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Regulatory Compliance in Lake Victoria Fisheries

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Abstract

This paper analyzes the causes for regulatory compliance using traditional deterrence variables and potential moral and social variables. We used self-reported data from Tanzanian artisanal fishers in Lake Victoria. The results indicated that the decision to be a non-violator or to be a violator—as well as the violation rate—are influenced by changes in deterrence variables (such as the probability of detection and punishment), but with respect to legitimacy and social variables. We also identified a small group of fishers that reacted neither to normative aspects nor to traditional deterrence variables, but persistently violated the regulation and used bribes to avoid punishment.

Key Words: Compliance, fisheries, Lake Victoria, legitimacy, normative, deterrence

JEL Classification Numbers: K42, L51, Q22

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Introduction

Poor people are frequently compelled to exploit their surroundings for short-term survival and are the group who most regularly must deal with natural resource degradation (World Bank 2002). Natural resources are often common use, which implies problems with overexploitation that sometimes are hard to manage, even in well-developed countries. Fish are a major source of protein for many poor people (UNEP 2002), and fisheries are frequently open access with no restrictions on entry or total catch. Almost half of the world's landings are in tropical waters (Pauly 1996), in countries with low to medium development levels and often lack even rudimentary tools for managing their fisheries (e.g., landing records). In such poor institutional settings, how individuals act and interact is of utmost importance to whether or not fish stocks can be sustained.

Predictions from the traditional economics-of-crime model are quite pessimistic. The seminal contribution by Becker (1968) basically outlined a choice between legal and illegal options. The major determinant for this choice is the expected payoff—which, simply put, is a function of the risk of being punished, the expected punishment, and the net profit from violating the law. On one hand, managing the deterrence model means that monitoring must increase and that penalties must be higher.[1] On the other hand, it is socially desirable that enforcement policy result in marginal deterrence,[2] which rules out the use of severe penalties for relatively mild

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[1] Becker (1968) assumed that the individual wants to maximize utility and the utility function may, of course, include moral and social aspects. Becker referred to one's "willingness to commit an illegal act," which seems to be exogenous. In general, little attention is given to this aspect in policy conclusions from the deterrence model.

[2] The term was first used by Stigler (1970) and means that those not deterred from doing harm should have a reason to moderate the level of harm they cause, i.e., most sanctions should be less than maximal.

violations, such as fishing a closed area or landing fish below minimum size. Otherwise, a criminal engaged in a minor crime might as well commit a more brutal, and more profitable, crime instead (Persson and Siven 2007). Monitoring fisheries and enforcing fishing regulations are costly and account for 25–50 percent of the public expenditures on fisheries (Sutinen and Kuperan 1999), which raises doubt as to whether increased monitoring and enforcement leads to social net benefits. Recent research in the social sciences has extended the deterrence model to include normative aspects of complying with the law, such as personal morality and legitimacy (Tyler 1990; Eisenhauer 2004).

This paper analyzes regulatory compliance in a developing country context. In addition to traditional deterrence variables (risk of detection, expected gains from violation, etc.), we explored potential reasons for following the rules, such as being moral and doing the right thing; obeying the rules due to peer pressure from other fishers; perceiving the regulation as legitimate; and perceiving that they (the fishers) had been involved in the regulation process. We used self-reported data from 459 Tanzanian artisanal fishers in Lake Victoria and focused our analysis on the minimum mesh-size regulation.

Our results indicated three categories of fishers. Forty-five percent of the fishers in our sample never violated the regulation, which is explained both with respect to deterrence and normative variables. We also identified a small group, 8 percent of the sample, who persistently violated the mesh regulation: these fishers appeared to react neither to normative aspects nor to traditional deterrence variables. They systematically violated the mesh-size regulation and, when arrested, bribed their way out of punishment. The third group of fishers, 47 percent of our sample, alternated between compliance and violating behavior and both deterrence and normative variables influenced their compliance/violation rate. This middle group of alternating violators was further investigated in the second stage of the sample selection model we used, which revealed additional information on their behavior.

2. Lake Victoria Fisheries

Lake Victoria is the world's second largest fresh water body and Africa's largest. Kenya, Uganda, and Tanzania share Lake Victoria. The Tanzania section encompasses 49 percent of the lakes' surface, while the Uganda and Kenya sections encompass 45 percent and 6 percent, respectively. The Nile perch was introduced to Lake Victoria in the 1950s and experienced explosive population growth in the 1970s. Its introduction led to increasing landings and a new source of cheap protein, while severely reducing biological diversity: the original 350–400 species of fish in the early 1900s are now fewer than 200 (Brundy and Pitcher 1995, 136;

Kudhongania and Chitamwebwa 1995). Today there are three commercially important species: Nile perch, dagaa, and tilapia, which constitute 60 percent, 20 percent, and 10 percent, respectively, of Tanzania's total Lake Victoria landings (Ssentongo and Jlhuliya 2000). The open-access nature of the lake fisheries combined with rapid population growth, lack of employment opportunities, and the increasing Nile perch market have led to an increasing number of fishers and a depletion of fish stocks (Ikiara 1999). This decline affects one-third of the population, or about 30 million people, supported by the lake basin in Kenya, Tanzania, and Uganda (LVFO 1999).

