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**An investigation of factors
affecting compliance
with fisheries regulations**

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An investigation of factors affecting compliance with fisheries regulations

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Abstract

Economic analysis of regulatory compliance often centres on an instrumental determination of individual behaviour in which the decision to violate regulations depends upon the anticipated net gains of doing so. This approach holds that, other things being equal, compliance will occur when the expected costs are greater than the expected benefits of violating regulations. The policy implication is that achieving a desired level of compliance requires either an increase in the expected costs of violation or an increase in the expected benefits of compliance. A more complete model of compliance behaviour would take into account social norms and other factors, including those associated with the "legitimacy" of regulations and the regulatory authority. We describe a current investigation into the factors affecting compliance with catch restrictions among UK fishermen and discuss some preliminary results from the study.

Introduction

In fisheries where a number of independently-operated vessels compete for a share of the catch there is a tendency for the fish stock to become over-exploited. As long as the market price for fish is high enough relative to the financial costs of fishing, and where firms have no incentive to limit their catches in order to minimise the effects on (a) the present catches of other vessels in the fishery and (b) the future productive potential of the stock, it is likely that yields from the fishery will be reduced to relatively low levels. Exacerbating factors will include technological progress, relative immobility of invested capital, low opportunity costs for labour in coastal regions and stochastic fluctuations in stock size. In extreme cases stocks may collapse and a profitable fishery becomes impossible.

For these reasons most fisheries are regulated to some extent, usually either directly or indirectly by the State. Regulations commonly take the form of restrictions on the number of vessels allowed to participate in the fishery, restrictions on other inputs (such as vessel size, engine power, size and type of gear, fishing time, etc.) and often also restrictions on catches (by means of quotas). If such regulations are to achieve their desired results compliance by fishermen is crucial, but compliance may be difficult to achieve if financial incentives exist to violate the regulations.

A fundamental problem in the regulation of a fishery is that it is very difficult both to define and then to control fishing "effort", which may be thought of as the totality of the catching power of the fleet. Regulations designed to control effort directly, although they tend to be relatively easy to enforce, are often not very effective and become increasingly ineffective in the face of advances in fishing technology. As a result such regulations usually have to be further tightened over time and supplemented with additional regulations. State-funded vessel decommissioning programmes may also be implemented in an attempt to control the expansion of fishing effort.

As a consequence, the catching power of the fleet often exceeds the level of catches which the regulator wishes to impose. Regulations designed to control catches directly (such as quota restrictions) therefore represent a significant constraint on the efficient operation of many fishing firms and strong financial incentives exist for vessels to violate quota regulations. Restrictions on quantities of fish landed, however, are often very difficult (and hence costly) to enforce.

In most fisheries management regimes, considerable resources are devoted to enforcement. Within the European Community, for example, the total annual cost of monitoring and enforcement of fisheries management systems is estimated to be around ECU 300 million (Commission of the European Communities 1997). It is often difficult, however, to measure the extent of violation and hence the productive value of enforcement expenditure (Sutinen and Hennessey 1986).

In comparison with the extensive economics literature which exists on the design and implementation of fisheries management instruments and policies, relatively little attention has been paid to the question of compliance and enforcement. Most economic studies of the enforcement problem in fisheries have moreover been theoretical rather than empirical, focusing on the impact of costly and imperfect enforcement on optimal levels of exploitation in a regulated fishery (e.g. Sutinen and Andersen 1985, Milliman 1986) and on the selection of efficient regulatory instruments (e.g. Anderson and Lee 1986, Anderson 1989, Mazany *et al* 1994)[1]. Relatively few studies have attempted to identify the determinants of individual

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[1] See Mazany (1993) for a review

fishermen's compliance behaviour and to measure their effects in relation to fisheries management objectives.

In this paper, we describe a current investigation into the factors affecting compliance with catch restrictions among UK fishermen. The study was designed, in particular, to examine the influence of various non-monetary factors in determining compliance with quantitative landings restrictions (quota limits).

1. Background: explaining individual compliance behaviour

1.1 Deterrence models

In most theoretical studies of fisheries law enforcement, as well as some empirical studies (see below), the approach to explaining individual compliance behaviour is based on the application of the economic theory of decision under uncertainty, following models originally formulated by Becker (1968) and others to explain criminal activity[2].

The central hypothesis of these models is that individuals choose to allocate their resources in a way that maximises the *expected utility* derived from their activities[3]. As with any other activity, illegal behaviour gives rise to an expected utility which can be related, positively or negatively, to a variety of factors, such as monetary benefits and costs, goods (and bads), as well as "psychic" factors (Mazany, 1993).

