MPRA
Munich Personal RePEc Archive

From the lab to the field: Cooperation among fishermen

Stoop, Jan; Noussair, Charles and van Soest, Daan
Tilburg University, CentER

16. September 2010

From the lab to the field: Cooperation among fishermen*

Jan Stoop†
Charles N. Noussair‡
Daan van Soest§

September 16, 2010

Abstract

We conduct a field experiment to measure cooperation among groups of recreational fishermen at a privately owned fishing facility. The parameters are chosen so that group earnings are greater when group members catch fewer fish, as in the Voluntary Contributions Mechanism (VCM). In a manner consistent with classical economic theory, though in contrast to prior results from laboratory experiments, we find no evidence of cooperation. We construct a series of additional treatments to identify causes of the difference. We rule out the subject pool and the laboratory setting as potential causes, and identify the type of activity involved as the source of the lack of cooperation in our field experiment. When cooperation requires a reduction in fishing effort, individuals are not cooperative, whether the reduction in fishing translates into more money or into more fishing opportunities for the group.

JEL Classification: C72, C92, C93.

*We are grateful to the Netherlands Organization for Scientific Research, NWO, for financial support as part of the Program on Evolution and Behavior. We would like to thank Ad and Thea van Oirschot for use of their fishing facility, and Stef van Kessel, Mike Groels, and Paul Ludeña Delgado for excellent research assistance. We are grateful to Niels van den Broek, Machiel Driesser, Patrick Hullegie, Sander Tuit, Alexandra van Geen and Peter van Oudheusden for their help in conducting the field sessions. We also thank Wieland Müller, Jan Potters, Ernan Haruvy, Amrita Ray Chaudury, Eline van der Heijden, David Voňka, Cees Withagen and especially Amos Zemel for their comments and suggestions on an earlier version of this paper.

†Tilburg University, Department of Economics and CentER, Tilburg, the Netherlands.

‡Tilburg University, Department of Economics and CentER, Tilburg, the Netherlands.

§VU University Amsterdam, Department of Spatial Economics and IVM, Amsterdam, The Netherlands, and Tilburg University, Department of Economics and CentER, Tilburg, the Netherlands.

1 Introduction

A large literature in experimental economics has focused on the extent to which individuals cooperate in social dilemmas. Social dilemmas are group interactions, in which an individual maximizes his own payoff when he does not cooperate, but where attaining the social optimum requires cooperation. One experimental paradigm commonly employed to study social dilemmas is the Voluntary Contribution Mechanism (VCM). In a canonical version of this game, each member of a group receives an endowment of money. The members of the group then simultaneously choose to contribute any portion of their endowment to a group account. Contributions to the group account benefit all members of the group. The tradeoffs are specified so that each individual has a dominant strategy to place his entire endowment in his private account, but the social optimum is attained only if all individuals contribute their entire endowment to the group account. Thus, classical economic theory, which maintains the assumptions of exclusively self-interested motivation and rational decision making, predicts that all individuals allocate their entire endowments to their private accounts.[1] The percentage of endowment placed in the group account can be readily interpreted as a measure of cooperation.

The behavior of individuals who repeatedly play the VCM has been shown to exhibit two robust patterns (for a survey, see Ledyard (1995)). The first pattern is that individuals' initial average contributions to the group account are significantly different from both zero and 100 percent of their endowment. This reveals positive, but less than full, cooperation on the part of the average individual entering a new social dilemma. The second pattern is that a decline in the level of cooperation occurs as the game is repeated (see, for example Isaac et al. (1985), Andreoni (1988), and Isaac and Walker (1988b)). The two patterns found in the laboratory are interpreted as evidence that behavior of individuals is systematically different

[1] If the game is repeated a finite number of times, the only subgame perfect equilibrium is for each individual to place his entire endowment in his private account in every period, regardless of the history of play. The social optimum requires all individuals to place their entire endowment in the group account in every period.

from that of self-interested rational agents. Explaining these patterns has been a focus of a number of models. The positive level of cooperation at the outset of interaction is one of the stylized facts motivating the modeling of other-regarding preferences (see for example Rabin (1993), Fehr and Schmidt (1999), Bolton and Ockenfels (2000), and Andreoni and Samuelson (2006)). The decline in cooperation with repetition of the game has been interpreted as a reduction of errors over time (Palfrey and Prisbey (1996), Andreoni (1995), and Houser and Kurzban (2002)), as reputation building (Andreoni (1988), Sonnemans et al. (1999), and Brandts and Schram (2001)), and as a result of a self-serving bias accompanying conditional cooperation (see for example Neugebauer et al. (2007)).