The Nile perch is exported to Europe, Asia, and North America. Processing and export industries were established in Kenya and Uganda during the 1980s and in Tanzania in the early 1990s. Dagaa is to a large extent processed domestically for household consumption and animal feed (fishmeal). Small-scale fishing units generate almost all of the fishing effort on the lake. These fishers use boats or canoes that are fitted with outboard motors, sails, or paddles and hold a total crew of two to six people, including the skipper. Fishers place their nets in the late afternoon and retrieve them in the morning. Dagaa is fished at night, when the moon is dark, using pressure lamps to attract the fish. Due to the need for lamps, the choice of dagaa fishing locations is limited to sheltered environments and areas fishers can easily reach from their own beaches.

Current regulations require fishers to pay an annual fee of approximately US$ 20, equivalent to the gross revenues from 1–2 days of fishing. Several minor restrictions exist, but the most important is the minimum gill-net mesh size, which is five inches (125 mm) for Nile perch and tilapia, and 0.4 inch (10 mm) for dagaa. There are 63 Tanzanian fishery officers who act as both extension and enforcement officers (LVFO 2004). These officers carry out lake inspections (in patrol boats) and landing inspections by randomly inspecting vessels and landing sites. When a violation is discovered, the catch is confiscated, fishers may lose their gear if they are convicted, and they may also be fined.

The focus of this study is on gill-net fishers, who either target Nile perch and tilapia or dagaa. In response to the declining catch per unit of effort, fishers employed more nets and used a mesh size smaller than prescribed. In the short run, a smaller mesh size leads to a larger catch, but the long-run implication is decreased stock and smaller sustainable landings. Reports in Tanzania district fishery offices show that fishers' compliance with regulations is poor, with the most violated regulations being illegal mesh sizes and beach seines, and fishing in restricted (or closed) areas (Wilson 1993).

In 1998, the Tanzanian government, supported by the World Bank, introduced local beach management units (BMUs), run by the Lake Victoria Environmental Management project. The aim was to improve community participation in surveillance and management and to stop detrimental fishing practices, such as using poison or dynamite. BMU leaders do not have any legal authority, but can identify culprits for enforcement officials. According to local fishery officers (G. Mahatene, District Fisheries Office, Mwanza, Tanzania, personal communication to R.B. Lokina, March 2003), the BMUs have been successful in reducing the use of poison and dynamite. A recent study also indicated that they have led to increased efficiency in both Nile perch and Dagaa fisheries (Lokina 2004), which could be explained by fishers exchanging information and learning from each other at the regular BMU meetings.

3. Methodology, Model, and Data

The original deterrence model by Becker (1968) led to a large number of empirical papers testing this hypothesis (starting with Erlich 1973; Gaviria 2000 is a later extension), which by and large confirmed the theory (See, e.g., Erlich 1996). Still, some methodological issues have been raised. One such issue is that the theory was developed on the individual level, while much of the empirical work has been based on some level of aggregation. If crime rate is defined as crime per capita, and the probability of being arrested is measured as the ratio of arrests to crimes, we have the number of crimes in the denominator of the independent variable and in the numerator of the dependent variable, which can imply a spurious correlation. Similarly, if notorious criminals are arrested and kept in custody, it implies a lower crime level, but the negative correlation between crime and arrest rates is not due to the risk of being arrested but to the actual captivity. Finally, more crimes lead to greater expenditure on law enforcement, which implies a simultaneous relationship between crime and enforcement levels. Manski (1978) suggested survey-collected individual self-reports as a means of avoiding these problems, since each individual will have a negligible impact on each of the three objections raised. Furlong (1991) applied these ideas to a sample of Canadian fishers and found them to be most sensitive to changes in the likelihood of detection, while fines appeared to create the greatest deterrence among various penalties.

The policy conclusions following the Becker approach are clear: an increased likelihood of detection and increased fines will lead to fewer violations. However, given the weaker deterrent threat facing people for minor violations, this approach cannot explain why the vast majority of people act in a way consistent with the law (Robinson and Darley 1997). Recent contributions to legal thought, which to a large extent are revivals of older ideas, provided

several suggestions. One reason to follow the rules is to avoid disapproval by one's social group; another is to see oneself as a moral being who wants to do the right thing (Robinson and Darley 1997). A third factor is legitimacy, where the individual feels that the authority enforcing the law is entitled to dictate behavior. This in turn depends on whether the individual thinks that the law is fair and applied in a fair manner. Whether legitimacy is maintained or undermined is dependent on people's experiences with legal authorities (Tyler 1990).

