact of wealth or income inequality is again ambiguous. This is because larger participants are inclined to contribute more whereas the reduced stake of the smaller ones has the effect of dampening their incentives to contribute (see Baland and Platteau, chap. of this book, for a most recent survey of this issue).

Our purpose in the present paper is to examine the rather unique experience of Senegalese small-scale fishermen with effort regulation during the 1990s in order to assess the potential role of various sources of heterogeneity. Indeed, an interesting feature of the Senegalese material under concern is that many of the aforementioned types of heterogeneity are present in the fishing centers where effort regulation has been attempted. Interestingly, not only have effort-restraining schemes been tried in some locations and not in others, and for some fish species and not others, but also they have been discontinued after some time in certain cases while enduring for a rather long time in other cases.

Section 1 provides the reader with background information about attempts at effort limitation by artisanal, maritime fishermen of Senegal. In Section 2, details about the sample and the data are presented. Section 3 proposes an econometric test to decide in which case (which location and which species) effort limitation is likely to have an effective impact on producer prices, the most important objective apparently pursued by the fishermen when setting their

effort restrictions. This will allow us to see whether there is a convergence between potentially and actually successful schemes. In other words, do we find that effort regulation occurs and persists where objective conditions (i.e., the market structure) for its success are comparatively good while it fails where those conditions are comparatively bad? If convergence is found, one can hypothesize that rules tend to be violated where a sufficient number of people have come to realize that they are not very profitable, thereby ultimately causing the collapse of the regulatory scheme. Section 4 forms the central part of the paper where the main findings regarding the influence of heterogeneity on collective action capacities are being assessed and discussed. Section 5 concludes.

1. A historical sketch of effort-limiting schemes along the Senegalese coastline

1.1 A first attempt to regulate access to the resource

In Kayar, one of the main fishing centers along the Senegalese coastline (located on the so-called Petite Côte, north of the Dakar Peninsula), competition for access to in-shore waters has been a constant source of tensions between migrant fishermen (from Saint-Louis in the extreme north of the country) 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 specialized in active fishing techniques while a category of fishermen from Saint-Louis operate bottom-set nets to the exclusion of any other technique¹.

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

¹ 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 Saint-Louis (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.

operating.² Unfortunately, conflicts between bottom-set net operators and other fishermen remained pervasive as illegal encroachments upon the exclusive zone were quite frequent. In most cases, they were not dealt with by the commission partly due to a lack of monitoring equipment.³

In 1990, leaders of the fishermen in both communities decided to take more initiative and, 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), they created the *Comité de solidarité Kayar-Guet Ndar* with a view to assuming more responsibilities in the monitoring operations and conflict resolution mechanisms. Results, however, remained quite below the expectations generated by this inter-community solidarity movement.

All this happened during a period of growing pressure on fish resources both because of increased activity of foreign and national industrial vessels in the in-shore waters and a rapid expansion of the artisanal fleet itself. The pressure even accelerated during the 1990s: between 1994 and 1997, for example, the number of pirogues operating in the different sites of artisanal fishing increased by as much as 42 percent!⁴ Furthermore, the artisanal fishing sector underwent rapid transformation, 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.

1.2 *Effort-restraining 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 was initially created with another purpose in mind (see supra). It is the desire to reduce the market power wielded by local fishmerchants (known as *mareyeurs* in Senegal)

² 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).

³ The commission had received a canoe equipped with an outboard engine for surveillance operations, yet the boat could not be operated because of a lack of working capital for fuel expenses and maintenance of the equipment.

⁴ 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 (Dakar) area, 31 percent in the Grande Côte, and 8 percent in the Petite Côte (CRODT, 1998 : Table 38 ; CRODT and DOPM, 1998 : Table 11).

and, more specifically, to increase producer prices for the pelagic species targeted by purse seines that motivated this first attempt. 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) was established to ensure proper enforcement of the rule. The scheme has persisted to this date.

Two years later (1994), 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 preempting 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 prices paid to the producer 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* !

Since 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.

Clearly, such a scheme proved more sustainable than lock-out movements –which are hard to maintain given the lack of intertemporal markets to smoothen temporary disruptions of economic activity– and 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 1992. 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. 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 (in the Dakar area), 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. In due time, however, serious tensions broke out 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.

In trying to emulate their colleagues from Yoff, fishermen of Soumbédioune (also in the Dakar area) 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.

2. The sample data

As is evident from the above historical sketch, Saint-Louis, Yoff, and, above all, Kayar are places where important experiments in effort regulation have been made. In these sites, as well as in two control sites, –Soumbédioune (in the Dakar area) where a short-lived experience of effort regulation has been attempted), and Hann (also in the Dakar area) where no such experience has ever taken place– household questionnaires were addressed to fishermen. The purpose of the household survey, conducted during the year 1997 (between April and July), was essentially to determine the level of support of regulatory schemes (whether existing in the location surveyed or not) among the fishermen as well as to examine whether some categories are more supportive than others and why.

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. In Table 1 are given the characteristics of the sample for each of the five aforementioned fishing sites.

Table 1 : The structure of the sample as per fishing site, technique and ownership status (numbers referring to cases where regulation has taken place are indicated in bold types)

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°	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.

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

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

The sample contains data about attitudes of two categories of fishermen, those who have gone themselves through a (sustained) experience of effort control and those who have not. The latter either belong to a location where effort control has been carried out with respect to some fishing technique (not the one which they themselves use), or not. 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. Adding the fishermen, both owners and crew laborers, belonging to these three locational-technical configurations, we have a sample of 127 units in the category of fishermen having experienced effort regulation (see the figures in bold characters). The remaining category comprises 193 fishermen. In our analysis (see *infra* Section 4), we will use mainly the complete sample of all fishermen (320 units).

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 sub-sample 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 laborers 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 laborers came to form about half the total sample of 320 households whom we could interview in good conditions⁵.

3. The effectiveness of effort-limiting schemes

From our historical overview in Section 1, it is patent that the main motive behind the efforts of Senegalese small-scale fishermen to limit their landings has been their desire to curb the market power of local fishmerchants and obtain higher prices for their fish rather than to manage and conserve the resource⁶.

⁵ 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).

⁶ This is in spite of the well-documented fact that pressure on fish resources has increased significantly during the last decades, particularly on bottom-dwelling species living in coastal waters which are considered to be overexploited (Barry-Gérard, Kebe, and Thiam, 1992 ;

The question then arises as to whether effort regulation can be actually effective in achieving its economic objective of increasing producer prices. 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. A value below -1 for demand elasticity would insure that a monopoly can find one positive level of output that maximizes profit and, therefore, that the fishermen's cartel can precisely define the target level of aggregate output.

Unfortunately, due to difficult logistical problems, we could only obtain from the CRODT (Centre de Recherches Océanographique 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 Francophone and cassava fish in the Anglophone 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.

Details about the econometric model used to estimate (inverse) demand elasticities are provided in Appendix I. In Table 2 below, we present the results obtained for the two types of sardines, the only pelagic species for which data are available. The inverse demand equation has the following form:

$$\ln P_t = a + b \ln Q_t + g \ln P_{subst} + d \ln P_{t+1}^e,$$

where P_t is the current estimated price of the fish species concerned, Q_t is the current quantity produced, P_{subst} is the price of a close substitute, and P_{t+1}^e is the anticipated price of the species.

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. Demand elasticities (the inverse of the b s shown in the table), are lower than -1 , which is conform to theory. 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

Barry-Gerard, Fonteneau, and Diouf, 1992). As for coastal pelagic species, biologists of the Centre de Recherche Oceanographique de Dakar-Thiaroye (CRODT) believe that they are rapidly nearing optimum exploitation. 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.

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 more isolated physically.

Table 2 : Econometric estimates of inverse demand functions for sardines (based on price and output data pertaining to the years 1991-1993)†

Inverse Demand Estimations : $\ln P_t = \alpha + \beta \ln Q_t + \gamma \ln P_{\text{subst}} + \delta \ln P_{t+1}^e$				
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 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). 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 (not shown here) 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.