Applications to fisheries law enforcement have tended to concentrate on the role of monetary factors, leading to models of behaviour which are specified in terms of *net benefits*[4]. In these applications, *costs* associated with illegal fishing usually include the total costs of undertaking such an activity (including the avoidance and opportunity costs of illegal fishing), as well as the anticipated costs of sanctions, defined as a function of the subjective probability of detection and conviction and the anticipated penalty. The *benefits* of illegal fishing usually include the monetary value of the illegal catch. Models predict that the individual will engage in illegal fishing as long as the expected net gains of doing so exceed the expected net gains of complying with the regulations.

While such models do not require that all agents have an equal propensity to violate under a given set of conditions, they suggest a common explanation of illegal activity, based on the existence of positive monetary incentives to violate regulations. The level of violation is thus defined as being inversely related to the probability of detection and conviction and to the size of the expected fine, and positively related to the net gains from illegal - as opposed to legal - fishing . Others things being equal, a higher probability of detection and prosecution (i.e. higher enforcement effort) and/or an increased severity of sanctions will deter fishermen from fishing illegally, leading to a greater overall level of compliance with regulations.

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[2] See, for example, Pyle (1983) for a review

[3] The concept of utility is central to economic theory. It corresponds to the capability for an agent to order the actions available to him according to their anticipated consequences. This is achieved by defining a utility function which, by assigning a unique value to the consequences of possible actions, allows those actions to be classified according to an individual's preferences. A rational agent, given all the information necessary, will in theory act in such a way that he maximises his utility. This representation of individual behaviour rests on axioms of coherence of individual preferences and deductive reasoning. Utility theory, therefore, explains actions, not motives.

[4] For a formal presentation of the deterrence model applied to fisheries law enforcement, see for example Sutinen and Andersen (1985).

Such *deterrence models* imply that regulatory policies should aim at modifying the monetary incentives individuals face in making their decisions about compliance, so that their utility-maximising behaviour leads to improved public outcomes. A related implication is that while in theoretical situations of perfect and costless enforcement it should be possible to ensure full compliance, where enforcement is imperfect and costly - which may be considered typical of many fisheries - a positive level of illegal fishing may appear socially optimal. This is because, at that level, the extra benefits associated with a reduction of illegal catch may not warrant the additional costs of monitoring and enforcement. To the extent that the deterrent effect is a simple function of the probability of detection and prosecution and of the size of the penalty, an efficient solution to the problem of fisheries law enforcement would thus appear to involve relatively low enforcement efforts and expected penalties as high as possible.

1.2 Empirical studies: the importance of non-monetary factors.

Empirical studies on individuals' compliance with fishery regulations have been reported by Sutinen and Gauvin (1989), Furlong (1991) and Kuperan and Sutinen (1995). Both Sutinen and Gauvin (1989) and Furlong (1991) explicitly recognise factors other than those directly related to the monetary costs and benefits of violation in the determination of compliance behaviour, but their influence is not fully explored. Furlong (1991) includes in his theoretical compliance model a vector of variables to capture "personal and household" characteristics. In his estimation of the model using data from a survey of Canadian fishermen he includes variables for age, the proportion of the family currently unemployed and the proportion of family income derived from fishing. These are designed to serve as proxies for individual differences in attitudes and proclivities towards violation. Sutinen and Gauvin (1989), in their study of compliance in the inshore lobster fishery of Massachusetts, similarly hypothesise that the incentive to violate is influenced by personal characteristics such as age, years in the fishery and income dependence.

Sutinen and Kuperan (1995) note that conventional deterrence models do not adequately explain observed enforcement and compliance patterns in fisheries (e.g. Sutinen *et al* 1990). In practice, the costs of enforcing fisheries regulations generally result in relatively low probabilities of detection, but penalties are not usually sufficiently high to produce a deterrent effect. Despite this, the authors observe that a high proportion of fishermen comply with regulations. This leads them to look for other factors explaining individual compliance behaviour. The authors develop an extended model which, alongside monetary incentives, includes variables such as "moral obligation" and "social influence". In their model, moral obligation includes variables related to moral norms, as well as the perceived legitimacy of the regulator and the regulations. The authors underpin their empirical model with the theoretical assumption that these non-monetary variables can be included in an extended utility function[5]. Kuperan and Sutinen (1995) use this model to examine compliance with fisheries zoning regulations in Malaysia. From an analysis of survey data they conclude that moral and

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[5] As Baland and Platteau (1996) point out, this is not without conceptual problems. For example, there is no single view in economics about how voluntary contributions to public goods (e.g. charities, blood donation, etc.) can be explained. Altruism is one motive which could explain such behaviour. One solution that has been proposed is to incorporate "concern for others" into the individuals' utility function: in other words, individuals derive utility from the welfare of others. However, this means that the welfare of others, itself, becomes a public good from which all individuals derive utility, and this recycles the problem of explaining how such a public good can be supplied voluntarily. Radical alternative approaches have been proposed. Etzioni (1988), for example, argues that while moral norms and self-interest may act together to determine an individual's actions, they should be considered in terms of two entirely separate and irreducible utilities.

legitimacy factors are important in determining levels of compliance, which cannot therefore be explained entirely in terms of a cost-benefit calculus.

