Risk Aversion: Experimental Evidence from South African Fishing Communities

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Working paper 227

July 2011

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July 19, 2011

Abstract

We estimate the risk attitudes of a large sample of small-scale fishers from various fishing communities along the west coast of South Africa, using subjects' choices over lotteries with real monetary prizes. We find that participants are moderately risk averse and that risk attitudes vary with certain socio-demographic variables. In particular, females are found to be more risk averse than their male counterparts, while quota holders are more risk loving. Logistic regression analysis indicates that risk attitudes have implications for non-compliance with fisheries regulation. Specifically, greater risk aversion translates into a reduction in the odds of catching illegally. Furthermore, in the case of gender, female fishers and female fishers with fishing rights are more likely to comply with fisheries regulation. These findings have important implications for the characterisation of risk attitudes in fisheries policy applications and for the management of marine resources.

Keywords risk attitudes risk aversion experiments fishing rights compliance and South Africa
JEL Classifications D81 and Q22

1 Introduction

Financial risk is embedded in the economic environment within which commercial and small-scale fishers operate: such risk derives from product price uncertainty, imperfect information regarding resource stocks and location, dynamic changes in stock levels and prices, and the evolvement of fisheries regulation (Smith and Wilen 2005; Eggert and Lokina 2007). As such, uncertainty and appetite for risk are important elements of any analysis of fisher behaviour (Mistian and Strand 2000).

In this study, we estimate the risk attitudes of a large sample of individuals from various fishing communities along the west coast of South Africa, using subjects' choices over lotteries with real monetary prizes. The majority of the subjects are involved in fishing-related activities. The relevance of this study stems from the persistence of non-compliance in South African fisheries – despite a significant strengthening in law enforcement over the past decade (Hauck 2009). Understanding fishers risk preferences is an important aspect of any analysis of fishers' behaviour (Eggert and Martinsson 2009). In this context, we characterise risk attitudes in these coastal communities in order to obtain a greater understanding of the factors influencing non-compliance. Hauck (2009) emphasises that a better understanding of the factors affecting fisheries non-compliance is a prerequisite in developing a more inclusive management strategy.

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Much of the empirical literature on fishers' risk preferences indicates that fishers are risk averse (Dupont 1993; Mistian and Strand 2000; Eggert and Tveteras 2004; Smith and Wilen 2005). In their seminal work, Bockstael and Opaluch (1983) analyse the annual location and species choices of New England fishers under conditions of uncertainty and inertia, using a random utility model. Fishers are found to have homogenous risk preferences - with a constant relative risk aversion coefficient equal to one. Dupont (1993) extends this analysis by adding price uncertainty to Bockstael and Opaluch's (1983) framework of annual fishery participation choices. The assumption that fishers are homogenously risk averse could not be rejected in three of four vessel types. Mistian and Strand (2000), examine short-run location choices in the North Atlantic fishery using data from around 2500 fishing trips taken by approximately 260 vessels. The authors find that risk preferences amongst fishers are heterogeneous and that 95% of fishing trips reflect risk aversion. Eggert and Tveteras (2004) study the short-run gear-choice decisions of Swedish demersal trawl fishers using trip data. The authors find that 70% of trips are characterised by risk aversion. Smith and Wilen (2005) use a random utility model to examine the daily fishing choices of commercial Californian sea urchin divers in response to both physical and financial risk. Sea urchin divers are found to be risk averse on average across both risk domains, preferring low revenue variance and calm seas. Results from recent experimental studies of fishers' risk preferences have proved to be less conclusive: Eggert and Martinsson (2004) find that a significant portion of fishers are characterised by risk-neutrality. Specifically, the authors elicit the risk preferences of Swedish commercial fishers using a stated preference technique (choice experiment). Participants choose between pairs of fishing trips with variable minimum, maximum and mean income levels. The authors find that 48% of fishers are risk neutral, 26% of fishers are moderately risk averse and 26% are strongly risk averse. Eggert and Lokina (2007) measure the risk preferences of Tanzanian artisanal fisherman using subject choices from an array of hypothetical fishing trips with different expected mean revenue and income variability. Using the relative risk premium specification, the authors classify 32% of fishers as risk averse, 34% as risk neutral and 34% as risk seeking. Nguyen (2009) simultaneously estimates risk and time preferences of fishers from various Vietnamese fishing villages. Subjects are assumed to behave in accordance with Prospect Theory. The author finds that fishers are less risk averse than subjects in alternate occupations.

Most studies of fishers' risk behaviour analyse commercial fisheries in developed countries (Eggert and Lokina 2007). While, to our knowledge, this is the first study of small–scale fishers' risk behaviour in a South African setting, in a broader context this study adds to the limited body of work on the risk preferences of small–scale fishers in a developing country context.

Our results indicate that the average participant is moderately risk averse and that risk attitudes vary with certain demographics. In particular, females, female fishers and female rights holders are more risk averse than their male counterparts. These same subjects are also found to be more likely to comply with fisheries regulation. As such, facilitating greater industry access for females has positive implications for achieving compliance. This is significant given that, during the time of these experiments, quota reforms had granted greater access and larger quotas to female (and black) fishers – creating considerable tension within these communities (Visser and Burns 2007).

The paper proceeds as follows: In Section 2 we provide an overview of the sample. The basic design of the experimental tasks as well as issues related to field setting and subject recruitment are reviewed in Section 3. Section 4 provides a brief overview of the expected utility specification while the results follow in Section 5. The implications for compliance are outlined in Section 6. Section 7 concludes.