To sum up, the hypothesis that regulation of fishing effort should be observed only where inverse demand is strongly elastic (or demand is rather inelastic) is broadly confirmed by our econometric testing procedure. Kayar, the place where the most successful experiments took root, appears indeed as the location where, at least before the devaluation, market conditions were clearly favorable to a producer cartel. Operators of purse seines in Saint-Louis also seem to wield potential market power.

Note however that, if marginal costs are (locally) steeply increasing, effort regulation may be profitable even in perfectly competitive conditions. This will happen when, owing to acute pressure of fishing effort, the resource becomes so

scarce in the in-shore waters that fishermen are compelled to reach more distant fishing grounds, thereby causing an increase in labor and input costs. In other words, in conditions of heavy pressure on fish resources, one cannot expect a one-to-one correspondence between poorly elastic demand curves and the existence of catch quotas in fishing locations. The fact that such one-to-one correspondence is almost obtained in the above test tends to indicate that output price (rather than cost) considerations are overriding in the minds of the fishermen when they set up catch limitations⁷. In the next section, another finding will confirm this conclusion.

Finally, it must be reckoned that, as discussions with fishermen leaders (particularly when presenting our results to a selection of them in the late nineties) have persuaded us, they tend not to have a good or quick grasp of the critical role of the market environment for effort-limiting efforts.⁸ Conceivably, they might thus embark upon such efforts even though they are not sustainable. This is one reason why it is important to have a complementary look at other factors –particularly, the various dimensions of heterogeneity which are the focus of this study– susceptible of influencing support for effort regulation. The other reason is more evident: a conducive market structure is a necessary but not sufficient condition for successful regulation (as witnessed by the eventual failure of the attempt to regulate effort among purse seine fishermen in Saint-Louis).

4. The impact of heterogeneity on the perceived success of effort-limiting schemes

4.1 Regulation methods in the light of various types of heterogeneity

Technical heterogeneity and differentiation of effort-limiting schemes

Specific characteristics of the fishing techniques used make it difficult to work out a single formula for implementing effort limitation. Disagreement is therefore bound to arise if uniform treatment of fishermen employing differing techniques is sought. Differentiation of the regulation methods applied appears as the only way out of this type of heterogeneity. In Kayar, revealingly, as pointed out in Section 1, methods of effort limitation differ between purse seine and line fishermen.

⁷ Pressure on fish resources in the in-shore waters is certainly as high in the Dakar area (where Soumbédioune and Hann are located) as on the Petite Côte (where Kayar is located).

⁸ Thus, at least some fishermen leaders from Soumbédioune wanted to emulate the experience of Kayar without realizing the differences in the market environment between the two areas. And fishermen leaders from Kayar complained about recent trends of diminishing fish prices in spite of their effort restrictions. Still, the measures were not called into question.

First consider the case of canoes operating purse seines. Regulation of fishing effort through catch quotas is hardly feasible. 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 motorized canoes. There are two distinct reasons why purse seine fishermen would 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 hauled in entails a much higher subjective cost than foregoing a potential catch that is not yet in the net. 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. 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 may fall well short of the authorized 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) constraints⁹.

Since the catching of fish with hooks and lines is a continuous process that can be interrupted 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 traveled 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 made of polystherene (a rather recent innovation brought in small-scale fisheries to help conserve fish on board), they undertake much longer voyages. They travel up to several hundred kilometers, northwards to Mauritania and southwards to Casamance and Guinea

⁹ It is a second-best method because fishermen are encouraged to circumvent the limitation by lengthening the fishing time, and increasing the productivity of each permitted trip, say through the use of more performing nets.

Bissau. Their voyages extend over several days and, increasingly, they come to exceed a week's time. For the operators of such canoes, catch quotas have not been a feasible proposition so far. This is true even allowing for the fact that quotas could be adjusted upwards to take account of the length of each fishing trip : for example, the landing 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 (in terms of both labor time and fuel expenditures) involved in long journeys to distant fishing grounds, it is doubtful that the fishermen concerned would accept to restrict their catches.

Heterogeneity in physical capital and the imposition of effort limits on a per unit basis

If a uniform limitation, whether in terms of fishing trips or fish boxes landed, would be imposed on all fishermen irrespective of the number of fishing units owned, comparatively big owners would immediately oppose it. Inequality in capital endowments would thus stand in the way of a workable regulation of fishing effort. In the communities of small-scale Senegalese fishermen concerned, however, effort limits are typically set on a per unit basis. 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 apparently exists a complete consensus about such a manner of sharing the burden of effort reduction. 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. With identical aggregate quotas, so it is felt, large owners would be suddenly deprived of the possibility to maintain the profitability of part of their fishing assets. In addition, crew labourers working on units prohibited from operating would become unemployed unless some employment-sharing mechanism is agreed upon within the fishing community. Even small capital owners insist that these consequences ought to be avoided.

Heterogeneity in ownership of physical capital obviously takes on an added dimension when the situation of crew labourers who do not own any fishing asset is being considered. None the less, a peculiar feature of labour contracts in small-scale fisheries not only in Senegal but all over the world is that workers are given a sort of fixed wage component, usually paid in kind, plus a predetermined share of the net proceeds accruing from the sale of the catches (Platteau and Nugent, 1992). In these so-called mixed share-cum-fixed wage contracts which answer the need for both insurance and incentive motives, it must be emphasized that the share component usually represents by far the largest portion of total labour remuneration. The immediate implication for our

purpose is the following : if the aim of effort-limitation and catch restrictions is to obtain better prices for fish so that the total value of the landings is increased, then crew workers should naturally support such schemes because they meet their own interests. Consequently, we ought not to observe more opposition to them among crew workers than among owners of fishing assets.

Heterogeneity in skills and the principle of skill-neutral quotas

Heterogeneity in skills is more difficult to handle than heterogeneity in techniques and inequality in capital endowments. This is essentially because skill levels are not easily observable. It is revealing that Senegalese small-scale fishermen consider 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 favor 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 practically impossible for fishermen to reach an agreement about their respective skill levels. It is not only that skill differentials are difficult to measure in an objective manner. Indeed, we do not doubt that fishermen have some clues about skill rankings within their community, at least regarding the best and worst performers. Yet, the interesting fact is that they do not want to disclose them in public because officializing them would give rise to unbearable tensions. Low performers would feel ashamed to admit their insufficiency while good ones are wary of self-declaring their superiority which could be interpreted as misplaced boasting. Community life encompasses many spheres of human interactions and tensions or frustrations in one sphere, say in meetings where regulatory schemes are discussed, can easily spill over into other walks of social life, including the domain of interpersonal relations and private affairs. This is especially true when fishermen belong to the same family or lineage.

From economic theory, however, we know that uniform quotas are bound to hurt the interests of the better-skilled agents –in this case, captains leading fishing teams– who may lose or gain little from effort regulation (Johnson and Libecap, 1982 ; Libecap and Wiggins, 1984 ; Libecap, 1990 ; Baland and Platteau, 1998, 1999). It is therefore to be feared that these agents will be prompted to abstain from supporting and perhaps even violate or circumvent the rules prescribing uniform treatment for all operators regardless of their skill levels. Unfortunately, we are unable to test that hypothesis to the desirable extent since we do not have at hand a comprehensive reliable yardstick of the

relative skill levels of sample fishermen. This said, we will see later that we have available to us two good indicators of at least who are among the most dynamic, progressive, venturesome, and skilled line fishermen (no equivalent indicator is available for operators of purse seines). By using them, we will show that the aforementioned hypothesis is partly borne out and partly rejected for reasons that are perfectly understandable on the basis of economic analysis.

To the extent that uniform quotas are hurting the interests of at least a fraction of comparatively skilled fishermen (whether purse seine or some category of line operators), it would be surprising if they were universally followed by all fishermen. It is therefore useful to pause for a while at this stage to ask what we do know about the incidence of rule-breaking.