Enforcement in fisheries has been a fairly neglected area of research (Sutinen and Hennessey 1986). The early contributions were theoretical and dealt with optimal stock if non-zero enforcement costs were introduced (Sutinen and Andersen 1985; Milliman 1986) and the choice of optimal government policy (Anderson and Lee 1986). The first empirical study confirmed the deterrence model, showing that an increased risk of detection and conviction reduced the violation rate in a fishery (Sutinen and Gauvin 1989). The simple deterrence model predicted that most fishers would violate the regulation when the risk of detection was low, fines were modest, and the profits from violation were substantial. Still, a vast majority of fishers in various fisheries seemed to comply with regulations, which contradicted the predictions based on this model (e.g., Kuperan and Sutinen 1998; Eggert and Ellegård 2003). Extended analysis is thus necessary to include both the instrumental and the normative perspective.

The empirical evidence from such an approach is mixed. Kuperan and Sutinen (1998) found that compliance in a Malaysian fishery depended on the tangible gains and losses, as well as the moral development, legitimacy, and behavior of others in the fishery. Hatcher et al. (2000) reached similar conclusions, while Hatcher and Gordon (2005) found less evidence in favor of normative influence on fisher compliance, while again confirming the deterrence effect. These studies dealt with trawl fisheries where the capital input was substantial, while our study is the first to analyze artisan fishers.

The fishers in our sample all had low levels of capital input, i.e., they operated simple, open wooden-hulled vessels. Almost half of the fishers' boats lacked motors and used sails or paddles for propulsion. Our theoretical point of departure was the model by Eisenhauer (2004), where the neoclassical utilitarian model of individual violation behavior using a concave utility function is extended to include normative and social judgments. Let Y denote wealth obtained from legal behavior and V wealth gained from illegal and immoral behavior ("sinful" wealth). V is discounted by a factor δ, which in this monetary context can be seen as a psychic tax rate that the individual places on illicit wealth. The psychic tax rate is assumed to be greater than zero and less or equal to 1, and fit into the relation $Y = (1- \delta)V$. Hence, all individuals experience some level of remorse, which lowers the value of acquired "sinful" wealth compared to Y and, for

those where $\delta=1$, "sinful" wealth does not increase utility at all. Expected utility can then be expressed as (Eisenhauer 2004):

$$EU = (1 - p)\, U[Y + (1- \delta)V] + pU[Y - F(V) + (1- \delta)V] , \qquad (1)$$

where p is the probability of detection, F is the penalty, which is assumed to increase with the size of V, i.e., $F'>0$. For a Taylor series expansion around $V = 0$, the first-order condition is

$$(1 - p)(1- \delta)U'(Y) + (1 - p)\,(1- \delta)2V\, U''(Y) + p(1- \delta - F')\, U'(Y)$$
$$+ p(1- \delta - F')2V\, U''(Y) \qquad (2)$$

which can be rearranged to give

$$V^* = \frac{1 - \delta - pF'}{A(Y)\sigma^2} , \qquad (3)$$

where $A(Y) = - U''(Y)/U'(Y)$ is the Arrow-Pratt measure of absolute risk aversion and $\sigma 2 = (1 - p)(1 - \delta)2 + p(1 - \delta - F')2$ denotes a variance, or risk factor. From equation (3), we have that risk, risk aversion, the public penalty, and private remorse all serve as deterrents to "sin" (Eisenhauer 2004). If fishers' behavior is influenced by perceived legitimacy of regulation, moral obligation to comply, social influence variables, or personal characteristics, these factors will influence the model via δ. We had no prior expectation of personal characteristics, while the other factors were assumed to be positively correlated with δ. If a fisher perceived the regulation as legitimate, felt a moral obligation to comply, or thought that everybody else was complying with the rules, these factors would be expected to reduce the violation rate. Estimates of $A(Y)$ required detailed information of assets of the respondents and the choice of a functional form of the utility function. We circumvented these potential problems by using estimated risk preferences from a risk experiment that was carried out in a previous round of interviews with the fishers in our sample (Eggert and Lokina 2007).

3.1 Econometric Specification

The point of departure was that the dependent variable—the number of *violating fishing days*—was a latent variable that described the degree to which fishers were in violation of the mesh-size regulation. Various specifications have been used in previous studies. Kuperan and Sutinen (1998), who had data on the number of violating days, used a Tobit model, but also divided their sample into non-violators and violators and used a binary probit model. Hatcher and Gordon (2005) collected violation rate as intervals from zero to more than 30 percent over allowed catch, which led to an ordered model with six ordered intervals.