2 Sample

We study the risk attitudes of a large sample of individuals from nine different fishing communities along the west coast of South Africa. We chose these communities in order to recruit subjects who are more representative of individuals affected by public policy changes in the management of South Africa's fisheries and who would have continuous exposure to conflict over natural resource management.

We use a sample of 555 subjects.[1] Table 1 provides a review of the sample statistics. On average, participants were 40 years old and had lived in their respective communities for most of their lives (just over 30 years). Participants almost exclusively spoke Afrikaans as their first language – with the exception of Community 1 and 2. Around 60% of the respondents were male, although this varies significantly by community. In terms of race, 66% of the subjects classified themselves as Coloured, while a majority of the remaining participants classified themselves as Black or Other. Educational attainments amongst participants are low. Subjects had, on average, obtained eight years of education (grade 8/standard 6). Just over 1% of the sample reported having no primary school education at all.[2] Approximately 33% had obtained some primary education; only 14% of this grouping had completed their primary schooling. Likewise, of the 63% who reported having obtained some high school education, only 9% had completed their grade 12 exam. Finally, only 3% of the sample had obtained a tertiary qualification.

Unemployment is high throughout the sample. Specifically, only 48% of participants reported having a job at the time of the survey. Approximately 62% of households are food insecure.

Approximately 67% (372 individuals) are involved in fishing-related activities. This is a broad category consisting of: subjects that spend a minimum of 2 days a week fishing; subjects who are breadwinners in households where fishing has been the primary source of income over the past 12 months; subjects with fishing rights, subjects living with household members with fishing rights and subjects belonging to a crew who received rights. The mean income from fishing-related activities is $119 per month[3]. Around 70% of subjects involved in fishing related activities are male.

With respect to the allocation of fishing rights, around 46% of the total sample (258 individuals) have themselves been allocated or work for a crew that has been allocated a quota and/or a permit (from here onwards described as rights).[4] Approximately, 72% of these rights holders are male. Furthermore, an additional 22 individuals live with a household member who has been allocated rights.

Of those 372 subjects involved in fishing related activities, 5% (167 individuals) are unemployed. Thus, of the 286 individuals in the total sample that are unemployed, 58% are involved in fishing-related activities. Of these unemployed subjects engaging in fishing-related activities, 66% (110 subjects) are rights holders. Isaacs *et al.* (2007) notes that, in transforming the fishing industry after apartheid, Marine and Coastal Management broadened the number of historically disadvantaged rights holders. However, in many cases, allocations have been too small to produce sufficient livelihoods.

Mean household per capita income for the whole sample was $47 per month, exceeded by the mean monthly household per capita expenditure of $55 per month. Note that income measures vary considerably across the different communities in the sample. In terms of the allocation of fishing rights, 70% of subjects perceive the officials allocating rights to be corrupt, while 78% perceive the allocation process to be unfair.

[1] 569 individuals were recruited. However, 14 subjects were excluded from the analysis: 1 participant left before completing all lottery tasks, 2 participants omitted important information and 11 participants made three or more inconsistent choices. The presence of inconsistent choices is not uncommon in research that does not force a switching point (Jacobson and Petrie 2008). In our case, 41% of subjects made at least 1 inconsistent choice. A Fechner error specification is used to account for any behavioural errors made by the subjects, for example through lack of understanding, carelessness or inattentiveness (Hey and Orme 1994).

[2] Participants had no formal schooling or had only completed Sub A or Sub B.

[3] ZAR/USD = 7.02020415 on 26 February 2011

[4] Where a quota refers to a quantity that is harvested and a permit refers to harvesting in a specified period. Participants were asked whether they were quota holders for any of the following species: West Coast rock lobster, abalone, hake (longline or trawl), or purseine fishing. Participants were asked whether they had fishing permits for any of the following species: recreational West Coast rock lobster, line-fish or pelagic species.

3 Experiment design

The following sections outline the experiment design, field setting and recruitment.

3.1 Risk experiment – basic design

We use a multiple price list (MPL) design to elicit risk attitudes. The MPL is a standard format whereby subjects are provided with rows of paired lottery options and, in each row, choose one of the lottery options (Andersen *et al.* 2006). The MPL design has been used to elicit risk attitudes by, among others, Holt and Laury (2002) and Tanaka, Camerer and Nguyen (2010). The MPL can be explained to subjects and implemented with relative ease; because one of the rows is later selected at random to be played, the MPL encourages truthful revelation (Andersen *et al.* 2006).

Before commencement of the experiments, the subjects were provided with documentation detailing the instructions and outlining the different lottery tasks. The instructions were also read aloud and subjects were encouraged to ask questions. The reader is referred to Appendix A and B to view this documentation.