In fact, data about actually observed infractions were not made available to us. Fishermen leaders sitting on the executive committees in charge of implementing the schemes argued indeed that there was no such thing as a diary reporting the known cases of rule violation. This was not considered to be an important shortcoming since, according to them, there had been only a few cases of clear infringement of the set regulations concerning effort restrictions. When asked again to describe cases of sanctioning by the committee in charge, they typically argued that punishing is rarely meted out because there are few rule-breakers. Following their account, only once had 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.¹⁰

The leaders' claim that the incidence of rule infractions is very low is not congruent with the following fact: in the case of line fishermen, the fine imposable in the event of rule-breaking has been gradually revised upwards (from 15,000 to 30,000 and then to 50,000 CFA) when it appeared that it was not dissuasive enough. On the other hand, our household questionnaire contains a question that allowed fishermen to express in the privacy of their home compounds their personal opinions about whether the effort-limiting schemes are effectively implemented. The general pattern of their answers turns out to be largely at odds with the optimistic assessment of the relevant committee's members. As a matter of fact, more than 40 percent of the sample fishermen

¹⁰ 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. However, grace delays to pay the fine are extendable to 10-15 days when the rule-breaker is a well-known fisherman with solvency problems. The same system applies to canoes equipped with lines : concealment of fish boxes exceeding the allowed quota is punished by a fine amounting to 50,000 CFA. 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 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).

consider that rule violations are frequent¹¹. Moreover, as further probing revealed, those fishermen who perceive the rate of infractions to be high also think that proper sanctions are not applied to the violators : enforcement of the rules is low with the attendant consequence that other participants are demotivated.

It bears emphasis that the subjective assessment of rule violations varies significantly between fishing techniques and locations. This is evident from Table 3. The perceived incidence of rule-breaking 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 Saint-Louis and especially in Kayar)¹². The fact that cheating is easier with lines than with purse seines largely accounts for this statistically significant difference. It is indeed 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 (thanks to mutual monitoring, violations are easily detected in this case). 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 catches under a system of catch quotas.

Table 3 : Frequencies of fishermen considering that rule violations are frequent, as per location 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%)

In addition, the perceived rate of infractions among purse seine fishermen is much larger in Saint-Louis than in Kayar. A crucial difference between the schemes implemented in these two locations seems to largely explain the poorer achievements of the former compared with the latter in terms of effectiveness of

¹¹ 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).

¹² According to the Fisher test, the difference between line and purse seine fishermen is statistically significant at 2 percent level of confidence.

enforcement. 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. The more stringent limitation imposed in Saint-Louis determines a comparatively strong reluctance of local operators to abide by the rule. In point of fact, fishermen are eager to work every day because ecological conditions may vary appreciably from day to day. They always worry that they might 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 donors and donees because 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 are discouraged to help poorer fellow fishermen who resent the new situation.

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 has practically vanished.

For all these reasons, it is not surprising that limitations of sea trips for purse seine canoes have been discontinued in Saint-Louis by the end of 1995 while they persisted in Kayar.

Socio-cultural heterogeneity along the native-migrant divide

We have already pointed out that in Kayar there is a deep antagonism between operators of passive gears (bottom-set nets) and operators of active gears (purse seines and lines) with the former all being migrant fishermen from Saint-Louis (see supra, Section 1). In other words, what we witness here is an area of

conflict between two different types of fishing techniques that arises from different patterns of use of the resource available in the in-shore waters. In a nutshell, there is heterogeneity of objectives regarding the resource and such heterogeneity can usually be overcome only through inter-group agreements about sharing the claimed territory. Yet, such agreements about regulation of access to the waters are hard to come by or unlikely to be effectively implemented, especially when heterogeneity in use patterns is compounded by a social or cultural heterogeneity.¹³ (Think of the difficulty of resolving conflicts between farmers and herders in many parts of SubSaharan Africa).

Unlike bottom-set net operators, fishermen handling purse seines or hooks and lines under their respective effort-restraining schemes are culturally heterogeneous. The presumption is that the deep-seated conflict that has long opposed native and migrant fishermen about the use of bottom-set nets is likely to rebound on the effectiveness of these other regulatory attempts that involve both groups of people. Our econometric estimates presented in a next subsection will enable us to test this hypothesis. Note furthermore that migrant fishermen from Saint-Louis are also present in significant numbers in Soumbédioune and that a fraction of them have even permanently settled there. It will be interesting to know whether opinions about the usefulness of regulatory schemes differ among these various categories of fishermen, bearing in mind that attempts at effort regulation have been short-lived in this location (see *supra*, Section 1).

Heterogeneity in bargaining power vis-à-vis fishmerchants

It is a common feature of many small-scale fisheries in the Third World that boat owners are sometimes involved in exclusive relationships with a particular fishmerchant through sales-tying debts (see Platteau and Abraham, 1987 ; Platteau and Nugent, 1992). Productive loans are thus given to fishermen on the explicit condition that their catches will be disposed of through the lender-merchant and interest payments will be typically subtracted from the sale proceeds, possibly in the form of reduced purchase prices. In this manner, merchants try to secure themselves a sufficient supply of raw material to keep their business running. If effort-limiting schemes devised by Senegalese fishermen are aimed at countering the bargaining power of fishmerchants, as we have documented in Section 1, we naturally expect that fishermen entangled in sales-tying debts will not easily participate in such schemes. The threat of lender-merchants asking for immediate repayment of their loans would surely act as a powerful deterrent discouraging any action susceptible of antagonizing them. Moreover, if it is the case that credit-cum-marketing relationships are pervasive in some fisheries, we would predict that catch limitations would be

¹³ Note that fishermen from Kayar are essentially from the same ethnic background (Wolof people) as those of Saint-Louis.

impossible to enforce for lack of a critical mass of operators ready to abide by the rules.

Table 4 shows precisely that there are significant variations across fishing techniques in the incidence of such interlinked relationships : it actually varies from a zero proportion of fishermen with exclusive sales arrangements in the case of line and purse seine fishing in Yoff to more than three-fourths of fishermen in this category for bottom-set net fishing in Saint-Louis. On an average, about a quarter of all the sample fishermen have special credit links with fishmerchants.

The most interesting finding emerging from the table is no doubt the existence of a significant, negative relationship between the incidence of sales-tying debts, on the one hand, and the presence of an effort-limiting scheme, on the other hand. Thus, these debts are especially pervasive for operators of bottom-set nets (close to 59 percent in Kayar and 76.5 percent in Saint-Louis), and for line fishermen in Hann (more than 71 percent) and Saint-Louis (close to 41 percent), all fisheries for which effort-limiting schemes are conspicuously absent. By contrast, the most active location for such schemes, Kayar, exhibits comparatively low proportions of fishermen tied to fishmerchants through credit links (about 22 percent for line fishermen and hardly 14 percent for purse seine operators). Low proportions are also observed for purse seine operators in Saint-Louis (15 percent) and line fishermen in Yoff (less than 17 percent), two other fisheries which have attempted to limit fishing effort.

Table 4 : 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 %

Note that the presence of an endogeneity bias –credit-cum-marketing relationships tend to disappear when effort regulation is adopted– is rather unlikely in so far as owners of fishing assets cannot easily terminate such agreements owing to the obligation to repay their debts in a short span of time.

4.2 Econometric results: characteristics of fishermen with an optimistic assessment of enforcement performances

From all what has been said above, we expect the perceived rate of rule violations to be relatively high among line fishermen and fishermen involved in exclusive sale relationships with particular merchants, and to be relatively low

among purse seine operators and the local leadership (as already pointed out, in public or in group interviews they made a very positive assessment of the scheme's success). These predictions are all confirmed in the logit model that we used to estimate the determinants of fishermen's beliefs regarding the extent of rule-breaking in the effort-limiting scheme that concerns them. The econometric results are presented in Table 5 based on the restricted sample of fishermen who have been actually involved in effort-limiting experiments, whether sustained to the time of interview or not. The dependent variable, denoted *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 by the fisherman concerned.