In our study, the violation rate was measured as the number of months in which the fisher violated the mesh-size regulation. The values, therefore, ranged from zero for non-violators to 12 months for persistent violators. In general, we specified our model as:

$$V_i = X_i'\beta + \varepsilon, \quad (4)$$

where X is a vector of an observable variable possibly governing V, and ε is normally distributed with mean zero and standard deviation σ. Data on V are only observed when $V = j$ for some j in (0, 1, 2), where 0 is for non-violators, 1 is for those who violated 1–10 months (alternating violators), and 2 is for those who violated for 11 months or more (persistent violators). We were interested in why fishers might choose to comply rather than violate the rules, and vice versa. It is often found that for any regulation there is a small subgroup of persistent violators (Feldman 1993), a condition which also seems to exist in fisheries (Kuperan and Sutinen 1998). Further, those who always obey (violate) the rules may on some occasions be attracted to deviate from their normal behavior, but lack the possibility to do so. A simple reason could be that they do not possess the illegal (legal) gear, which implies that the model will fit those who actually alternate between legal and illegal acts. Excluding the others would be a waste of information and lead to biased estimates, as there is self-selected participation. In this study, we used the generalized Heckman procedure (Heckman 1979). In the first step, the probability that a given individual fisher would violate the mesh-size regulation was determined from an ordered probit model, using all available observations in the three categories. The inverse Mills ratio term is:

$$\lambda(x) = \phi(X)/[1 - \Phi(X)], \quad (5)$$

where X is a vector of regressors related to the violation decision, ϕ is the standard normal probability density function, and Φ is the standard normal cumulative distribution function.

In the second step, the lambda is used as an instrument variable in the regression on the sub-sample of alternating violators to correct for potential bias. The ordered probit model is:

$$V^* = x_i'\beta + u \quad (6)$$

$$V = \begin{pmatrix} 0 \text{ if } v^* \le \mu_1 \\ 1 \text{ if } \mu_1 < v^* < \mu_2 \\ 2 \text{ if } v^* \ge \mu_2 \end{pmatrix}$$

where V^* is not observed and V is its observed counterpart, x_i is a vector of explanatory variables, μ_1 and μ_2 are threshold parameters to be estimated with the βs, the subscript i is the index of the individual, and the error term u is distributed as standard normal (Greene 2000).

3.2 Survey Description and Data

The data for this study was collected using a questionnaire during April–June 2003 in three regions—Kagera, Mwanza, and Mara, all bordering Lake Victoria. A total of 459 fishers were interviewed face-to-face (approximately 160 fishermen from each region), in collaboration with the staff of the Tanzania Fisheries Research Institute (TAFIRI) in Mwanza. Tanzanian fishers used suitable landing sites that we referred to as beaches. In collaboration with the TAFIRI staff, 22 beaches equally spread across the three regions were selected. We recruited 20–25 fishermen from each of the selected beaches who volunteered for the interviews. These fishermen were all skippers and decision makers of fishing vessels and did not receive any payment for their participation. The questionnaire was administered in face-to-face interviews with vessel skippers with an assurance of individual anonymity and confidentiality. Care was taken in the design of the questionnaire to maximize the likelihood of honest responses, particularly regarding questions about the fishers' own violation behavior. The questionnaire was administered in collaboration with the TAFIRI staff.[3]

A pilot survey was conducted at three landing sites, i.e., beaches that were not in the sample, after which we made revisions and minor changes. The respondents were asked about their own violation rates during the previous 12-month period and gave answers such as "zero," "1 month," "2–3 months" or "12 months," etc. Hence, the number of days violating the regulation was not exactly known. We identified three subgroups, which we labeled non-violators, alternating violators, and persistent violators, with zero, 1–10 months, and 11 months or more of violation, respectively. Zero violation meant that respondents had not broken regulations for the past 12 months; 1 month meant that in the past 12 months, they broke regulations only 1 month; and so on.

Sixty-minute individual interviews were also carried out and included questions on respondent attitudes and perceptions about the legitimacy of mesh-size regulation, social pressures to comply, attitudes towards violation, and feelings of obligation to comply.[4] Questions related to legitimacy concerned the perceived effectiveness and fairness of mesh-size regulations, the legitimacy of management institutions, and the involvement of fishers in the management of the fisheries. The questions were in the form of statements, to which the respondents ranked their

[3] The staff at TAFIRI in Mwanza has extensive working experience in the field and has regular contact with fishers around the lake. Most, if not all, of the fishers were aware that the staff were not enforcement officials.

[4] The questionnaire design was to a large extent based on the questionnaire used by Kuperan and Sutinen (1998).

level of agreement on a four-digit scale (a higher score meant stronger agreement). Socio-economic characteristics of the fishers were recorded either directly (e.g., age and experience as a skipper, household size) or where appropriate, using an interval scale. (For example, household income was recorded in this way to minimize the concern of confidentiality and accuracy.) We also included questions related to the subjective probability of detection, arrest, and conviction.