This observation has two interesting implications. Firstly, it becomes theoretically possible to observe full compliance, even where enforcement is imperfect and costly, if the regulations accord with the individual's sense of what is "right" and the regulator and regulations are considered legitimate (see below). Secondly, there is a possibility that the policy recommendations of the deterrence model might lead to counterintuitive results: if violation occurs because regulations conflict with moral values or perceptions of legitimacy, an increase in penalties or enforcement effort might actually lead to higher, rather than lower, levels of illegal activity.

1.3 Extended models of individual behaviour

Several authors have considered the role of social norms in explaining individual compliance behaviour in fisheries. Sutinen and Kuperan (1995) observe that many fishermen refer to the need to "do the right thing" in justifying their behaviour. According to Baland and Platteau (1996), people will be more willing to comply with regulations if they perceive the regulations as "appropriate" and consistent with their views about justice. In a review of the literature on fisheries regulation, Cross (1993) notes that the importance of "goodwill" on the part of the fishermen is often acknowledged, though rarely explored in detail.

It would therefore seem that (i) individual perceptions of "what is right" influence compliance decisions; (ii) such perceptions may also determine the perceived legitimacy of rules and regulators; and (iii) greater legitimacy leads to greater observed compliance.

In a study of compliance with the law, Tyler (1990) reviews different perspectives from which individual behaviour has been explained in the social sciences. From his discussion, three main categories of factors that could influence compliance with fisheries regulations can be identified.

- **Social control factors**: behaviour is influenced by conditions *external* to the individual, determined in part by the authorities, which have an impact on his utility. As in the deterrence model discussed above, the focus for the authorities is then on altering behaviour *by changing the environment* in which individuals make decisions.

- **Normative factors**: behaviour is influenced by norms *internal* to the individual. In this case, the individual may conform to regulations because of a personal attitude such a decision, rather than its consequences for him. It is the act of conforming or deviating from a regulation *in itself* that appears important in this case. For example, individuals might comply with a regulation even when violation would go undetected and thus unsanctioned. Indeed, the importance of normative influences in the context of law enforcement is that they may lead individuals to act against their self-interest.

  Tyler distinguishes two types of factors explaining such behaviour: (i) *personal morality*: the individual's sense of what is right and wrong. This may or may not accord with the regulation considered and its objectives, and may thus act in favour or against compliance; and (ii) the *legitimacy* of the regulation, the regulatory process and the regulatory authority. This relates to the recognition (or denial) by individuals of the right of an external authority to dictate their behaviour (see Sternberger, 1968), whatever the nature and consequences of the obligations imposed on them. It will therefore always act in favour of compliance.

- **Social relations factors**: individual behaviour is influenced by other people's judgement and

behaviour. The influence of the group may appear as a form of social control, for example through the use of rewards and punishments. Such influences are not controlled by public authorities, but act in a similar manner to public deterrent effects. Alternatively, they may appear as normative if the individual derives his perception of appropriate conduct from the social group to which he belongs[6].

The present study aimed at applying this typology to the explanation of fishermen's compliance behaviour with quota restrictions. We were specifically interested in whether the sort of findings reported by Kuperan and Sutinen (1995) might be observed in the complex political and regulatory environment of a European fishery, and in particular in the extent to which perceptions of the legitimacy of the regulations and the regulatory authorities might have a measurable impact on levels of compliance.

Our approach to investigating the role of normative and social influences on fishermen's compliance behaviour is based on that employed by Tyler (1990) in his "Chicago study" of US citizens' compliance with the law. Legitimacy is assessed with primary reference to a particular regulation and regulatory system rather than to an authority in general terms, so that the obligation to comply perceived by individual fishermen is measured more or less directly. Where appropriate, attention is focused separately on *process* and *outcome* and on *fairness* and *efficiency* (or effectiveness): in other words, is the regulation effectively and fairly enforced, and is the regulation itself effective and fair in the results it produces?