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

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	-.1009126	1.986973
cons	.0151894	.3768604	0.040	0.968	-.7234434	.7538221

Log Likelihood = -75.822999

Number of obs = 127
chi2(6) = 20.92
Prob > chi2 = 0.0019
Pseudo R2 = 0.1213

Four explanatory variables turn out to be statistically significant. First, the dummy *exclus*, which has unit value when the fisherman is committed to a particular merchant through a credit link and zero value when he is free to sell his catches to whomever he wants, comes out with a positive coefficient (significant at 90 percent confidence level). As expected, 'free' fishermen are more positive than 'tied' fishermen regarding the extent of rule-breaking. Second, the dummy *purseseine*, with unit value when the fisherman is a purse seine operator and zero value when he works with hooks and lines, has a negative coefficient (significant at 95 percent confidence level), indicating that purse seine operators have a more optimistic assessment of the effectiveness of the schemes' enforcement than line fishermen.

Third, we have the dummy *leadkay* which is intended to identify fishermen leaders in Kayar. It takes on value one when the fisherman is relatively old (more than 47 years old) and has three wives (no fisherman has more than three wives in the locations surveyed), and value zero otherwise. These two criteria, indeed, are important indicators of high social status in fishermen communities. Seniority still remains an important basis for exercising authority and wielding prestige while the number of wives is a good proxy for wealth and is actually strongly correlated with the number of fishing units

owned. The coefficient of *leadkay* has the expected negative sign that confirms the public statements made by the members of the Kayar's elite, that is, 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 the case that they are more confident in its eventual success in spite of what they perceive as minor problems which they are therefore prone to downplay.

Note carefully that, if the coefficient of *leadkay* is significant only at the 90 percent confidence level, it is entirely due to strong multicollinearity: indeed, this variable is highly correlated with *educ* (leaders tend to have comparatively high levels of education as measured in the way explained below) and, above all, with *purseseine* (only 10 percent of Kayar's leaders do not own at least a purse seine).¹⁴ It is obviously impossible to remove the latter variable from the regression owing to the critical influence of fishing technique on the assessment of rule-breaking. Revealingly, the proportion of comparatively old fishermen with three wives who stated a low incidence of rule infractions in Kayar is as high as 90 percent compared with only 57 percent for all other categories taken together, a phenomenon that is observed neither in Saint-Louis nor Yoff (where interaction of age and marriage position has no impact on the perception of rule-breaking). This probably 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 high 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 fishermen are completely specialized in fishing activities and therefore migrate to other fishing grounds when fish disappear from the local waters or when the sea is too rough (see supra). Apparently, fishing communities are traditionally less cohesive but also less hierarchically structured than peasant societies. Two reasons at least may account for this difference. For one thing, there are probably fewer needs for coordination in fishing societies because of a smaller range of externalities that are obvious for the people –external effects are much

¹⁴ If we would add another dummy variable to determine whether the fisherman is an equipment owner or a simple crew labourer, the coefficient of *leadkay* would just stop being significant (more precisely, it would be significant at 86 percent level of confidence only). This is again due to multicollinearity since all leaders in Kayar are equipment owners.

more complex in fishing than in agriculture so that people do not easily grasp them (see Baland and Platteau, 1996: Chap. 10; forthcoming). And, for another thing, agricultural villages are typically founded by particular families or lineages that were first to ‘clear the bush’ and delimit the corresponding land territory. As a consequence, they retain a dominant socio-political position on account of their role as first settlers (see, e.g., Gruenais, 1986 : 290-91). Such is not the case in maritime fishing areas where the water space is not easily appropriable or delimitable by a particular lineage. Access is therefore more open and relationships between resource users more horizontal and decentralized.

Fourth, the dummy *ymarkay* represents another specific combination of age and marriage characteristics. It is equal to one when the fisherman is a relatively young person (between 24 and 35 years of age) who has one or several wives and is working in Kayar, while it is equal to zero when he does not fall into that age category or does it yet is still a bachelor¹⁵. The significantly negative coefficient of *ymarkay* means that this category of presumably prosperous and dynamic young fishermen tend to have an optimistic appreciation of the fishermen’s ability to enforce their regulatory measures (see Appendix II for a more detailed tentative explanation).

On the other hand, the migrant-native divide in Kayar does not appear to influence the subjective perceptions of rule-breaking : the coefficient of the variable *migrkay*, –a dummy with unit value when the fisherman is a migrant from Saint-Louis operating in Kayar, and with zero value otherwise– is non-significant. The same holds true of education, here measured by another dummy variable called *educ*, which takes on value one when the fisherman has more than either six years of coranic schooling or six years of primary school in French language, and zero value otherwise.

4.3 Econometric results : characteristics of fishermen with a positive assessment of the effectiveness of effort regulation

Since effort-regulation attempts in Senegalese maritime communities were historically motivated by the objective of countering the fishmerchants’ market power, fishermen were explicitly asked whether they believed that objective had been effectively attained, that is, whether catch limitations actually resulted in higher purchase prices. In addition, because there is increasing talk, at least in public meetings of various fishermen’s organizations (such as the Collectif National des Pêcheurs Sénégalais and the Fédération des Groupements d’Intérêt Economique), about the need to reduce pressure on fish resources thought to be threatened with over-exploitation, we have also asked fishermen whether they

¹⁵ To arrive at the specific combinations of age and marriage characteristics represented by the *leadkay* and the *ymarkay* variables, we have actually followed a progressive procedure that is more fully described in Appendix II.

believed that their effort restrictions were ecologically useful. The underlying idea is that beliefs about the likely effects of such restrictions either have an important influence on the actual behaviour of fishermen vis-a-vis the rules, or serve to rationalize their actions so as to prevent cognitive dissonance.

In order to differentiate the fishermen according to the way they answered these questions, we have chosen to estimate a multinomial logit model in which three dummies appear as dependent variables in three successive regressions: *econly*, which is equal to one when the fisherman professed a belief in the economic but not in the biological effect, and which is equal to zero otherwise; *bionly*, equal to one when the fisherman mentioned the biological but not the economic effect, and equal to zero otherwise; and *ecobio*, equal to one when the fisherman pointed to the two effects simultaneously, and equal to zero otherwise. The comparison group is composed of those fishermen who expressed clear scepticism about both the biological and economic effects of the regulatory measures. The objective pursued is therefore to identify factors susceptible of explaining adherence to the three other groups.

We have opted for estimating the model on the basis of the whole sample because, even in locations where no effort-limiting scheme has been attempted or more than short-lived, fishermen are usually well-informed about the existence of such schemes in Kayar and Saint-Louis. Quite significant results actually emerge from Table 6 where many new explanatory variables appear that are being defined in the course of the following discussion.

(i) The first thing to note is that fishermen operating in locations with a significant experience of regulation (line fishermen in Kayar and Yoff, purse seine operators in Kayar and Saint-Louis) are more prone to mention economic or ecological, or both effects than fishermen working in other locations. The coefficients of the variable *exper*, a dummy with unit value when the fisherman is in the former case and with zero value when he is in the latter case, are indeed highly significant in the three regressions. Such a neat finding may be interpreted in at least two different ways. On the one hand, it can be seen as an almost tautological confirmation of the fact that people did not start effort-limiting schemes in locations where they were not convinced that they could properly work. In other words, the causal relationship would be the opposite to that suggested by the estimated regressions. On the contrary, it might be the case that a regulatory experiment, once started for one reason or another in a given location, tends to breed confidence in the fishermen's ability to produce the expected benefits, or causes them to justify their regulatory efforts *ex post*.

(ii) Second, it is noteworthy that the variable *infrac*, -a dummy equal to one when the fisherman believes there are many rule violations, and equal to zero when he believes those violations are few- has a highly significant influence on *bionly*, yet no impact on *econly* or *ecobio*. In words, fishermen who point exclusively to biological effects of effort limitation, compared to those who do not mention any effect, tend to be simultaneously persuaded that regulatory

measures are not well followed or rigorously enforced. In fact, as many as three-fourths of such fishermen believe that rule-breaking is pervasive.¹⁶ According to us, this result throws a lot of suspicion on the seriousness of answers regarding biological effects. From various encounters, indeed, we gathered the impression that biological concerns are often voiced in a rather perfunctory manner by fishermen. Revealingly, local leaders often express the view that output regulation for commercial purposes should serve as a crucial step towards a much more difficult-to-attain objective, i.e., to bring awareness among fishermen of the need to manage the resource for the sake of its conservation in the long term.