Respondents were also asked to report their own compliance behavior as well as their perceptions of other fishers' compliance behavior at the same beach. Further, questions related to the level of fishers' involvement in policy or regulation formulation and enforcement were asked. Self-reports might imply a risk of biased data, especially as respondents were asked about their own illegal activities, but the overall impression was that the fishers were cooperative and generous with their answers, including their own violations. Nonetheless, the potential magnitude of penalties in the case of conviction seemed to be impossible for many of the fishers to assess, which led to exclusion of that question.

4. Results

The descriptive statistics are reported in table 1. The sample consisted of 459 fishers, of whom 45 percent were non-violators, 47 percent were alternating violators, and 8 percent persistent violators. The overall violation rate was 29 percent, which was substantially higher than the rate reported in previous studies (see Kuperan and Sutinen 1998), and the persistent violators were responsible for 30 percent of the violations.[5]

The deterrence variables included specific aspects, such as the expected gain per unit effort from violating; how often officials appeared; a dummy for previous arrests; and the respondent's subjective judgment of the probability of detection, of arrest, of being taken to court, and of being found guilty. The probabilities for detection, of arrest, being taken to court, and being found guilty increased, which is intuitive: those who are more likely to be convicted will more likely be taken to court, etc. The probability of being taken to court was an exception and was lower than that of being arrested. This was the stage where bribes were most likely to occur and it could be that the respondents adjusted for the use of bribes. If we disregard the effects of bribes, the average perceived overall probability of being detected and punished is 7 percent, which is substantially larger than the "below 1 percent, and often at or near zero" found in

[5] We assumed that the number of trips per month and year were equally distributed among the three groups.

Table 1 Descriptive Statistics

Name	Variable description	Mean	Std dev.
	Socio-economic variables		
AGE	Age of the skipper	33.36	9.43
EDUCATION	Skipper's years in school	6.45	2.24
SKIP_EXP	Years of fishing experience as a skipper	4.81	4.25
SOURCE	Fishing is the main source of income (1/0)	0.86	0.35
OWNERPC	Owner is onboard either as crew or as skipper (1/0)	0.58	0.49
MOTOR	Dummy for boat outboard motor	0.54	0.50
NILE PERCH	Dummy for targeting Nile perch	0.80	0.37
MWANZA	Dummy for Mwanza region	0.39	0.49
MARA	Dummy for Mara region	0.31	0.46
RISKAVERSE	Risk averse respondent according to experiment	0.29	0.45
	Deterrence variables		
SEEN	Number of times the unit has seen the officials when landing	0.70	0.46
DCPUM	Expected difference in value ('000 Tanzanian shillings) between illegal and legal catch per crew member	30.21	36.80
PROBD	Subjective probability of being detected	0.37	0.30
PROBDA	Subjective probability of being arrested if detected	0.58	0.32
PROBDAC	Subjective probability of being taken to court if arrested	0.50	0.35
PROBDACG	Subjective probability of being found guilty if in court	0.65	0.32
	Social variables		
BMU	Existence of active beach management unit (1/0)	0.42	0.49
PERVIOL	Percentage of fishers perceived to be violating the regulation	0.41	0.35
ATTIT	Peer attitudes towards violation (1=wrong; 0=not wrong)	0.39	0.19
	Legitimacy variables		
FVIEW	Fishers' views are considered during regulation design (1/0)	0.69	0.46
RIGHT	Government is doing the right thing by imposing the regulation(1/0)	0.60	0.65
NONCONSIST	Regulation is not enforced consistently (1/0)	0.84	0.36
JUST	Mesh-size regulation is a fair regulation (1/0)	0.74	0.44
EVERYONE	Mesh-size regulation improves the well-being of all (1/0)	0.54	0.47
WELLEST	Mesh-size regulation improves the well-being of a few (1/0)	0.37	0.42
NODETECT	Many of the violators are not detected (1/0)	0.56	0.50
PENALFIT	The penalty given to violators fits the offence (1/0)	0.56	0.49
ADEQUATE	The enforcement in one's fishing area is adequate (1/0)	0.48	0.50

previous studies (Kuperan and Sutinen 1998). The social and legitimacy variables were all measured by a four-digit scale. However, in the final analysis, these answers were recoded as dummy variables with levels three and four being 1 and levels one and two being zero, where 1 indicated that the fisher agreed with the statement. The correlation between all of the used variables was estimated, but did not exceed 0.54.