Table 2 replicates the eight tasks presented to subjects. For each binary-choice lottery task, subjects picked either Lottery A or Lottery B.[5] Given the low literacy rates of subjects and the fact that the participants had little or no experience with experiments, the experiment was kept as simple as possible. For this reason, fixed probabilities of 100% and 50% were used in the experiment.[6] In the first task, subjects have a 100% chance of receiving R20 (approx. US$3) under Lottery A; under Lottery B they have a 50% chance of receiving R20 and a 50% chance of receiving nothing. The payoff associated with Lottery A declines systematically throughout the eight tasks, while the payoff for Lottery B remains unchanged. The expected values of the two lotteries, which are replicated in the fourth and fifth columns of Table 2, were not shown to subjects. A risk-loving participant would choose Lottery B in the first lottery task, while a risk-averse subject would choose Lottery A in the eighth lottery task (Harrison *et al.* 2005). As a risk-neutral participant should change from Lottery A to Lottery B when the expected value of both is approximately the same (Harrison *et al.* 2005b), a risk-neutral participant would select Lottery A for the first three tasks and Lottery B thereafter. Following the discussion in Andersen *et al.* (2008) and Fudenberg and Levine (2006), we assume a constant relative risk aversion (CRRA) utility function defined over the non-negative lottery prize. The CRRA function is of the form $U(x) = (x^{1-r})/(1-r)$ where x is the lottery prize and r is the latent risk coefficient.

After the experiment was concluded, one of the eight tasks was selected at random and played for real money.[7] This mechanism motivates participants to consider each choice carefully and rewards participation (Harrison *et al.* 2010). Participants were told upfront they could not lose any money, irrespective of which lotteries they selected. Besides it being morally indefensible to ask low-income participants to gamble their own money during experiments, subjects would be constrained from choosing riskier alternatives should their own money be at risk, introducing the effect of liquidity constraints into the analysis (Binswanger 1980).

3.2 Field setting and recruitment

As outlined in Visser and Burns (2007), the experiments were performed manually with a sample of 569 participants in field laboratories across nine communities. Various methods were used to recruit participants to minimise the potential for sample selection problems: specifically, participants were

[5] An explicit indifference option was not provided.

[6] Our experiment design is theoretically similar to that of Holt and Laury (2002), but differs in that, instead of changing probabilities and fixing payoffs, we fix probabilities and change payoffs.

[7] The subjects were told before the experiment commenced that at the end of the session one of them would be asked to draw a number between 1 and 8 out of a bag. The number randomly selected from the bag represents the lottery task that was elected for payout.

recruited through the use of community leaders, fishers' associations, local newspapers and flyers, and adverts in community centres and harbours (Visser and Burns 2007). Both males and females were targeted for participation, given that fishing rights have been allocated to women in the last half a decade.

At least one month prior to the execution of the experiments, participants attended an initial session during which they completed a comprehensive questionnaire covering a wide demographic spectrum including their socio-economic background, employment activities, fishing experience; and including a host of attitudinal questions (Visser and Burns 2007). These participants were allocated randomly to groups for the risk experiments which took place one month later (Visser and Burns 2007).

4 Choice under uncertainty: Expected-utility specification

A brief exposition of the estimation procedure follows. The discussion is derived from the following studies: Harrison *et al.* 2008, 2009, 2010; and Andersen *et al.* 2008, 2010, 2011.

Under an expected-utility theory (EUT) specification of choice under uncertainty, we assume a constant relative risk-aversion (CRRA) utility function defined as $U(x) = \frac{(x^{1-r})}{(1-r)}$ where x signifies the lottery prize and r is the CRRA coefficient to be estimated: with $r = 0$ denoting risk neutrality, $r > 0$ indicating risk aversion, and $r < 0$ denoting risk loving (Andersen *et al.* 2008).

If there are k possible lottery outcomes and the probabilities for each lottery outcome, $p(k)$, are specified by the experimenter, then expected utility (EU) for lottery task i is denoted as: $EU = \sum_{k=1,K}(p_k \mathrm{x} U_k)$, where expected utility is the utility of each lottery outcome weighted according to its probability (Harrison and Rutström 2008). The EU of each lottery task is calculated "for a candidate estimate of r" (Harrison *et al.* 2009:8), enabling us to calculate the following latent index: $\bigtriangledown EU = (EU_R - EU_L)/\mu$ where EU_R is the right lottery (*risky* Lottery B), EU_L is the left lottery (*safe* Lottery A) and μ is a Fechner noise parameter[8] (Andersen *et al.* 2008). Following Harrison and Rutström (2008), $\bigtriangledown EU$ index is linked to the subjects' observed choices using cumulative probability distribution function, $\Phi(\bigtriangledown EU)$.

The conditional log-likelihood is reflected as:

$$\ln L^{EUT}(r; \mu, y, X) = \sum_i [(\ln \Phi(\bigtriangledown EU)|y_i = 1) + (\ln \Phi(1 - (\bigtriangledown EU))|y_i = 0)] \tag{1}$$

where $y_i = 1(0)$ denotes the choice of the right (left) lottery in task i, and X is a vector of individual characteristics (Harrison and Rutström 2008).

We include a number of independent variables in the model. Six are binary variables indicating the subjects' gender (*Female*), racial classification (*Coloured*), employment status (*Unemployed*), whether the subject is the breadwinner (*Breadwinner*), whether the subject is involved in fishing-related activities (*Fisher*), whether the subject is a rights holder (*Rights*), and finally, a relative income variable describing whether the familys' financial status is perceived as middle income to rich, as opposed to lower income to poor (*Relative inc.*). We also include age in years (and age in years squared), education in years (and education in years squared) and monthly income.

The model is replicated for three different samples: (i) the full sample, (ii) a sample of those participants involved in the fishing industry (fishers), and (iii), a sample of fishers with fishing rights.