The problem lies in the fact that many fishermen do not seriously consider the possibility of their being partly responsible for over-fishing and, therefore, the idea that they could combat environmental degradation by restricting their own fishing effort still seems alien to them. There is a clear tendency to externalize 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).¹⁷

(iii) Third, leaders from Kayar (see the *leadkay* variable in the third regression), as previously identified, tend to acknowledge both the economic and the biological effects simultaneously.¹⁸ Actually, the level of significance of the coefficient of *leadkay* in the third regression could be easily increased by removing one or two variables with which *leadkay* is strongly correlated, particularly the *owner* and the *purses* variables (see *supra*, our comments

¹⁶ Considering only the restricted sample of fishermen who have actually experienced an effort-limiting scheme, we find that about 66 percent of them have signaled the biological effect whereas about 61 percent of them have signaled the economic effect (whether jointly with the other effect or not). However, when only fishermen who believe in a low incidence of rule violations are taken into account, the proportion signaling the biological effect comes down to 54 percent while the proportion signaling the economic effect now rises to almost 70 percent. Note furthermore that, when the whole sample is considered, less than half of the fishermen signal the biological effect whereas almost 60 percent of them admit to the economic effect of effort regulation.

¹⁷ As should now be clear to the reader, we do not lend much credence to the following, alternative explanation behind the significant relationship between beliefs in rule-breaking and beliefs in ecological effects of effort limitation: 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 large scale.

¹⁸ The *leadkay* variable is dropped in the first regression because no leader has signaled the economic effect only.

around Table 5). Such a result is not surprising in the light of all what has been already said about their critical role in the initiation, laying down and implementation of the regulatory measures. What deserves to be emphasized here is that the Olsonian argument cannot be invoked to explain the leadership role played by comparatively wealthy fishermen. As a matter of fact, because of the large number of fishermen concerned by the regulatory measures in Kayar as well as the relatively low degree of concentration of asset ownership in the hands of the individual members of the local elite (who are heavily represented among purse seine owners),¹⁹ there is no way the benefits internalized by the latter can realistically cover the costs of initiating collective regulation, unless, of course, they could form a kind of coalition. The involvement of the elite in a variety of other activities suggests that political dividends, gains in terms of social prestige and recognition as well as perks²⁰, are the genuine benefits that comparatively wealthy fishermen can hopefully obtain from their leadership role.

(iv) Fourth, turning to the influence of fishing techniques, simple line fishermen have a higher propensity than operators of other techniques to state the two advantages of effort limitation (the coefficient of *purses* in the third regression is negative). A plausible explanation behind this result is that line fishermen target high-value species of fish for which price effects can represent large income increases. Furthermore, the rate of over-exploitation of these bottom-dwelling species appears to be more serious than that of pelagic species targeted by purse seine operators (see *supra*, Section 3, footnote 4). Regarding the latter effect, bear in mind that the influence of beliefs in rule-breaking is duly controlled for since *infrac* is present in the estimated equation.

On the other hand, those line fishermen who operate canoes equipped with ice boxes are comparatively reluctant to admit to the advantages of effort limitation, especially the economic effect. As a matter of fact, the coefficient of *icebox* - a dummy equal to one when the fisherman operates such a canoe, and to zero otherwise²¹ - is highly significant and strongly negative in the third

¹⁹ It is noteworthy that the average number of purse seine fishing units owned by members of the elite (as defined by our *leadkay* variable) works out to 3.111 to be compared with 1.873 for the other owners. In addition, 45 percent of the purse seine owners belong to Kayar's elite according to our definition (statistic inferred from our sample data).

²⁰ Thus, leaders belonging to fishermen's organizations do sometimes travel abroad upon the invitation of various non-governmental organizations in the northern hemisphere and international agencies such as the European Community. They also gain privileged access to logistical means (e.g., vehicles, telephones) put at the disposal of their organization by foreign funding agencies. They can even benefit from handouts coming from the government if the latter is willing to 'buy' their cooperation and avoid political spillover effects resulting from the formation of independent grassroot organizations.

²¹ When the two technological dummies, *purses* and *icebox*, have zero value, it means that the technique used by the fisherman is simple lines, bottom-set nets, or a beach seine

regression while it is close to significance and also negative in the first regression (yet far from significance in the second regression). This result no doubt reflects the aforementioned fact that line fishermen using ice boxes operate in conditions (long journeys out at sea) that make collective schemes of effort regulation especially hard to accept (see *supra*, Section 4). It therefore confirms the aforementioned hypothesis of Johnson and Libecap since they are comparatively dynamic fishermen who tend to be hurt by an uniform quota system that applies indiscriminately to all line fishermen.

A last but not least important finding related to the influence of technical heterogeneity is to do with the impact of *dist*, a dummy with value one when 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 with zero value otherwise. These fishermen can be considered to belong to the most dynamic and progressive sections of their fishing communities because they have responded to the 50 percent devaluation of the CFA (in 1994) by shifting to exportable species of fish and thereby showing their eagerness to seize upon new economic opportunities and their quick adaptability to changing circumstances.

From Table 6, it is evident that the coefficient of *dist* is highly significant and strongly positive in all the three regressions (in fact, the value of the coefficient turns out to be the highest in all of them), implying that, contrary to expectations, these dynamic and progressive fishermen have a very marked tendency to emphasize the importance and potential effectiveness of catch limitations. This directly follows from the fact that profitability of effort control resulting in a rise of unit producer prices is likely to increase with the initial level of these prices which is comparatively high in the case of exportable varieties which they specially target. Since the uniform quotas applied to all line fishermen are specified in quantity rather than value terms, the interests of the category of fishermen concerned here are not hurt as hypothesized by Johnson and Libecap. Economic analysis obviously enables us to understand the reasons underlying the different attitudes of the above two categories of dynamic fishermen vis-a-vis catch limitations.

It bears noticing that the majority of the progressive fishermen considered here are line fishermen belonging to Hann and Soumbédioune, that is, two locations with no real experience of effort limitation.²² This may seem strange since they could have acted as determined leaders in initiating and devising the

(fishermen using the latter two techniques are not numerous enough to make up a separate category).

²² More exactly, while their overall proportion is 11 percent in the whole sample, 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.

Table 6 : Multinomial logit estimates of the determinants of fishermen's beliefs in economic and biological effects of effort regulation (all locations and all fisheries)