The results of the first-stage ordered probit model are presented in table 2. A highly significant estimate of μ indicated that the three categories in the response were indeed ordered

Table 2 Ordered Probit Violations Model

Variable	Coefficient	Standard error	Variable	Coefficient	Standard error
Socio-economic variables			***Social variables***		
EDUCATION[a]	0.573**	0.266	BMU	0.118	0.122
SKIP_EXP[a]	0.101	0.138	PERVIOL	0.341**	0.169
SOURCE	0.080	0.170	ATTIT	0.319	0.297
OWNERPC	-0.448***	0.123	***Legitimacy variables***		
MOTOR	0.577***	0.129	FVIEW	-0.186	0.130
NILE PERCH	0.004	0.170	RIGHT	-0.030	0.088
MWANZA	0.603***	0.157	NONCONSIST	0.024	0.159
MARA	0.104	0.159	JUST	-0.243*	0.134
RISKAVERSE	0.205*	0.126	EVERYONE	-0.236*	0.143
Deterrence variables			WELEST	0.431***	0.151
SEEN	-0.042	0.146	NOTEFF	-0.169	0.120
DCPUM	0.727***	0.167	ADEQUATE	-0.339***	0.123
PROBD	0.127	0.202	NODETECT	0.162	0.117
PROBDA	-0.016	0.188	PENALFIT	0.260**	0.121
Constant	-1.019**	0.488	Number of Observation	459	
M	1.804***	0.109	Prob [chi^2] > value	0.00	
Log likelihood function	-367.84				

***, **, * significance at the 1%, 5% and 10% levels, respectively.

[a] Variable scaled by a factor 0.1

(Liao 1994). In the model, the dependent variable was an ordered rank of violation frequency where non-violation had a rank of zero, 1–10 months of violation had a rank of 1, and 11 months or more during the last 12-month period received a rank of 2.[6] Many of the variables were statistically significant and significant variables could be found in all of the four variable subgroups, i.e., *socioeconomic, deterrence, social*, and *legitimacy* variables.

In table 3, we present the marginal effects for the statistically significant variables, which measured the increased (decreased) probability that the fisher would have been in the violation category, given one more unit of the explanatory variable with the other variables held at their mean. For the binary variables, the interpretation was the increase (decrease) in probability if the binary variable was equal to 1. For example, the marginal value for non-violation for education was -0.023, which indicated that the probability of a fisher being a non-violator would decrease by 2 percent for every extra year of schooling. The probability of being in the group of persistent violators was higher if the fisher possessed an outboard motor and was from the Mwanza region. Otherwise, explanatory variables were not significant for this group.

Whether a fisher always obeyed the regulations was significantly indicated by a number of variables. More education, being from Mwanza, and possession of an outboard motor implied a reduced probability of always obeying the law, while having the owner onboard a vessel supported non-violation. Among the *deterrence* variables, *DCPUM* was significant, which indicated that if the expected gains between legal and illegal behavior were increasing, then more non-violators were likely to become alternating violators. To our surprise, we found that the risk-averse fishers were likely to belong to the violators. Eggert and Lokina (2007) found that risk-averse fishers had limited assets, used boats without motors, and earned lower incomes than other fishers in Lake Victoria. However, their risk-averse preferences were elicited from choices between alternatives, which all entailed positive net revenues. Kahneman and Tversky (1979) and Tversky and Kahneman (1992) suggested a value function, which is concave for gains, convex for losses, and steeper for losses than for gains. In case our risk-averse fishers lived close to the subsistence level and struggled to make ends meet, their choice was potentially made in the loss region, in the sense that a poor catch was below subsistence level. The implication was

[6] Several cut-off points were tested without any major difference in the parameter estimates or the level of significance.

Table 3 Marginal Effects of Significant Variables in the Violations Model

	Non-violators		Occasional violators		Persistent violators	
Variable	***Coefficient***	***b/std. error***	***Coefficient***	***b/std. error***	***Coefficient***	***b/std. error***
Socio-economic variables						
EDUCATION	-0.023	-2.152	0.0167	2.139	0.006	0.951
OWNERPC	0.174	8.422	-0.123	-15.108	-0.050	-0.670
MOTOR	-0.225	-8.459	0.166	6.155	0.059	2.053
MWANZA	-0.231	-8.217	0.160	5.829	0.071	2.138
RISKAVERSE	-0.080	-3.088	0.057	2.684	0.023	0.501
Deterrence variables						
DCPUM	-0.286	-4.358	0.210	4.295	0.076	1.191
Social Variables						
PERVIOL	-0.134	-2.016	0.099	2.012	0.036	0.988
Legitimacy variables						
JUST	0.096	4.059	-0.073	-4.981	-0.023	-0.412
EVERYONE	0.092	4.118	-0.065	-5.245	-0.027	-0.408
WELLEST	-0.170	-6.774	0.133	5.295	0.038	1.347
ADEQUATE	0.133	5.949	-0.098	-8.381	-0.035	-0.541
PENALFIT	-0.102	-3.956	0.076	3.358	0.027	0.675

that these poor risk-averse fishers were, in fact, risk seeking and chose the more risky violating behavior that was—in case of success—more profitable.

Several of the *social* and *legitimacy* variables were significant, indicating that these variables had an impact on the decision to be a non-violator or to break the rules. The significant variable *PERVIOL* indicated that the higher the perceived percentage of fishers violating, the lower the probability of the fisher remaining a non-violator. Similarly, if the fishers thought that the mesh-size regulation improved the well-being of a few well-established fishers (*WELLEST*), they were likely to be alternating violators. If the mesh-size regulation was seen as a fair regulation (*JUST*) and the enforcement in their fishing area was *ADEQUATE*, the fishers were likely to be non-violators.