Given the possibility of correlation between responses by the same subject, the standard errors are adjusted for clustering (Harrison *et al.* 2009).

[8] The Fechner error specification, popularised by Hey and Orme (1994), account for any errors made by the subjects; in the case of a binary lottery, this is when the probability of selecting one of the lotteries is not equal to one, despite the expected utility of that lottery exceeding the expected utility of the other (Harrison and Ruström 2008).

5 Results

Table 3 presents the estimates from the expected-utility theory specification. Panel A replicates the results for the full sample assuming no covariates. The remaining panels signal the effects of demographic characteristics on risk attitudes. Specifically, panel B replicates the results for the full sample including covariates; panel C presents estimates for the sample of subjects involved in fishing-related activities (fishers) and panel D replicates results for a sample of subjects involved in fishing-related activities who have been allocated *fishing rights*. For this CRRA specification, negative values denote risk loving, a value of zero indicates risk neutrality and positive values denote risk aversion (Harrison *et al.* 20010). The regression-model coefficients are interpreted as the marginal effect of each variable as compared to the default case (Harrison *et al.* 2007).

As evident from panel A, the coefficient of CRRA is estimated to be 0.393 (p-value = 0.000), implying moderate risk aversion. While this result is comparable to estimates obtained in developed and developing countries using comparable methods, it indicates a lower average degree of risk aversion. Harrison *et al.* (2010) (Ethiopia, India and Iganda) estimate the coefficient of CRRA to be 0.54; Galarza (2009) (Peru) derives an estimate of 0.45 when including covariates.

There is a significant effect from age: Panel B: 0.023, p-value = 0.034; Panel C: 0.021, p-value = 0.049. Risk aversion increases with educational attainment across all sub-samples (Panel B: 0.09, p-value = 0.015; Panel C: 0.085, p-value = 0.057; and Panel D: 0.091, $p-$value = 0.059). Tanaka *et al.* (2010) find that subjects that are both older and more educated are more risk averse.

Females are more risk averse than men (Panel B: 0.254, p-value = 0.0004). This is in line with Croson and Gneezy's (2009) review of the experimental literature relating to gender differences in risk behaviour. They find that women are consistently more risk averse than men. Our results further indicate that female fishers (Panel C: 0.266, p-value = 0.005) and female fishers with fishing rights (Panel D: 0.296, p-value = 0.023) are also more risk averse than their male counterparts. These results may have positive implications for compliance with fisheries regulation, given the increased presence of females in the fishing industry in the last half a decade.

In line with the results of Binswanger (1980) and Mosley and Verschoor (2005), we find no significant correlation between risk attitudes and wealth across all sub-samples. This finding is inconsistent with the commonly held assumption of Decreasing Absolute Risk Aversion (DARA).

We also find that subjects involved in fishing-related activities are more risk averse than workers in alternate occupations: risk aversion increases by 0.184 if the subject is involved in fishing-related activities (Panel B: p-value = 0.054).

Finally, rights holders are less risk averse than non-rights holders (Panel B: -0.139, p-value = 0.044; Panel C: -0.131, p-value = 0.049).[9]

6 Exploring the relationship between risk aversion and compliance

Engaging in illegal activities is synonymous with engaging in risky behaviour. Using an expected utility framework, Eisenhauer (2004) concludes that risk aversion acts as a deterrent to "sin". In this context, we use the estimated (experimental) risk preferences to examine the relationship between risk and non-compliance (catching illegally). Assuming that the probability of detection is sufficiently large and the punishment for transgression sufficiently severe, we anticipate risk-averse subjects to be less likely to catch illegally relative to their more risk-loving counterparts.

[9] An area for future research would be to determine whether risk loving individuals become rights holders or whether rights holders become more risk loving during the course of their fishing activities.

6.1 Analysis of those catching illegally

The results from the risk analysis indicate that (i) female fishers are more risk averse, (ii) female fishers with rights are more risk averse, and (iii), rights holders are more risk loving. We analyse the implication of these findings for resource usage by analysing subjects' responses to questions of compliance.

Subjects answered a number of questions around issues of compliance. These questions ascertained: (i) whether subjects have caught more than their quota states, fished outside the specified dates of their permit, or fished without a quota or permit; (ii) the number of times subjects have been charged or arrested for violating fishing regulations in the previous year; (iii) whether it was correct that they were charged or arrested on these occasions; and (iv), whether they stopped violating the regulations after being charged or arrested. We used subjects' responses to the above questions to collate a list of subjects who have violated fisheries regulation.

We calculate that 180 subjects (32% of the sample) have caught illegally. Around 16% of the sample (87 subjects) indicated directly that they had caught more than their quota states, fished outside the specified dates of their permit, or fished without a quota or permit (the answered question (i)). An additional 93 subjects, who did not answer question (i) but answered question(s) (ii), (iii) and/or (iv), were added to the list of participants who have caught illegally. With regard to question (ii), 31 subjects have been charged or arrested once in the past 12 months for violating fisheries regulations, while 12 subjects have been charged/arrested twice and 7 subjects have been arrested three or more times over the same period. With respect to question (iii), 33 subjects indicated that it was correct that they were charged/arrested, while 10 subjects noted that it was correct on some occasions and 84 subjects stated that it was not correct. With respect to question (iv), 38 subjects that been charged/arrested said they had changed their behaviour, while 15 subjects noted that their behaviour changed after being charged a few times. Seventeen subjects stated that being charged did not change their behaviour. Of these 180 subjects, 158 are involved in fishing-related activities and 22 are involved in non-fishing-related activities.