2. Survey description

Sea fisheries in the UK are regulated within the framework of the common fisheries policy of the European Community. In particular, the UK Government is required to implement measures to restrict the total volume of landings of a number of commercially important fish stocks to within agreed national quotas. Under the UK's quota management system the bulk of national quotas are allocated each year to nineteen officially recognised *producers' organisations* (POs) to which most of the fleet belongs. Each PO is then responsible for the uptake of its quota allocations by its membership[7]. A small portion of each national quota is retained by the Government for those vessels which do not belong to a PO (so called "non-sector" vessels).

The regulatory environments under which the non-sector and PO vessels operate are somewhat different. Non-sector vessels must comply with the monthly quota restrictions (set directly by the Government) which are specified in their licences. PO members, on the other hand, are subject only to the restrictions imposed by their own PO. Non-sector vessels commit an offence if they land more than the quantity specified in their licence within a calendar month. No such offence applies to PO members since if they exceed their restrictions they are merely infringing the (private) rules of their PO. In practice, however, all violations are hidden from both the Government Sea Fisheries Inspectorate and the POs' officers by falsifying landings declarations which are monitored by the POs as well as by Government. Whereas the logbooks required to be kept at sea allow a 20% margin of error in recording quantities of fish retained

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[6] The separation between legitimacy, personal morality and self-interest is not an easy one, nor is legitimacy a singular or absolute concept. For example, it appears that legitimacy as a normative influence should be enduring and constant as the circumstances of individual action change. If, on the other hand, legitimacy is judged contemporaneously in terms of the outcomes or the regulatory process, it could be said simply to reflect self-interest.

[7] Hatcher (1997) describes the management of quotas by producers' organisations in the UK.

on board, landings declarations must be accurate. Despite the legalistic differences, therefore, in practice the act of violation is the same for all vessels: violation means exceeding quota restrictions and falsifying logbook records and/or landings declarations (certainly the latter).[8]

The study population was the fishing industry of the X region of England[9], including all vessels of over 10m in length and subject to quota restrictions. Vessels of 10m or under in length were excluded, since these are not normally subject to quota restrictions under the UK's quota management system. Vessels of over 10m which do not target quota species were also excluded. Three sub-populations were identified: vessels belonging to PO A, those belonging to PO B and non-sector vessels based in the region. Sampling was done on a stratified random basis within each sub-population. PO vessels were stratified by vessel size (10-20m and over 20m) and by fishing method while the smaller number of non-sector vessels was stratified by size only. The final sample size and composition is summarised in Table 1 below.

Table 1: *Sample details*

Population	Population size	Sample size
PO A vessels	115	34 (30%)
PO B vessels	75	23 (31%)
Non-sector vessels	45	12 (27%)
All vessels	235	69 (29%)

All data were collected by means of face-to-face interviews with the skippers of the selected vessels during the winter of 1997/98. Structured questionnaires were used in order to record respondents' perceptions about the effectiveness and fairness of quota restrictions, the effectiveness and fairness of enforcement, the authority of management institutions, the involvement of fishermen in the management system, the compliance behaviour of others, personal experience of enforcement and conviction, as well as own compliance behaviour and expected costs of illegal fishing if detected and sanctioned. Additional questions were designed directly to elicit perceptions of moral obligation to comply with quota restrictions. The age of the skipper, his length of involvement in the industry, his owner/employee status, the size of the vessel and its gross annual turnover were also recorded.

3. The data

A significant degree of self-reporting of violation behaviour was observed in the study. From a total of 69 respondents interviewed only one refused to answer questions about his own compliance record. Of the remaining 68 respondents, 18 (26%) stated that they did not exceed quota restrictions in the previous year, 30 (43.5%) stated that their landings of quota species were over-quota by 10% or less, while 20 (29%) admitted that their landings had been over-quota by a margin of 25% or more (see Table 2).

Table 2: *Over-quota % of landings*

Response	%	Frequency

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[8] The statutory maximum penalty in UK law for submitting a false landings declaration is £50,000.

[9] Because of the sensitive nature of the data the study region is not identified.

0%	26.1	18
10% or less	43.5	30
25%	13.0	9
50%	8.7	6
75%	5.8	4
100%	1.4	1
Refused	1.4	1
Total	100.0	69

Similarly, 18 respondents (26%) stated that none of their gross earnings in the previous year were attributable to over-quota fish, 24 (35%) stated that 1-2% of their earnings came from over-quota landings while 26 (38%) said that 5% or more of their earnings were due to over-quota landings (see Table 3).