	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]	
Log likelihood = -352.16769						
						Number of obs = 320
						LR chi2(39) = 147.31
						Prob > chi2 = 0.0000
						Pseudo R2 = 0.1730
1. econly						
exper	1.178039	.4878299	2.41	0.016	.2219098	2.134168
educ	.0883489	.3447767	0.26	0.798	-.5874011	.7640988
migrkay	-.1001034	.4929281	-0.20	0.839	-1.066225	.8660179
migrsou	(dropped)					
infrac	-.8140154	.6839465	-1.19	0.234	-2.154526	.526495
purse	-.5211292	.4419912	-1.18	0.238	-1.387416	.3451575
icebox	-.7565727	.5077676	-1.49	0.136	-1.751779	.2386334
dist	2.574937	.8172829	3.15	0.002	.9730914	4.176782
altinc	-.6441158	.3276672	-1.97	0.049	-1.286332	-.0018998
owner	.3394312	.3792033	0.90	0.371	-.4037936	1.082656
leadkay	(dropped)					
ymarkay	-1.63661	1.295696	-1.26	0.207	-4.176127	.9029083
exclus	.7522756	.3981906	1.89	0.059	-.0281636	1.532715
collus	.5580536	.3613722	1.54	0.123	-.150223	1.26633
cons	-1.210506	.4503323	-2.69	0.007	-2.093141	-.3278709
2. bionly						
exper	1.526973	.6433665	2.37	0.018	.2659979	2.787948
educ	.9408976	.464309	2.03	0.043	.0308687	1.850926
migrkay	-1.825366	.7766712	-2.35	0.019	-3.347613	-.3031181
migrsou	(dropped)					
infrac	2.298184	.659787	3.48	0.000	1.005025	3.591342
purse	-.1826157	.5219761	-0.35	0.726	-1.20567	.8404387
icebox	-.1458068	.7848137	-0.19	0.853	-1.684013	1.3924
dist	2.480358	.9877117	2.51	0.012	.5444785	4.416237
altinc	-.1268197	.3740559	-0.34	0.735	-.8599558	.6063164
owner	.2345744	.5027768	0.47	0.641	-.75085	1.219999
leadkay	1.948714	1.518434	1.28	0.199	-1.027362	4.924789
ymarkay	-.4679588	1.404365	-0.33	0.739	-3.220464	2.284546
exclus	-.1134151	.5500672	-0.21	0.837	-1.191527	.9646968
collus	.1348904	.4606805	0.29	0.770	-.7680267	1.037808
cons	-2.618907	.6173145	-4.24	0.000	-3.828821	-1.408993
3. ecobio						
exper	1.51357	.4621019	3.28	0.001	.6078672	2.419273
educ	.6629818	.335252	1.98	0.048	.0059001	1.320064
migrkay	-1.969361	.5882808	-3.35	0.001	-3.12237	-.8163513
migrsou	1.358992	.5981695	2.27	0.023	.1866012	2.531383
infrac	.6506135	.5829321	1.12	0.264	-.4919124	1.793139
purse	-.8800446	.4013151	-2.19	0.028	-1.666608	-.0934815
icebox	-2.03067	.6038505	-3.36	0.001	-3.214195	-.8471449
dist	2.849458	.8284455	3.44	0.001	1.225735	4.473182
altinc	-.1607671	.2559887	-0.63	0.530	-.6624958	.3409616
owner	.289335	.3610338	0.80	0.423	-.4182783	.9969483
leadkay	2.11969	1.212832	1.75	0.081	-.2574163	4.496796
ymarkay	.0654685	.9562028	0.07	0.945	-1.808655	1.939592
exclus	-.1754582	.4087137	-0.43	0.668	-.9765223	.6256059
collus	.37683	.3427116	1.10	0.272	-.2948724	1.048532
cons	-.6106197	.3859348	-1.58	0.114	-1.367038	.1457986

required regulatory measures. However, one should not lose sight of the fact that Hann and Soumbédioune are both located in the Dakar area with the consequence that they are strongly integrated into the most important fish market centre (see *supra*, Section 3). Unless quota restrictions are tightly coordinated between the various fish landing sites in and around Dakar, they have therefore no chance of succeeding. As a matter of fact, a fisherman of Hann who would want to evade local restrictions could easily move to Soumbédioune or another landing site to dispose of his catches if rules in the latter locations were rather poorly enforced. Of course, opportunistic behaviour would most probably characterize fishermen with smaller interests in the regulations, such as those operating canoes equipped with ice boxes, who are also a dynamic and venturesome lot. Under such circumstances, heterogeneity of the fishing population appears as a serious impediment to collective action.

Incidentally, note that the different impact on *eco* or *ecobio* of the variables *icebox* and *dist*, - which refer to two categories of (line) fishermen who go relatively far into the sea- implies that cost considerations are not an important motive behind effort-restraining attempts (if this were not the case, the coefficient of *icebox* would have come out with a positive sign).

(v) The next findings have to do with the influence of the native-migrant divide on the beliefs and assumed behavior of Senegalese fishermen vis-à-vis regulatory measures, whether they actually exist or not in their village. There are two results here. For one thing, we find that (temporary) migrant fishermen (from Saint-Louis) operating in Kayar tend to have a much more pessimistic appraisal of the effectiveness of these measures than native fishermen, as evidenced by the highly significant and negative signs of the coefficients of *migrkay* in the second and third regressions. Note also that these two coefficients have comparatively high values. Such a result bears out our aforementioned hypothesis that unresolved acute tensions around the use of passive gears in Kayar's waters by migrant fishermen rebound on the latter's attitudes and behaviors regarding effort limitations (see *supra*, Section 4).

In addition, 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: fishermen from Saint-Louis tend to be united in their antagonisms against native fishermen, whether permanent residents or temporary migrants, which might partly result from the fact that bottom-set net operators are actually found in both categories of fishermen.

For another thing, (temporary) migrant fishermen (again from Saint-Louis) operating in Soumbédioune have a marked proclivity to stress both the economic and biological effects of catch restrictions compared with residents.

Indeed, the coefficient of *migrsou*, –a dummy equal to one when the fisherman has this characteristic, and equal to zero otherwise– is highly significant and positive (and also of a relatively high value) in the third regression.²³ It is thus remarkable that migrant fishermen who are natives of the same fishing site have a completely different assessment of the usefulness of regulatory schemes according to whether they operate in Kayar or in Soumbédioune. Such a difference evidently reflects the above-stressed damaging social effects of protracted conflicts around the use of bottom-set nets in the former area which have never existed in the latter area. As for the fact that migrants in Soumbédioune are even more supportive of effort restrictions than residents, it is probably due to their having been exposed to an experience of such restrictions in Saint-Louis where market conditions are more conducive to effective regulation than in landing sites in and around Dakar (see supra).²⁴

(vi) Sixth, the coefficient of *educ* is significant and positive in the second and third regressions, meaning that more educated fishermen (with at least six years of French or Coranic school) are more inclined to signal the biological advantages of effort-restraining schemes, together with the economic advantages or not. This finding probably reflects the fact that people with a longer schooling experience have been more sensitized to the importance of environmental problems. 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 organizing collectively in order to reduce the power of merchants.

(vii) Seventh, fishermen involved in sales-tying debts with merchants tend to state the economic effect of catch quotas more often than fishermen who are free to dispose of their catches in whichever way they like. This is reflected in the positive sign of the significant coefficient of *exclus* in the first regression. Such a result is not surprising given that fishermen committed to particular merchants usually get lower prices for their landings (see supra). They are therefore more sensitive to the potential gains that can be earned through collective organization. On the other hand, since there is no reason why such

²³ Note incidentally that migrant fishermen from Saint-Louis operating in Soumbédioune never mentioned the economic or the biological effect alone (*migrsou* is perfectly predicted in the first two regressions).

²⁴ This interpretation is consistent with the following finding : the coefficient of *migrsou* in the third regression ceases to be significant if temporary migrants from Saint-Louis are clubbed together with permanent residents native of Saint-Louis. The implication is that, unlike what we observed in the case of Kayar, fishermen from Saint-Louis hold varying opinions depending on whether they are residents or temporary migrants who regularly return to their native location where attempts at effort limitation have been made.

fishermen should be more alert to the environmental benefits of collective action, the absence of significant relationships between *exclus* and either *bio* or *ecobio* is perfectly understandable.

(viii) The last significant effect is that of *altinc*, a continuous variable obtained through the principal component analysis method, and taken in logarithms, that is intended for measuring the extent of alternative incomes available to fishermen.²⁵ As is evident from Table 6, the coefficient of *altinc* is significant with a negative sign in the first regression. In other words, fishermen with more alternative income possibilities appear to be less sensitive to the economic impact of regulatory schemes. The prediction for the impact of this type of variable is actually ambiguous. On the one hand, when they can rely on complementary sources of income, fishermen can be expected to be 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. Yet, on the other hand, fishermen with greater alternative income opportunities may pay less attention to their fishing incomes and feel less ready to incur sacrifices in order to increase them. 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 within the household.