Table 4 provides a breakdown of those 180 subjects who have violated fishing regulations. Males are responsible for the majority of violations. Specifically, of those catching illegally, 83% are male. A two-sample Wilcoxon non-parametric test confirms that males typically tend to overfish more relative to females ($z = 19.918, p < 0.01$). This result supports our experimental finding that women are more risk averse.[10]

Around 90% of poaching/overfishing is carried out by fishers (subjects involved in fishing-related activities). Of these fishers who catch illegally, 86% are male. While the dominance of males in terms of non-compliance is explained by their larger presence in terms of absolute numbers in the fishing industry (see sample statistics), in percentage terms, only 17% of all female fishers have acknowledged poaching/overfishing versus 50% of men.

In terms of fishing rights, 79% of those overfishing have rights or work for a crew that has been allocated rights. This result explains the prevalence of illegal activities carried out by fishers. Of those 180 subjects catching illegally, 158 are fishers. This seems to contradict our findings that fishers are more risk averse. However, of these fishers, 77% are rights holders. Thus, of fishers who catch illegally, the large majority are rights holders.

Of these rights holders who overfish, 86% are male. Once again, the fact that overfishing is

[10] A discussant queried whether woman may be less inclined (than men) to report their illegal activities given that they are more risk averse. It is more likely that, given the possibility of being apprehended and charged, a higher degree of risk aversion in females manifests in a reduction in illegal fishing activities relative to men. As will be discussed in Section 7, correspondence with officials from the compliance division of Marine and Coastal Management confirm that fewer women are charged in connection with illegal fishing activities than men: Specifically, in the Overberg, in the past 5 years, about 89 women have been charged in connection with poaching, compared to around 1200 men (personal communication). However, we do not know the proportion of male and female fishers in this region and assume that there are more male fishers relative to females. Finally, all respondents were assured that their answers would remain anonymous and that researchers solely represented the University of Cape Town; there is no reason to believe that women where more sceptical of these assurances than men.

undertaken predominantly by male rights holders reflects the small presence of female rights holders in the industry. However, as a percentage, 23% of female rights holders have admitted to catching illegally, versus 57% of male rights holders. The two-sample Wilcoxon non-parametric test confirms that non-compliance stems from rights holders ($z = -15.820, p < 0.01$). While it seems intuitive that rights holders' active role in illegal catching may be due to the fact that they have a plausible reason to be out on the water fishing, our experimental findings in Table 2 indicate that having access to fishing rights has a direct impact on individuals' level of risk preferences. Our results show that rights holders are both less risk averse and more likely to engage in poaching activities.

Just less than 90% of those catching illegally perceive fishing rights to be allocated unfairly, while 78% feel that the officials allocating quotas are corrupt. Again, from the non-parametric tests, those who perceive the quota allocation process to be unfair ($z = -7.048, p < 0.01$) and corrupt ($z = -7.646, p < 0.01$) typically overfish/poach more relative to those who do not.

6.2 Linking risk attitudes and compliance

The relationship between risk attitudes and compliance is assessed more formally with the use of logistic regression analysis – the results of which are displayed in Table 5. The dependent variable, *overfish*, takes on a value of 1 if subjects have caught illegally.

Panel B is analogous to Table 3 in that it contains the same set of covariates.

Additional variables have been added in panel C: Compliance is also a measure of cooperation in a common-pool resource[11] (CPR) context and constitutes an important social norm. Evidence from the lab indicates that the sanctioning of free-rider in a CPR and public good context promotes cooperation (Ostrom 2000, Ostrom *et al.* 1994, Ostrom *et al.* 1999, Fehr and Fischbacher 2004, Gächter and Herrmann 2009, Ledyard 1995, Gächter 2007). In a public good setting, Fehr and Gächter (2000), Fehr and Gächter (2002) and Anderson and Putterman (2006) find that punishment increases as the differential between individual contributions and average group contributions widens, while Gächter et al. (2008) conclude that deviations from the punisher's contribution are sanctioned. It is evident that subjects, in collective action dilemmas, will punish below–average contributors (at their own personal cost). For this reason we include *social sanctioning as a proxy for cooperativeness.* As such, we include in the model the variable, *report*, which indicates whether a subject would report illegal fishing activities to the authorities.[12]

Given the large proportion of subjects who feel that the rights-allocation process is both corrupt and unfair, we analyse the role of perceptions of fairness in the allocation of rights by including the variables, *corrupt* and *unfair.*

While the inclusion of variables *report, corrupt* and *unfair* is considered important in the context of an analysis of illegal fishing behaviour, we excluded these variables from the experimental risk analysis in Section 5, as we assumed them not to be relevant determinants of a subject's broad risk profile. As before, the regressions are estimated for various samples: the full sample (columns 1,2 and 5); a sample of full-time fishers (columns 3 and 6); and finally, a sample of full-time fishers with rights (columns 4 and 7).

In panel A, the estimated experimental risk parameters (see Section 5) are regressed on the dependent variable, *overfish.* The results signify a link between risk aversion and non-compliance: an increase in the experimental risk measure (as participants become risk averse) translates into a reduction in the odds of catching illegally (column 1: p-value = 0.001). We therefore anticipate that more risk-averse subjects, such as females, would more readily comply with fisheries regulation, while more risk-loving subjects, such as quota holders, would be more likely to catch illegally.