Table 3: *% gross earnings from over-quota fish*[10]

Response	%	Frequency
0%	26.1	18
1-2%	34.8	24
5%	10.1	7
10%	10.1	7
20%	10.1	7
30% or more	7.2	5
Refused	1.4	1
Total	100.0	69

Tables of responses to a selection of the questions designed to explore respondents' perceptions of legitimacy and the importance of social influences, as well as the expected probability of being caught and prosecuted, are given in the Appendix.

Considering the sample as a whole, a third of the respondents perceived the probability of getting caught landing over-quota fish to be relatively high (25% or more) while nearly half thought the risk was much smaller (5% or less).

With regard to the perceived legitimacy of the quota regulations themselves, 84% of respondents thought that quotas were ineffective in conserving fish stocks but less than 60% thought they would still be ineffective even if complied with. More than two-thirds of respondents considered the quota restrictions applied to their vessel to be unfair. Almost a third of respondents thought that most fishermen in the region did not comply with quota restrictions, while a further 25% thought that many did not comply. Only 16% thought that quotas were exceeded by just a few fishermen.

Around 65% of respondents considered that quota restrictions were well or adequately enforced and more than three-quarters thought that the enforcement process was fairly applied.

Assessing the legitimacy of the regulatory authority is complicated in the context of fisheries management in the UK because of the obligations under the EC's common fisheries policy which is almost universally reviled by the domestic fishing industry. The issue was explored in

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[10] This variable was used to model compliance behaviour as described in the next section. Note that this table is not directly comparable with the previous one because total earnings include revenues from landings of non-quota species.

a number of questions, some of which related to local management by the POs and some of which related to possible changes in the management system: themes which are still under study. Asked whether they agreed that the Government had a duty to control their catches as a member of the EU, however, just over half of all respondents said that they did.

Less than 15% of respondents said that they felt significantly involved in the design and implementation of the fisheries management system while more than two-thirds felt uninvolved or actively ignored.

Asked about the compliance behaviour of their peer group, around half of respondents thought that most or all were compliers and just under a third thought that many or most were regular violators. Some 68% considered the view of their peers to be that violating quota restrictions was basically wrong but an economic necessity. Only 4% thought the view was that exceeding quota restrictions was very wrong, while just under 19% considered that the general attitude was that violation was not wrong.

A series of questions were designed to gauge overall moral obligation to comply by recording agreement or disagreement with certain value statements. More than half disagreed that quota restrictions should be complied with because they are the law, while over three-quarters disagreed that quota restrictions should be complied with because otherwise one is taking more than one's fair share. Nearly as many disagreed that quota restrictions should be complied with even if one thinks they are not effective or fair.

4. An econometric model

An econometric model was specified in order to test whether the survey data conforms to any of the theoretical propositions concerning fishermen's compliance behaviour discussed above. The approach is similar to that developed by Kuperan and Sutinen (1995) in that both deterrence factors and factors related to perceived legitimacy and social influence are included as explanatory variables.

The general form of the model of fishermen's decision to violate quota restrictions is specified as follows:

$$V = f(P, F, I, M, L, S)$$

where

V = self-reported violation rate

P = perceived probability of detection

F = anticipated level of fine[11]

I = a set of variables describing the characteristics of the individual fisherman (e.g. age, years in the fishery, gross earnings, etc.)

M = a set of variables related to the stated moral obligation to comply

L = a set of variables related to the perceived legitimacy of the regulation, regulatory

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[11] Other studies have included the relative net benefits of illegal fishing, as opposed to legal fishing, as explanatory variables. In our case, the data available does not allow us to identify whether the net gains from illegal landings are significantly different from the net gains from legal landings. In the fishery under study, however, over-quota landings can be assumed to entail fairly similar benefit and cost schedules as legal landings, as they appear to be predominantly caught under similar fishing conditions and landed through normal marketing channels.

process, and regulatory authorities

S   = a set of variables related to the perceived social influence on individual compliance decisions

As in other studies where data is obtained directly from fishermen, we hypothesise that the self-reported rate of violation and the subjective probability of detection could be jointly determined. It has been recognised in the literature (Sutinen and Gauvin, 1989; Furlong, 1991; Kuperan and Sutinen, 1995) that ignoring such joint determination would introduce simultaneity bias in the model estimates. To overcome this problem, the perceived probability of detection was specified as:

$P = f(E, I, V)$

where

P   = perceived probability of detection

E   = a set of variables related to the experience of enforcement effort at landing and to the experience of previous convictions

I   = a set of variables describing the characteristics of the individual fisherman (e.g. age, years in the fishery, gross earnings, etc.)

V   = self-reported violation rate

Table 4 presents the specific variables which were used to estimate the econometric model below.