The *PENALFIT* variable had an unexpected significant positive sign for alternating violators, indicating that fishers who believed that the penalty fit the offense were more prone to

break the rule. The study of Malaysian trawl fishers experienced a similar result where violators thought that the government was right in imposing a regulation and that the enforcement was adequate. Kuperan and Sutinen (1998) suggested that weak enforcement combined with high social and moral compliance increased the marginal value of violation, which explained why violators were in favor of the measure. The parallel to the Tanzanian fishers was that the violators enjoyed better returns from violating when not all fishers violated, due to a suitable penalty. Added to this, it could be that non-violators thought that the penalties were too low, while violators thought they were low enough to make violation profitable. We had no follow-up questions on these issues and, as noted earlier, many fishers found it hard to assess penalties in the case of conviction.

Table 4 shows the results of the corrected least square estimation of the violation rate for the alternating violators. There is evidence that participation was positively selected, since the lambda (λ) is positive and statistically significant, and is now being adjusted for. From the socio-economic variables, we see that fishers from the Mara region or skippers with greater experience tended to violate more. It is notable that while target species had no influence on being a non-violator or a violator, it was a significant variable among alternating violators. Those who targeted Nile perch violated to a lesser extent, which was likely due to the fact that Nile perch fishers supplied the fish processing factories and these factories required a fish size corresponding to the legal mesh size of five inches or more. Thus, if a fisher targeted Nile perch, the market requirements reduced the probability of this fisher violating the regulation by 0.44 units compared to the others.

For the *deterrence* variables, the difference between illegal and legal mesh-size values of catch per crew member effort (*DCPUM*) was still significant in explaining the violation decision. The variable *SEEN* was insignificant for the whole sample, but alternating violators responded by reducing their violation rate the more often they saw officials. According to the *ARRERATE*[7] variable, fishers who had experienced higher arrest rates tended to violate less. All four of the subjective probabilities now showed the expected negative sign. However, only *PROBDAC* was statistically significant at the 10-percent level. The probability of being taken to court after being

[7] In order to reduce the problem of correlation between being arrested and violation frequency, the number of arrests was divided by the number of violating months.

Table 4 Least Squares Estimates of Violation Frequency for Alternating Violators

Variable	Coefficient	Standard error
Constant	1.049***	0.171
Socio-economic variables		
AGE	-0.004	0.004
SKIP_EXP	0.130***	0.051
NILE PERCH	-0.441***	0.074
MWANZA	-0.064	0.067
MARA	0.185**	0.078
RISKAVERSE	0.076	0.054
Deterrence variables		
SEEN	-0.139**	0.061
DCPUM	0.120*	0.073
ARRERATE	-0.293**	0.111
PROBD	-0.078	0.091
PROBDA	-0.151*	0.080
PROBDAC	-0.062	0.070
PROBDACG	-0.115	0.080
Social and legitimacy variables		
BMU	-0.060	0.051
PERVIOL	0.218***	0.073
ATTIT	-0.067	0.130
RIGHT	-0.084*	0.046
FVIEW	-0.052	0.059
NONCONSIST	0.056	0.066
JUST	-0.008	0.059
EVERYONE	-0.133**	0.065
NOTEFF	0.091	0.060
λ (Selectivity correction)	0.151*	0.087
D-W statistics		1.65
Number of observations		216
Adjusted R-squared		0.348

***, **, * indicate significance at the 1%, 5%, and 10% levels, respectively.

arrested (*PROBDAC*) was not at all significant and, according to the fishers, it was at this stage one avoided punishment by offering bribes. All of the 459 fishers in the sample had been arrested, and 40 percent of them had used bribes to avoid being taken to court. In fact, 23 percent of those who had not violated the regulation during the last 12 months had used bribes when arrested to avoid the problems of being taken to court, even though they were innocent. In the group of persistent violators, 93 percent avoided being taken to court when arrested by the use of bribes.

When it comes to *social* and *legitimacy* variables, their influence on the violation rate seemed reduced compared to their importance in the decision whether a fisher would violate or not violate the regulation. Those who did, in fact, violate were still influenced by the perceived violation rate among their colleagues; if they thought many others violated, the probability to violate was high (*PERVIOL*). Similarly, they tended to comply if they thought that the government was doing the right thing by imposing the regulation design (*RIGHT*), and if they believed that the regulation benefited all fishers (*EVERYONE*).

A fundamental question to address was whether the deterrence or the social and legitimacy variables could be excluded. If we look at the adjusted R^2 excluding deterrence or social and legitimacy variables, the full model is reduced from 0.35 to 0.28 and 0.23, respectively. We further explored this issue using the F-statistics comparing various regressions. The null hypothesis that all social and legitimacy variables are zero can be rejected at the 1-percent level of significance (4.090, critical level 2.47), and similarly the null that all deterrence variables are zero can be rejected at the 1-percent level (6.532, 2.64). Hence, we concluded that both deterrence and social and legitimacy variables were vital in explaining the behavior of the alternating violators.