[11] Common-pool resources are resource systems characterised by subtractability and difficulty of exclusion (Ostrom *et al.* 1999).

[12] Subjects were asked the following question: If you knew that someone in your community was fishing more than their quota, would you report them to the police? Around 51% (277 subjects) answered yes. We have information on compliance for 244 of these subjects. Specifically, of these 244 subjects, a minority of around 36% have caught illegally.

In this context, not only are females less likely to catch illegally (column 2: p-value = 0.000; column 5: p-value = 0.000), but females in the fishing industry are less prone to non-compliance (column 3: p-value = 0.000; column 6: p-value = 0.000). This is also the case for female fishers with rights (column 4: p-value = 0.000; column 7: p-value = 0.000). These results correspond with the experimental measure for risk aversion where women were found to be more risk averse. It is clear that, in terms of policy implications, granting greater access to females has positive implications for compliance.

The odds of poaching are higher for rights holders (column 2:$p-$value = 0.068; column 3: p-value = 0.070: column 5:$p-$value = 0.033; column 6: p-value = 0.036). Again, this result is compatible with the result in Table 3, where rights holders are found to be more risk loving.

Subjects who would report illegal fishing activities to the authorities are less likely to catch illegally (*Report*) (column 5: p-value=0.012; column 6: p-value = 0.009; column 7: p-value = 0.017).

Finally, we find no significant effect on poaching from perceptions of fairness: While the coefficient of *corrupt* is positive, indicating that subjects who perceive the officials allocating quotas to be corrupt are more likely to overfish, this result is only significant at the 11% level (column 5:$p-$value = 0.106; column 6: p-value = 0.112: column 7:$p-$value=0.119).

7 Discussion

In this study, we estimate the risk attitudes of a large sample of individuals from various fishing communities along the west coast of South Africa, using subjects'choices over lotteries with real monetary prizes. The majority of these individuals are involved in fishing-related activities. We estimated a CRRA utility function defined over the lottery prize.

Our results indicate that the average participant is moderately risk averse and that risk attitudes vary with certain socio-demographic variables. In particular, we find female fishers to be more risk averse than their male counterparts. These same subjects are also found to be more likely to comply with fisheries regulation. Conversely, rights holders are found to be more risk loving and less likely to comply.

The experimental evidence we have presented in this paper suggests that fishers' risk preferences have implications for compliance with fisheries regulation. In particular, we find that risk-averse subjects are less likely to catch illegally relative to their more risk-loving counterparts. From this analysis we derive three significant conclusions:

Female fishers and female fishers with rights are more risk averse than males in the same category. Given this higher degree of risk aversion, females in the fishing industry are less likely to overharvest relative to male fishers. Correspondence with officials from Marine and Coastal Management confirmed this finding: around 89 women have been charged in connection with poaching in the Overberg over the past 5 years, compared to 1200 men (personal communication). The implication is that increasing the presence of females in the industry has positive implications for compliance.

Rights holders are found to be both less risk averse and more likely to engage in illegal fishing activities than fishers without rights. The idea that rights holders are more predisposed towards illegal fishing activities contradicts the general argument that attaching property rights to individuals, groups or communities resolves the "*tragedy of the commons*" and prevents over-exploitation of the resource by eliminating the root problem of open access (Jentoft *et al.* 1998). Joubert *et al* (2008) argue that a quota system reduces overfishing by constraining fisher effort and preventing the derby effect whereby, in the absence of individual allocations, fishers harvest as much of the season's quota as possible. However, our results indicate that granting rights to a resource does not necessarily translate into sustainable resource usage; rather rights holders – who have a legitimate reason to be at sea – are provided with an opportunity to overharvest.

Just less than 80% of subjects believe the rights allocation process to be unfair while 70% believe the officials allocating rights to be corrupt. However, we find no significant increase in poaching amid perceptions of "unfairness." Hauck (2009) provides an overview of the role of legitimacy on compliance: specifically, that the obligation to comply with fisheries regulation is eroded when the regulation is perceived as unjust. In this context, we would expect to find a significant effect from perceptions of unfairness. We surmise that, given the pervasiveness of unfairness perceptions throughout the sample, such perceptions are not actual determinants of illegal activities. For example, of those who have caught illegally, 78% believe the officials allocating rights to be corrupt while 87% believe the process to be unfair. In the case of those subjects who have not caught illegally, the corresponding percentages are 68% and 76%, respectively.

Conversely, subjects who would report illegal fishing activities to the authorities are found to be less likely to engage in illegal fishing activities. Fehr and Fischbacher (2004) use evidence from the lab to consider the emergence and enforcement of social norms and the factors underlying cooperative behaviour. The authors note that evidence from public good experiments indicates that contribution rates are higher than is predicted by economic theory, but that cooperation declines over time when non-cooperation goes unpunished. However, the introduction of sanctioning opportunities and associated sanctioning behaviour significantly enhances cooperation. The authors find that a credible threat of sanctions is critical to sustain cooperative behaviour. We refer to subjects who are willing to sanction below-average contributors as *norm enforcers*. In the context of this paper, a norm enforcer is an individual who would report someone engaging in illegal fishing activities to the police. Our results suggest that norm enforcers are more likely to adhere to the social norm of refraining from illegal fishing activities. Strengthening the norm-enforcement capacity of locals in the fishing industry could thus have positive implications for compliance. Given the pervasive perception that the allocation process is both corrupt and unfair, and the potential for enhanced norm enforcement capacity to impact positively on compliance, resource management might well benefit from a partnership arrangement whereby resource users are involved in the design, implementation and enforcement of fisheries regulation, as well as the allocation of fishing rights (Hauck and Sowman 2001).