Table 4: *Definition of the variables used in the estimation*

	Dependent variables	
D	Perceived probability of detection, coded 0 if low (5% or less) and 1 if high (10% or more)	
V	Coded 0 if complies and 1 if lands over-quota fish	
	Explanatory variables	
R	Gross earnings, coded 1 to 12, from less than £50,000 (= 1) to £800,000 or more (= 12)	
A	Age of skipper	
Y	Years in fishing	
G	Vessel size	
F	Coded 0 if the anticipated level of fine is low (£10.000 or less) and 1 if it is high (above £10.000)	
E_1	Coded 1 if landings have been checked by an inspector in the past 12 months	
E_2	Coded 1 if experienced conviction related to landing over-quota fish in past 10 years	
M	Coded 1 if agree that quotas should be complied with even you think they are unfair	
S_1	Coded 1 if a significant number of peers are considered to land over quota fish	
S_2	Coded 1 if peers are considered to think over-quota landings as *not* being wrong	
L_1	Coded 1 if agree with the effectiveness of quotas in practice	
L_2	Coded 1 if agree with the effectiveness of quotas in practice if fishermen complied with them	
L_3	Coded 1 if agree with the fairness of quotas restrictions	
L_4	Coded 1 if most or many fishermen in region are thought to land over-quota fish	
L_5	Coded 1 if quotas are considered to be adequately enforced	
L_6	Coded 1 if agree that Government has a duty to restrict catches as an EU member	
L_7	Coded 1 if considered involved in the regulatory system	

The two binary variables model we estimated in this study is that developed by Maddala (Maddala 1983, Greene 1995, 1997). The model is defined as a system of two simultaneous equations of the form:

$$y_1^* = \alpha_1 y_2^* + \beta_1' x_1 + \varepsilon_1,$$
$$y_2^* = \alpha_2 y_1^* + \beta_2' x_2 + \varepsilon_2,$$

where starred y_i variables are latent variables, their counterparts being y_1 and y_2[12]. Both y_1 and y_2 satisfy the assumptions of the probit model and take values of 0 or 1. The error terms, ε_i, are assumed to follow a bivariate normal distribution with zero means.

In our model, the first equation explains the subjective probability of detection, while the second explains the self-reported violation rate. The first dependent (endogenous) variable y_1

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[12] $y_i = 1$ if $y_i^* > 0$, $y_i = 0$ if $y_i^* \leq 0$, $i = 1,2$.

corresponds to the perceived probability of detection, and takes a value of 0 if the perceived probability of detection is relatively low (5% or less), and 1 if the perceived probability is higher (more than 10%). The second dependent (endogenous) variable y_2 corresponds to the self-reported violation rate, and takes a value of zero if the fisherman is a "complier" (no reported violations), and 1 if he is a "violator". x_1 (*E, A, G*) and x_2 (*F, A, Y, M, S, L*) are vectors of the explanatory variables listed in Table 4.

The reduced forms, in which X is the full set of exogenous variables in both equations, are

$$y_1^* = \pi_1' X + v_1$$
$$y_2^* = \pi_2' X + v_2$$

A two step procedure[13] is used to estimate the two reduced form equations by the maximum likelihood estimation (MLE) method.

4.1.1 Estimation Results

Table 4 defines the variables used in the deterrence and violation equations.[14]

Table 5 below presents the results of the perceived probability of detection equation. Statistically significant parameter estimates show that the perceived probability of detection is positively related to experience of enforcement. This confirms the hypothesis of other studies regarding the determinants of fishermen's representation of the risks of detection and conviction, and in particular the role of experienced level of enforcement effort (Sutinen and Gauvin, 1989, Kuperan and Sutinen, 1995). It is also interesting to note that older fishermen also appear to consider the probability of being detected landing over-quota fish to be higher. Finally, the size of interviewed fishermen's vessels also has a positive effect on the perceived probability of detection, which could be related to the fact that larger vessels are known to be targeted by landings inspectors.

Table 6 presents the results of the self-reported violation equation. The perceived probability of detection and perceived level of fine coefficients have the correct negative sign and are significant, which confirms the classic deterrence hypothesis. This was also found by Kuperan and Sutinen (1995) using similar methodology[15]. The deterrence effect appears to be tempered by certain personal characteristics of the fishermen. In particular, the level of gross earnings is positively related to the probability of violation of quota restrictions, indicating that the relative costs of sanction are somewhat lower for fishermen with high levels of earnings. Also, because quota restrictions are flat rate (the same in nominal terms for all vessels), they are more constraining financially on the larger, higher earning vessels.