In this paper, we consider whether these two patterns appear in a framed field experimental environment. The setting of our field experiment is a privately owned fishing pond where recreational fishermen can catch rainbow trout. We create a social dilemma similar in structure to the VCM. The fishermen are assigned to anonymous groups of four persons, who interact for six forty-minute periods. In each period, each fisherman is allowed to catch a maximum of two fish, which are his to keep. However, for each fish an individual foregoes catching, each of the three other members of the group receives a cash payment. Thus, a social dilemma is created in that each individual has a dominant strategy to catch two fish in each period, while the social optimum requires all individuals to forego their catches. Cooperation measures are derived from the actual catch of fish, and from the effort made to catch fish, relative to a control treatment in which no collective incentives exist to reduce the catch of fish.[2]

[2]Our work bears a relation to a number of other field experiments that focus on cooperation. An active literature is investigating influences on charitable giving (see for example List and Lucking-Reiley (2002), Frey and Meier (2004), Martiny and Randal (2005), Alpizar et al. (2008) and Croson and Shang (2008)). Another strand of research uses artefactual field methods to study behavior of non-student subject pools in the VCM game (see for example Barr (2001) and Ruffle and Sosis (2007)), and a closely related paradigm, the common pool resource game (see for example Cardenas (2003), Cardenas (2004), Cardenas and Ostrom (2004), and Rodriguez-Sickert et al. (2008)). These studies all find positive cooperation in the VCM game among the subject pools studied. The available evidence from framed and natural field experiments is mixed. Erev et al. (1993) find considerable evidence of free-riding when students pick oranges under team incentives.

As described in section 2, we find strong support for classical economic theory in our field experiment. There is no evidence of cooperation, even in the initial periods. Beginning in the first period, and continuing throughout the sessions, fishermen in the treatment with group-level gains from cooperation fish with the same effort and catch the same average number of fish as those in the treatment without such potential gains. To explore the source of the difference between our setting and received results from the laboratory, we conduct four additional treatments. Three of these treatments are implemented in the laboratory, and the fourth one is an additional field treatment. These treatments are described and reported in sections 3 and 4.

These four treatments establish that the discrepancy in cooperation is not due to the fact that: (i) the framing is contextualized in the field experiment, (ii) the subject pool differs, (iii) the field experiment is conducted in a natural rather than in a structured laboratory setting, or (iv) the group benefits and private costs of cooperation are denominated in terms of different units (money and fish) in the field experiment. Rather, the data from these treatments suggest that the key difference between the laboratory and our field setting is the decision variable, the activity that must be undertaken in order to cooperate. When cooperation requires a reduction of fishing, individual behavior conforms to classical economic theory, and there is no cooperation. This is independent of whether the reduction in catch results in more money — as is the case in the field experiment described above — or into more fishing opportunities for the group.

The treatment developed to test the last claim (iv), FieldDyna, is of particular interest for two reasons. The first reason is that the assumption that a social dilemma exists depends on no assumptions other than that

When groups act individually, subjects pick thirty percent fewer oranges than when a bonus is given to the group with the highest output. In a one-shot social dilemma setting in a restaurant, Gneezy et al. (2004) find that students choose more expensive meals when the costs are split with five other students, than when each pays for her own meal, and thus exhibit a considerable tendency toward free-riding. Bandiera et al. (2005) report a substantial degree of cooperation in a fruit picking firm, but only when the subjects are able to monitor each other.

individuals prefer to catch more fish to less fish (as described in section 2, the initial field experiment described above constitutes a social dilemma only under certain, albeit in our view weak, assumptions on the relative value of fishing and monetary payments). The second reason is that FieldDyna constitutes the first experimental test of the canonical renewable resource model (see for example Brown (2000)) with human participants.

Our framed field experiment can be viewed a controlled test of the external validity of an artefactual field experiment. This is the case because we observe members of the same non-student pool of subjects in the laboratory, as well as in the field, performing a similar task. Several other field experiments have documented a positive relationship between individuals' cooperativeness in an experimental VCM game and pro-social behavior in another activity (see for example Carpenter and Seki (2005), Laury and Taylor (2005), Benz and Meier (2008), Fehr and Leibbrandt (2008). Cardenas (2004), Henrich et al. (2004), and Ruffle and Sosis (2007)). However, there are other studies that do not find such a relationship. For example, List (2006) and Karlan (2005) find that subjects act more cooperatively in laboratory settings than they do outside the laboratory. These latter papers suggest that the laboratory may not always be well-suited to test the effectiveness of policy interventions to promote cooperation. Here, we also find that cooperative behavior in an artefactual field experiment does not carry over to a similar field setting, in this case a framed field experiment.