(ix) Finally, a few variables do not have any significant effect on *econly*, *bionly*, or *ecobio*. This holds true for *ymarkay* (already defined) and for *collus*, a dummy equal to one when the fisherman has explicitly mentioned the existence of collusive practices among fishmerchants, and equal to zero otherwise. Especially worth stressing is the absence of any influence of *owner*, another dummy which takes on unit value when the fisherman is an owner of

²⁵ The *altinc* variable has thus been constructed as the first principal component of a series of variables aimed at identifying the possible sources of alternative incomes available to fishermen. The selected variables are the following : the number of traders (whether in the fish or any other business) in the fisherman's household; the number of artisans or agriculturalists in the household; the number of employees (with a salaried income) in the household; a binary variable indicating whether someone in the household is engaged in an activity implying political responsibilities; and, lastly, another binary variable indicating whether the household owns some agricultural land or not. All the scoring coefficients attaching to these variables have a positive sign in the first principal component obtained through the multivariate analysis used. Note that other ways of defining the *altinc* variable have been tested –for example, by considering a simple dummy equal to one if at least one member of the household earns incomes from an activity other than fishing (and this includes activities centered on the marketing of fish, or organizational 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). The main, and reassuring, lesson from these different experiments is that changing the definition of *altinc* does not alter the results of the estimated multilogit model in any sensible manner.

fishing assets and zero value when he is a simple crew laborer. The fact that owners and crew do not hold different opinions regarding the usefulness of effort-limiting regulations is entirely according to our expectations (see supra, Section 4).

In contrast, when asked the following question –Do you think that you could personally benefit from the setting up in your village of a scheme centralizing the sale of all fish catches (in the way it is done in Joal for the octopus) ?– owners and crew workers answer in a highly differentiated manner. Indeed, the former turn out to be much more supportive of a centralized marketing organization than the latter. A plausible explanation behind the workers' reservations lies in the fact that a sales organization, so they believe, is likely to 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, competitive sales carried out on the beach are much more transparent than those which would be run through a centralized organization.

4.4 Econometric results : characteristics of fishermen with a positive attitude vis-a-vis a centralized sales organization

In fact, an econometric attempt at identifying the characteristics of fishermen who support or do not support the creation of a centralized sale organization yields unexpectedly good results. Those results are reported in Table 7 in which the dependent variable, labeled *saleorg*, is a binary variable set to one when the fisherman expresses support, and to zero when he does not. All explanatory variables have already been defined.

In addition to the above-stressed, highly significant influence of the *owner* variable, several other characteristics appear to bear upon the fishermen's attitudes regarding the creation of a centralized sales organization. Thus, progressive fishermen bent on catching valuable species in distant fishing grounds (those for whom *dist* = 1) tend to oppose a marketing organization. This contrasts with their positive attitude vis-a-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 and managing a viable sales organization. On the other hand, leaders from Kayar show a strong support for such an organization (note the high value of the coefficient of *leadkay*) which they were actually trying at the time of the survey and which they strongly defended in public meetings (which we attended) in spite of the serious problems that we pointed out to them.²⁶

²⁶ In actual fact, they acquired a second-hand truck (donated by a fishermen's organization from Brittany, France) in order to transport the collected fish to Dakar and sell it directly to fish-processing factories. The experience was far from successful since the leaders concerned

Their attitude seems to be one of indiscriminate support for any sort of collective action that unites fishermen together.

Table 7: Logit estimates of the determinants of fishermen's support for a centralized marketing organisation (all locations and all fisheries)

saleorg	Coef.	Std. Err.	z	P> z	[95% Conf. Interval]
exper	.3517422	.3589815	0.98	0.327	-.3518485 1.055333
educ	.3703224	.2628684	1.41	0.159	-.1448901 .885535
migrkay	-.4722798	.4146468	-1.14	0.255	-1.284973 .3404131
migrsou	-1.128803	.5377852	-2.10	0.036	-2.182843 -.0747638
infrac	.6618487	.412135	1.61	0.108	-.1459209 1.469618
purse	-.6563138	.3154664	-2.08	0.037	-1.274617 -.0380111
icebox	.555796	.4463842	1.25	0.213	-.3191011 1.430693
dist	-.8764431	.4181625	-2.10	0.036	-1.696027 -.0568596
altinc	-.525266	.214819	-2.45	0.014	-.9463035 -.1042286
leadkay	2.132948	1.16829	1.83	0.068	-.156859 4.422755
jmarkay	-.8699168	.7094797	-1.23	0.220	-2.260471 .5206379
owner	1.041513	.2907046	3.58	0.000	.4717425 1.611283
exclus	.1077307	.316558	0.34	0.734	-.5127115 .728173
collus	.1292957	.2697297	0.48	0.632	-.3993648 .6579561
cons	-.2169205	.315327	-0.69	0.492	-.8349501 .4011091

Log likelihood = -185.09259

Number of obs = 320
 LR chi2(14) = 44.18
 Prob > chi2 = 0.0001
 Pseudo R2 = 0.1066

Interestingly, fishermen operating purse seines tend to have a negative opinion about the role of a sales organization compared to other fishermen. The explanation behind this different attitudes 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 fishermen's organization to specialized 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 decentralized network of fishmerchants operating at wholesale and retail levels.

Another highly significant determinant is provided by the *altinc* variable. Fishermen with alternative income opportunities appear to be opposed to a centralized marketing organization even controlled by the fishermen themselves. A possible reason underlying this negative attitude is the following: 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 organization and they tend to communicate their scepticism to their relatives specialized in fishing activities. Another, probably more convincing explanation is simply that household members engaged in fish marketing, when this is the case, view the creation of a centralized sales organization as a direct threat to their own business and livelihood.

were eventually obliged to rent the truck out to local fishmerchants so as to be able to repay the debts incurred.

An additional result emerging from table 7 is the positive influence of the *infrac* variable. True, the level of statistical significance is only 90 percent, yet this is mainly due to the fact that this variable is strongly correlated with some others present in the regression (*leadkay*, for example). The fact that fishermen who have a pessimistic stance about enforcement of catch quotas tend to have a positive attitude vis-a-vis the establishment of a marketing organization is not really surprising. For them, it seems, the latter provides an alternative organizational form which would hopefully raise fishermen's incomes more effectively than quotas.

Finally, we find that migrant fishermen operating in Soumbédioune are opposed to the idea of a centralized sales organization (the value of the coefficient of *migrsou* is the highest after that of the coefficient of *leadkay*). And if permanent residents native of Saint-Louis are clubbed together with temporary migrants from the same location, the (negative) effect becomes even stronger and more significant.²⁷ We have no ready explanation for this last finding.

5. Conclusion

Given that attempts at effort limitation in Senegalese small-scale fisheries have been clearly motivated by economic rather than by ecological considerations, and by output price rather than input price considerations, it is evident that such attempts cannot yield satisfactory effects if demand is perfectly elastic with respect to prices, such as happens under well-integrated markets approximating perfect competition. It is revealing that effort-restrictions tend to have been longer sustained precisely in the areas and the fisheries in which negative price-effort elasticities have been observed. It is nevertheless useful to inquire into the complementary role of various dimensions of group heterogeneity that are likely to shape fishermen's attitudes towards effort regulation. This is so not only because a conducive market structure is a necessary but not sufficient condition of successful regulation, but also because fishermen, at least in the short run, do not arguably have a good understanding of the critical role of the prevailing market structure (they might thus embark upon non-sustainable effort-limiting efforts).

What are thus the main lessons to be drawn from our inquiry, bearing in mind that our results are based on opinions privately expressed by fishermen in a sample of locations and fisheries that may or may not have succeeded in laying

²⁷ Operating a similar clubbing for fishermen from Saint-Louis operating in Kayar does not alter the results : there is no influence of the native location on the opinions expressed by fishermen of Kayar about the issue at hand.

down and implementing effort-restricting rules during a significant period of time?