The table also shows statistically significant relations between the self-reported violation rate and some of the legitimacy and social influence variables. Agreement by fishermen with the statement that quota restrictions should be complied with even if they are thought to be unfair is related to higher levels of compliance. On the other hand, the fact that fishermen consider that their peer group in the same area regularly lands over-quota fish is associated with a

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[13] The code was provided by William Greene *(pers. Comm)*. We are also grateful to Professor Richard Harris for his advice.

[14] Means and standard deviations are not reported here but are available from the authors.

[15] Although our findings cannot directly be compared with other studies (Sutinen and Gauvin 1989, Furlong 1991), which have utilized different types of dependent variable (eg. illegal landings, time spent fishing illegally, etc).

higher probability of violation. An interesting finding in the context of the recent debate on decentralised fisheries management is that the probability of compliance also appears to increase with the feeling of involvement of fishermen in the design and operation of the quota management system. An unexpected result of the estimation is that the variable representing peer attitude towards compliance was found to be statistically significant (at the 10 percent level) but of the wrong sign. One explanation could be that this perception is closely linked to the self-reported violation rate. Other variables were not significant in this preliminary analysis.

Cross-sectional analysis of such behavioural (subjective) variables may yield misleading conclusions if there are unobserved individual fixed effects which are correlated with other personal characteristics, and unidentified other factors or the reported violation rate itself. This problem could for example be addressed using panel data. Here the problem has been partially taken care of by using the latent variables simultaneous equations system proposed by Maddala (1983). Two other problems have been reported in the literature. One is a measurement error problem and the other is the question of causality in the relationships exhibited. We believe that the technique we use here takes care of these problems and that the results are unbiased.

Table 5: *Simultaneous Probit Model of perceived probability of detection*

Variable	Coefficient	t-values
V	0.0022	0.634
G	0.0939**	2.404
A	0.0318*	1.795
E_1	1.1576*	1.836
E_2	0.1786	0.282
Constant	-3.807***	-3.146

Log-likelihood = -39.22; zero-slopes χ^2 (5) = 15.81; % correct predictions = 65%; *** significant at 1% level; ** significant at 5% level; * significant at 10% level

Table 6: *Simultaneous Probit Model of violation rate*

Variable	Coefficient	t-values
D	-0.641**	-2.252
F	-1.448*	-1.871
Y	0.0397	1.098
R	0.647**	2.280
M	-2.713***	-2.493
S_1	2.694***	2.565
S_2	-2.267*	-1.867
L_1	-0.876	-0.956
L_2	0.790	0.125
L_3	0.929	1.140
L_4	0.0626	0.098
L_5	0.598	0.890
L_6	-0.400	-0.703
L_7	-1.781***	-2.432
Constant	0.882	0.537

Log-likelihood = -17.50; zero-slopes χ^2 (14) = 43.59; % correct predictions = 88%; *** significant at 1% level; ** significant at 5% level; * significant at 10% level

5. Discussion

In the predominantly social sciences literature on local management, participatory management or "co-management" approaches to fisheries governance, it is often suggested (implicitly if not explicitly) that greater involvement of fishermen in the management process will lead to increased levels of compliance with regulations because those regulations will be accorded greater legitimacy (e.g. Jentoft 1989, Pinkerton 1989, Nielsen 1994, Jentoft and McCay 1995, Ostrom 1995, Dubbink and van Vliet 1996, Nielsen and Vedsmand 1997, Symes 1997). While theory, intuition and even circumstantial evidence might argue the case, there appears to be little in the way of direct empirical evidence to support or refute such a notion.

Preliminary findings from the present study certainly support the view that non-monetary factors influence the compliance behaviour of fishermen in the UK. The fact that most of the "legitimacy" variables were not significant in our initial violation model may of course reflect generally poor perceptions among all respondents about many aspects of the existing management regime. We have, however, found a significant effect from variables for aspects of moral obligation, perceived behaviour of others and involvement in the system.

Refinements of the data analysis described are being undertaken and some additional data not presented here have yet to be analysed. There is some evidence, for example, that perceptions of the legitimacy of fishermen's own producers' organisations are quite different to those of the EU or the UK Government. There is also evidence that perceptions would be significantly different if there were, for example, greater autonomy over fishing within national limits (although not all fishermen appear to interpret such a scenario in a similar fashion).

Further analysis of the data from this study may clarify some of the findings. At this stage, however, it seems clear that there is potential for more work in this area, both on the empirical aspects of explaining compliance behaviour in fisheries, and in the context of the theoretical debate concerning how normative influences and self-interest may be integrated in a united analytical framework.