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Table 1: Sample Statistics by Community

Variable	ALL *n=555*	Com 1 *n=44*	Com 2 *n=103*	Com 3 *n=103*	Com 4 *n=21*	Com 5 *n=8*	Com 6 *n=68*	Com 7 *n=88*	Com 8 *n=21*	Com 9 *n=99*
Male (%)	0.59	0.91	0.50	0.17	0.52	0.88	0.59	0.99	0.67	0.58
Coloured (%)	0.66	0.61	0.74	0.62	0.60	0.75	0.61	0.60	0.52	0.77
White (%)	0.02	0.20	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.02
Black (%)	0.17	0.20	0.16	0.13	0.15	0.00	0.23	0.20	0.19	0.19
Indian (%)	0.00	0.00	0.01	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Other (%)	0.14	0.00	0.10	0.25	0.25	0.25	0.16	0.20	0.29	0.02
Afrikaans %)	0.88	0.51	0.75	0.99	1.00	1.00	0.91	1.00	1.00	0.85
English (%)	0.09	0.44	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.07
Xhosa (%)	0.03	0.05	0.01	0.01	0.00	0.00	0.09	0.00	0.00	0.08
Age	40.30	50.41	38.03	39.01	49.10	59.13	32.87	43.27	54.24	35.56
	(13.54)	(12.79)	(12.22)	(12.99)	(18.31)	(4.52)	(12.15)	(11.25)	(11.98)	(10.08)
Yrs. in	30.31	30.66	27.90	31.16	29.20	26.58	27.35	36.13	40.90	27.14
Community	(13.05)	(18.85)	(7.83)	(13.65)	(8.26)	(9.11)	(11.10)	(14.32)	(12.92)	(11.97)
HH size	5.13	4.24	5.48	5.00	5.10	5.86	5.15	5.75	4.62	4.76
	(2.34)	(2.39)	(2.31)	(2.14)	(2.17)	(3.34)	(2.11)	(2.77)	(1.68)	(2.13)
Yrs. education	8.35	7.45	8.18	8.94	7.05	5.50	9.00	8.13	7.80	8.68
	(2.42)	(2.09)	(2.33)	(2.34)	(3.04)	(1.75)	(1.81)	(2.63)	(1.87)	(2.44)
Employ. (%)	0.48	0.63	0.50	0.57	0.29	0.38	0.49	0.58	0.33	0.31
Fisher (%)	0.68	0.91	0.68	0.50	0.48	0.75	0.56	0.94	0.52	0.70
HH per capita	332.84	652.58	290.15	344.23	509.34	464.84	165.99	300.36	349.21	334.10
Inc.	(460.12)	(991.70)	(392.09)	(340.05)	(565.57)	(430.66)	(139.94)	(419.04)	(346.92)	(386.47)
HH per capita	382.83	531.18	373.23	360.25	737.99	106.25	177.74	433.90	317.91	420.24
Exp.	(442.09)	(432.66)	(408.61)	(264.86)	(698.65)	(0.00)	(119.80)	(673.96)	(305.45)	(409.69)
Quota (%)[1]	0.30	0.18	0.42	0.26	0.19	0.13	0.24	0.39	0.29	0.30
Permit (%)[1]	0.44	0.50	0.54	0.21	0.43	0.13	0.43	0.69	0.38	0.34
Rights (%)[1]	0.46	0.50	0.56	0.26	0.43	0.13	0.43	0.74	0.27	0.39
Corrupt (%)	0.70	0.68	0.71	0.67	0.76	1.00	0.65	0.77	0.71	0.68
Unfair (%)	0.78	0.73	0.73	0.76	0.71	0.88	0.81	0.89	0.86	0.75

Note: [1] Subjects that have been allocated rights or that work for a crew that has been allocated rights; standard deviation in parenthesis

Table 2: Experimental design

Task	Lottery A	Lottery B	EV^A	EV^B
1	R 20	0.5 of R20; 0.5 of R0	R 20	R 10
2	R 15	0.5 of R20; 0.5 of R0	R 15	R 10
3	R 12	0.5 of R20; 0.5 of R0	R 12	R 10
4	R 10	0.5 of R20; 0.5 of R0	R 10	R 10
5	R 8	0.5 of R20; 0.5 of R0	R 8	R 10
6	R 6	0.5 of R20; 0.5 of R0	R 6	R 10
7	R 4	0.5 of R20; 0.5 of R0	R 4	R 10
8	R 2	0.5 of R20; 0.5 of R0	R 2	R 10