To begin with, *wealth inequality* does not appear to have been a serious impediment to collective action. In the most successful case, that of Kayar, the evidence even points to the positive role of the wealthy local elite made of prosperous polygamous elders who, it must be admitted, also often enjoyed high positions in the traditional social structure. Such a finding, however, does not bear out the Olsonian hypothesis according to which wealthier resource users may be more willing to initiate and organize collective action because they internalize a comparatively large share of the expected benefits. (Bear in mind that effort restrictions under all existing schemes are strictly proportional to the asset base). Political dividends and social prestige gains seem to be the real motive prompting Kayar's elite to bear the costs of initiating collective regulation.

Moreover, the division between owners of fishing assets and simple crew workers does not hamper the effectiveness of effort limitations: other things being equal, the latter are as supportive as the former of attempts in that direction. This is not surprising at all since a large part of labor remuneration is calculated as a proportion of the proceeds from the sale of the catches. By contrast, when inequality in asset ownership is reflected in the fact that poorer owners have got indebted to fishmerchants to whom they have committed their landings while more well-to-do owners remain free from such sales-tying debts, it is bound to hamper collective action. The evidence here is compelling: in fisheries or locations where the proportion of fishermen entangled in credit-cum-marketing relationships is quite large, no regulatory measures have been attempted. This is in spite of the fact that tied fishermen appreciate the potential (economic) advantages of such measures even more than the others.

Technical heterogeneity is potentially an important obstacle to collective organization. This is most vividly illustrated by the failing attempts to share the fishing space of Kayar's inshore waters between operators of passive gears and those of active gears. As far as catch-restricting schemes are concerned, however, the problem of technical heterogeneity has been generally well overcome by devising measures specific to each fishery or technique so that peculiar characteristics could be taken into account (the case of Kayar again springs to mind here). A major problem remains with line fishermen operating canoes equipped with ice boxes (all found in the Dakar area) who, for understandable reasons related to the long journeys they are making out at sea, are strongly opposed to effort restrictions. Their attitude is thus at variance with that evinced by other line fishermen who are involved in one-day fishing trips and essentially target the same species.

The native-migrant divide has proven a rather intractable problem in the otherwise successful case of Kayar. None the less, it bears emphasis that the difficulties encountered within regulatory schemes enforced for operators of

lines and purse seines among whom there are both native and migrant fishermen, –the latter being much less supportive of the schemes than the former– are largely a reflection or an upshot of a deep antagonism originating elsewhere. This is the acute and prolonged conflict that has always opposed these two categories of fishermen around the use of passive gears (bottom-set nets) which are exclusively operated by migrant fishermen from Saint-Louis against the will of native people (see supra). In other words, the problematic factor here is the polarization that has been caused by the total specialization of migrant fishermen in the debatable technique. Confirmation of this interpretation is provided by the available evidence for a fishing village located near Dakar (Soumbédioune) where, as a matter of principle, migrant operators did not show less support for regulatory measures as native operators (the opposite is actually the case). In this instance, indeed, no polarization process has been created by the use of passive gears that are not suitable in this area.

Skill heterogeneity is probably the most serious hurdle standing in the way of effective collective regulation. It is also a dimension of heterogeneity that is not easy to observe or measure because people are not willing to disclose their assessment of relative rankings in terms of competence or skills. This said, we are fortunate enough to have available to us a good (partial) proxy of skills in so far as fishermen who have quickly adapted to a substantial devaluation of the CFA money (in 1994) by shifting to exportable species even at the cost of longer-distance journeys can no doubt be considered as comparatively progressive fishermen. (At least, this holds true for line fishermen). It is worth noticing that the most statistically significant result of our study precisely concerns that category of fishermen and unambiguously shows that they are strong supporters of effort-restricting measures. In fact, the standard argument that comparatively skilled resource users are susceptible of losing most from uniform catch quotas and should therefore oppose them does not apply in the case under study. The reason is straightforward : since they target the most valuable (exportable) species, they are actually the most likely to gain from unit price increases possibly resulting from collusive practices among producers.

Line fishermen using ice boxes and travelling far away on long journeys to also catch valuable species of fish can equally be considered among the most skilled fishermen employing hooks and lines. In their case, as has been pointed out above, opposition rather than support regarding catch quotas is the rule. Such a difference between the two categories of relatively progressive and skilled line fishermen is perfectly explainable in terms of economic analysis : to sum up, while the interests of the former (who adapted quickly to devaluation) are not hurt by uniform quotas (specified in quantity rather than value terms), those of the latter (equipped with ice boxes) are especially damaged owing to the presence of sizeable fixed costs.

Finally, *heterogeneity in terms of access to alternative income sources* constitutes a potential problem that ought not to be downplayed. As a matter of

fact, intra-household opinion divergences and conflicting positions are bound to arise regarding the usefulness of effort-restricting measures if some members (typically the fishermen's wives) are engaged in fish marketing and their interests are going to be hurt as a result of such measures. This possibility is confirmed in our study.

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APPENDIX I : Estimating inverse demand functions for various species of fish and various locations

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 labor 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 :

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

$$\text{(supply)} \quad \log Q_t = \bar{a} + \varepsilon * \log P_t^e + v_t$$

$$\text{(inverse demand)} \quad \log P_t = \phi + \rho * \log Q_t + \acute{o} * \log P_{t+1}^e + \grave{e} * \log P_t^{\text{subst}} + w_t$$

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 \hat{a} and \hat{g} , which are real vectors, and \hat{a} , \hat{a} , e , f and r , 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).

APPENDIX II : Identification of fishermen according to their assessment of enforcement performances

In order to determine the characteristics of the fishermen who believe that the incidence of rule-breaking is large, we started by estimating a logit model in which explanatory variables include an indicator of wealth, –the continuous variable *wives*, which measures the number of wives of the fisherman–, an indicator of the age of the fisherman, –another continuous variable, *age*, measured in years–, a variable determining whether the fisherman is an equipment owner or a crew labourer –the dummy *owner* with value one if he is an owner and with value zero otherwise– plus the variables *exclus*, *pursese*, *migrkay*, and *educ* which have been already defined in the text. Note incidentally that there is not 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). The results of this first attempt are shown in Table II.1 below.

Table II.1 : Logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking

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
pursese	-.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

Log Likelihood = -76.883164

Number of obs = 127
chi2(7) = 18.80
Prob > chi2 = 0.0088
Pseudo R2 = 0.1090

A striking finding is that, controlling for age, fishermen with more wives –that is, comparatively rich fishermen– 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: 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. 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.

(ii) 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)²⁸.

²⁸ It is certainly not easy to explain why 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 ? 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)²⁸ 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. 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

Table II.2 summarizes these findings in the light of which it is now possible to improve upon the initial econometric model. Towards that purpose, we give up the rather rough explanatory variables measuring the fishermen's age and number of wives and replace them by the *leadkay* and *ymarkay* dummies (see the main text for definition). The new results are displayed in Table II.3.

Table II.2 : 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 %)

Table II.3 : A new logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking

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
pursese	-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

Log Likelihood = -75.335438

Number of obs = 127
chi2(7) = 21.90
Prob > chi2 = 0.0026
Pseudo R2 = 0.1269

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 can be put 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 realize that collective regulations are plagued with the opportunistic acts of a significant number of them and they come to a more realistic assessment of the effectiveness of their enforcement. In this, they exhibit more flexibility than the old elite whose identification with the regulatory measures is stronger. 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.

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 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. It is therefore easy to make the *leadkay* variable become statistically significant by removing some correlated variable(s). This is done in Table II.4 where the *owner* variable has been left out, which is sufficient to cause the coefficient of *leadkay* to become significant. On the other hand, while the coefficient of *educ* was significant in Table II.1, it is no more so in Table II.3 and Table II.4.

Table II.4 : A new logit estimate of the determinants of fishermen's beliefs regarding the extent of rule-breaking (ownership variable omitted)

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
purse	-.9869905	.4222457	-2.337	0.019	-1.814577	-.1594042
exclus	.9430304	.5326338	1.771	0.077	-.1009126	1.986973
cons	.0151894	.3768604	0.040	0.968	-.7234434	.7538221

Number of obs = 127
chi2(6) = 20.92
Prob > chi2 = 0.0019
Pseudo R2 = 0.1213

Log Likelihood = -75.822999