5. Policy Implications and Conclusions

This analysis of the Tanzania Lake Victoria fishers' compliance gives support to the traditional economics-of-crime model. The results also showed that the extension of the basic deterrence model, which included moral development, legitimacy, and considerations regarding the behavior of others in the fishery, led to a richer model with substantially higher explanatory power. In a second stage analysis, we focused on the middle group, i.e., the occasional violators, and found that the moral and legitimacy variables had less impact on their decision and violation rate compared to the influence of these variables on being a non-violator or not. Still, the normative variables were significant in explaining the violation rate for this middle group. Our

interpretation was that if the fisher broke the rules, moral and legitimacy factors were less important in influencing the decision to violate or not.

A potential problem in a study like this is self-serving bias, when measuring attitudes and opinions by posing questions to individuals and having them provide answers about what motivates their actual behavior. The fishers in this study were generous with their answers, even the answers concerning their own violation rates. For the fishers concerned with their reputations or self-images, reducing the stated violation rate instead of trying to find arguments for violation in the legitimacy and moral variables seemed more plausible. For those who were non-violators, the incentive to, for instance, state that fishers' views were taken into account as a defense that they were obeying the rules seemed even weaker. In the case of strategic answers, we rather expected to find insignificant variables. Unfortunately, we could not find any data from the authorities on violation rates to cross-validate the reported violation rates, which could have been an indicator of misrepresentation in the data.

In the Lake Victoria fishery, as indicated also by previous studies on fishery compliance, there was a small group of persistent violators. These fishers seemed to have found that constant violation was the most beneficial strategy, irrespective of deterrence variables or legitimacy and social variables. Whether the fishers had undertaken any particular evasion investments was unknown, but in principal they always used the illegal mesh size and used bribes to reduce or escape from penalties. The fishery management implication for systematic violators would be temporary withdrawal of the fishing license and even incarceration if the violations were repeated. However, this was more easily said than done.

According to Transparency International (2004), its Corruption Perceptions Index 2004 found that 60 countries scored less than 3 out of 10, indicating rampant corruption. One such country was Tanzania, with an estimated value of 2.8 and a confidence range of 2.4–3.2, securing 90th place of 146. The frequent use of bribes was also confirmed by our study; all of the respondents had been arrested and 40 percent had used bribes to avoid being taken to court. In fact, in the group of non-violating fishers, 23 percent used bribes to avoid the bother of court proceedings and the risk of being convicted despite being innocent. Given the fact that all fishers had been arrested, the high perceived overall probability of being punished (7 percent), and the existing corruption indicated that the inspection officers' personal gain from bribes might even reinforce the frequency of arrests. How to handle corruption is beyond the scope of this study, but the general policy recommendation is to increase an individual firm's ability to refuse to use bribery, which can be supported by measures, such as disseminating information about corrupt

practices and recognizing those who are doing a good job by resisting corruption (Svensson 2003).

One critique of the deterrence model is that fishers comply with a regulation to a larger extent than predicted by the model. Such a critique does not apply to this fishery, where the overall violation rate of 29 percent was substantially higher than the rate previously found in developed and newly industrialized countries. We see two potential explanations. First, Tanzanian fishers are poorer than previously studied colleagues and cannot afford moral and legitimacy concerns to the same extent. Second, the ubiquitous level of corruption most likely had a negative impact on compliance. Even when a fisher who obeyed the rules was arrested and had to use bribes to avoid being taken to court, we would expect that this would increase "his willingness to commit an illegal act."

Compliance with the minimum mesh size does not solve the overcapitalization problem that follows from the open access regime, but given that the minimum size of fish caught is large enough, female fish will be able to reproduce at least once and the stock will not fall below a viable minimum level (Townsend 1986). If all fishers start to use the small mesh size, the risk that female fish would be caught before reaching sexual maturity would increase, leading to a complete stock collapse (Clark 1990). The local beach management units, which were initiated to improve community participation in surveillance and management, seemed to have been successful in stopping the use of poison and dynamite, but not in achieving minimum mesh-size compliance. According to our results, the BMUs did not have an impact on fishers' decisions not to violate the regulation, i.e., to always obey the mesh-size regulation. While fishers agreed that poison or dynamite could easily harm them or those nearby, their perception of the stock deterioration mechanism might be more vague. Such misperceptions of bio-economics were found in an experiment with people from the fisheries sector in Norway (Moxnes 1998). Instituting the BMUs and understanding the importance of conserving the juvenile fish seem to be low-cost management options. Combined with increased deterrence activity, they might contribute to more sustainable fishing practices in Lake Victoria.

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