Table 3: Maximum Likelihood Estimates of CRRA utility function

	A	B	C	D
	All	All	Fisher	Fisher with rights
Constant	0.393**	-0.503	-0.171	0.271
	(0.028)	(0.367)	(0.377)	(0.458)
Age	-	0.023**	0.021**	-0.000
		(0.011)	(0.011)	(0.013)
Age squared	-	-0.000**	-0.000*	-0.000
		(0.000)	(0.000)	(0.000)
Education	-	0.098**	0.085*	0.091*
		(0.040)	(0.045)	(0.048)
Education sq	-	-0.005***	-0.004**	-0.004**
		(0.002)	(0.002)	(0.002)
Female	-	0.255***	0.266***	0.300**
		(0.088)	(0.095)	(0.130)
Race	-	-0.111*	-0.097	-0.077
		(0.060)	(0.066)	(0.068)
Unemployed	-	0.111	0.064	0.016
		(0.070)	(0.067)	(0.079)
Breadwinner		-0.058	-0.077	-0.019
		(0.065)	(0.070)	(0.088)
Income	-	-0.008	-0.011	-0.042
		(0.024)	(0.022)	(0.032)
Fisher	-	0.184*	-	-
		(0.095)		
Rights	-	-0.139**	-0.131**	-
		(0.069)	(0.067)	
Relative inc.	-	-0.064	-0.097	-0.139
		(0.086)	(0.085)	(0.096)
Log pseudo-likelihood	-2594	-1379	-1140	-937
No. of obs.	4440	2416	2024	1640
Wald chi(df)	-	215.04(12)	130.14(11)	88.62(10)
Prob>chi2	-	0.000	0.000	0.000

Notes: Observations are multiples of 8 given that each subject provided 8 lottery choices; robust standard errors in parenthesis; *, ** and *** denotes significance at the 10%, 5% and 1% level, respectively.

Table 4: Analysis of those catching illegally

Variables	**%**
N=180	
Male	83
Female	17
Employed	54
Unemployed	46
Fisher	88
Fishing rights	79
Allocation process perceived to be corrupt	78
Allocation process perceived to be unfair	87

Table 5: Logistic regression estimates, catching illegally

	A	**B**			**C**		
	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	All	**All**	**Fisher**	**Fisher with rights**	**All**	**Fisher**	**Fisher with rights**
Exp risk	0.098***						
	(0.072)						
Female		0.177***	0.149***	0.146***	0.208***	0.165***	0.155***
		(0.061)	(0.055)	(0.060)	(0.077)	(0.066)	(0.070)
Fisher		2.463			2.688		
		(1.519)			(1.844)		
Rights		1.987*	2.012*		2.375**	2.441**	
		(0.746)	(0.775)		(0.964)	(1.040)	
Report					0.458**	0.418***	0.421**
					(0.143)	(0.139)	(0.153)
Corrupt					1.858	1.901	1.962
					(0.711)	(0.769)	(0.848)
Unfair					0.842	0.856	0.647
					(0.366)	(0.399)	(0.351)
No. Of obs.	287	287	247	202	265	230	190
Wald chi (df)	10.71 (1)	48.30 (12)	44.40 (11)	30.70 (10)	48.05 (15)	42.54 (14)	31.04 (13)
Prob>chi2	0.001	0.000	0.000	0.000	0.000	0.000	0.003
Pseudo R^2	0.028	0.164	0.148	0.130	0.185	0.181	0.164

Note: All regressions in panels B and C include controls for age, education, race, employment status, income, relative income and breadwinner status; robust standard errors in parenthesis;, ** and * ** denotes significance at the10%, 5% and 1% level, respectively.*

Appendix A: Instructions for Players

We will begin the first experiment, which involves real money. You will be asked to make a number of repeated choices. We will only pay you for one of the choices you make in this exercise. However, you do not know yet for which of the choices we will pay you, so you must think about each question very carefully. You will only find out at the end of today's session for which of these questions you are going to be paid . So, it is in your interest to treat each of the choices as if this were the only choice you made and as if ***this*** is the question for which you are going to be paid. Is this clear?

The questions deal with whether **you prefer to have a smaller amount of money for sure,** OR a **larger amount of money where there is some risk** that you end up not getting anything.

You can never lose any money irrespective of what you choose.

For example, consider the following two options:

Option A: You get R10 for sure.   OR

Option B: We will flip a coin. If it comes up heads, you will get R20. However, if it comes up tails you will get nothing.

If you choose Option A, you know what you get for sure. If you choose Option B, where we flip a coin, you might get R20, but there is also some chance you will get nothing.

We will now ask you 8 questions like these, but with different numbers. These differences are important. **Remember, the best you can do is to think carefully about each question as if it were the only choice you made.**

Once you have made your 8 choices, I will collect your forms. At the end of today's session, we will ask one of you to draw a number between 1 and 8 out of a bag. **Whichever number is picked from the bag will be the choice that counts for you.**

If you decided to take the money for sure, that is the amount you will get. But if you decided to flip the coin, we will then flip the coin. If it comes up heads, you will win R20, but if the coin comes up tails, you will not win anything.

Is this clear? Are there any questions before we begin?

Appendix B: Experimental design

Question 1: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R20 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20, if it comes up tails, you get nothing.

Question 2: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R15 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20, if it comes up tails, you get nothing.

Question 3: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R12 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20, if it comes up tails, you get nothing.

Question 4: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R10 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20, if it comes up tails, you get nothing.

Question 5: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R8 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20, if it comes up tails, you get nothing.

Question 6: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R6 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20; if it comes up tails, you get nothing.

Question 7: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R4 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20; if it comes up tails, you get nothing.

Question 8: Which alternative do you choose? (Tick the relevant box.)

• Option A: You get R2 for sure.

• Option B: Flip a coin: If coin comes up heads, you get R20; if it comes up tails, you get nothing.