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Appendix: tables of responses to selected questions

Probability of detection

Q36: If you were to retain on board and land over-quota fish, what would you consider to be your overall chances of getting caught?

Response	%	Frequency
Very high (50% or more)	11.6	8
High (25%)	21.7	15
Quite possible (10%)	17.4	12
Moderately low (5%)	26.1	18
Very low (1% or less)	23.2	16
Total	100.0	69

Legitimacy of the regulation: effectiveness

Q1: Quota restrictions are effective in conserving fish stocks

Response	%	Frequency
Agree strongly	1.4	1
Agree	14.5	10
Disagree	42.0	29
Disagree strongly	42.0	29
Total	100.0	69

Q2: Quota restrictions would be effective if fishermen complied with them

Response	%	Frequency
Agree strongly	4.3	3
Agree	37.7	26
Disagree	39.1	27
Disagree strongly	18.8	13
Total	100.0	69

Legitimacy of the regulation: fairness

Q6: Would you say that the quota restrictions that apply to your vessel are generally

Response	%	Frequency
Very fair?	4.3	3
More fair than unfair?	24.6	17

Slightly unfair?	33.3	23
Very unfair?	37.7	26
Total	100.0	69

Legitimacy of the regulation: respect by others

Q26: Do you think it is likely that most, many, a sizeable minority or just a few fishermen in the region regularly land over-quota fish?

Response	%	Frequency
Most	31.9	22
Many	24.6	17
A sizeable minority	27.5	19
Just a few	15.9	11
Total	100.0	69

Legitimacy of the regulatory process: effectiveness

Q9: Overall, how well do you think that quota restrictions are enforced on UK vessels? Are they

Response	%	Frequency
Well enforced?	24.6	17
Adequately enforced?	40.6	28
Not adequately enforced?	20.3	14
Hardly enforced at all?	14.5	10
Total	100.0	69

Legitimacy of the regulatory process: fairness

Q15: In general, how fair do you think fishery officers or inspectors are in deciding whether or not to inspect a particular vessel? Would you say that the pattern of inspections is on the whole

Response	%	Frequency
Fair?	76.8	53
Not very fair?	13.0	9
Very unfair?	10.1	7
Total	100.0	69

Legitimacy of the regulatory authority

Q19: The UK Government has a duty to restrict catches because it is a member of the European Union

Response	%	Frequency
Agree strongly	1.4	1
Agree	49.3	34
Disagree	37.7	26
Disagree strongly	11.6	8
Total	100.0	69

Involvement in the regulatory system

Q24: How big a say do you think you personally have in the design and operation of the quota management system? Are you

Response	%	Frequency
Very involved?	5.8	4
Quite involved?	8.7	6
Involved a little?	15.9	11
Not involved?	56.5	39
Actively ignored?	13.0	9
Total	100.0	69

Compliance behaviour of peers

Q44: Considering the skippers of other vessels in your PO/other local non-sector vessels would you say that

Response	%	Frequency
All comply with quota restrictions most of the time?	10.1	7
Most comply with quota restrictions most of the time?	42.0	29
A large minority regularly land over-quota fish?	15.9	11
Many regularly land over-quota fish?	11.6	8
Most regularly land over-quota fish?	20.3	14
Total	100.0	69

Peer attitudes to violation

Q45: Among other skippers in the PO/other local non-sector skippers is landing over-quota fish generally regarded as being

Response	%	Frequency
Very wrong?	4.3	3
Basically wrong, but understandable every so often?	8.7	6
Basically wrong, but an economic necessity?	68.1	47

Neither wrong nor right?	4.3	3
Fine if you can get away with it?	14.5	10
Total	100	69

Moral obligation to comply

Q47: Quota restriction should be complied with because they are the law

Response	%	Frequency
Agree strongly	1.4	1
Agree	40.6	28
Disagree	43.5	30
Disagree strongly	14.5	10
Total	100.0	69

Q49: Quota restriction should be complied with because otherwise you are taking more than your fair share

Response	%	Frequency
Agree strongly	1.4	1
Agree	21.7	15
Disagree	58.0	40
Disagree strongly	18.8	13
Total	100.0	69

Q50: Quota restriction should be complied with even if you think they are not effective in conserving fish stocks

Response	%	Frequency
Agree strongly	0.0	0
Agree	29.0	20
Disagree	62.3	43
Disagree strongly	8.7	6
Total	100.0	69

Q51: Quota restriction should be complied with even if you think they are unfair

Response	%	Frequency
Agree strongly	0.0	0
Agree	31.9	22

Disagree	59.4	41
Disagree strongly	8.7	6
Total	100.0	69