Levitt and List (2007, 2008) have taken the view that social preferences appear with different prominence in the laboratory and in field settings. Our results are consistent with this view. Furthermore, for the particular game we study, we are able to identify several distinct sources of differences in cooperativeness between the laboratory and the field. Our fishermen exhibit more cooperation than student subjects when making decisions in a laboratory environment, fishermen display more cooperation when making decisions in a natural environment than in a laboratory setting, and making the fishing task real rather than virtual reduces cooperation. Nevertheless, the absence of cooperation in our framed field experiment can only be attributed to the fishing task being real rather than virtual, since the effects of subject pool and of the structured laboratory setting operate in the opposite direction.

We make no claims that our field experiment is any more generic than the traditional experiment conducted in the laboratory, or that commercial fishermen would necessarily behave in a similar manner to recreational fishermen. Rather, we claim only to support the contention that the typical empirical pattern observed in a common laboratory implementation of a social dilemma is not universal, and that the behavior of non-student subjects in a contextualized laboratory experiment is not necessarily predictive of their behavior in the field.

2 The FieldVCM treatment

The first pair of treatments we describe consist of a field implementation of the Voluntary Contributions Mechanism, and a control treatment. The treatments, which constitute a framed field experiment in the sense of Harrison and List (2004), are described in section 2.1. In sections 2.2 and 2.3 we consider methodological issues that arise under our design. We present the analysis of the data in section 2.4.

2.1 The setting, game, and experimental design

The sessions were conducted at a commercial trout fishing facility called 'De Biestse Oevers', located in the village of Biest-Houtakker.[3] This village lies in close proximity to Tilburg, in Noord-Brabant province, in the south of the Netherlands. De Biestse Oevers is privately owned, and comprises three separate fishing ponds with surface areas of about 12,000 square feet each. One of these ponds served as the venue for our experiment. On a typical day, when no experiment is taking place, a customer can fish for four hours for €12.50. The pond has space for twenty fishermen at a time. For each paying customer, four rainbow trout are put into the pond (for an extra fee, salmon trout, a larger variety of trout, can also be thrown in).

[3] See www.biestse-oevers.nl for pictures of the site.

There are strict rules regarding the fishing gear and type of bait that may be used, but a customer is allowed to catch as many fish as possible. Also, because of sanitary considerations with respect to the remaining fish, any trout caught cannot be thrown back into the pond and must be taken away from the site (presumably home). Customers therefore have experience with negative externalities, since when an individual catches a fish he reduces the number of fish available for others. The typical customer, and hence our typical participant, is Dutch, male, and over fifty years old.

Participants were recruited for our experiment two weeks in advance by distributing flyers on site which informed customers of the opportunity to take part in a study conducted by Tilburg University. A maximum of sixteen people was allowed to participate in each session.

Two treatments, FieldVCM and FieldPI, were conducted under the following conditions. A session consisted of six consecutive periods of forty minutes each, and therefore took four hours to complete. Within a session, each period proceeded under identical rules. Participants were assigned to groups of four, and group membership remained fixed throughout the session. Subjects were not informed at any time of the identity of the other members of their group. At the end of each period, each participant was informed privately of the total number of fish caught by his group.

Before a session began, two rainbow trout per participant were put into the pond, plus an additional six trout. For a session with 16 participants, we thus threw in 38 rainbow trout. The number of fish we put into the pond was common knowledge. Before the first period, the participants were randomly assigned a spot at the pond by picking a numbered spot tag out of a bag. This random assignment procedure was repeated before periods three and five. The rotation of positions was intended to create a degree of procedural fairness, since many fishermen believe that their physical position at the pond influences their probability of catching a fish.[4]

Each participant was allowed to catch a maximum of two fish per period (rainbow trout or salmon trout, because the latter could still be present

[4]Our data show no actual significant relationship between location and the number of fish caught, suggesting that this belief may be incorrect or exaggerated; see appendix A.

because of previous use of the pond). Any fish caught was his to keep, as the standard rules and regulations of De Biestse Oevers prohibit throwing trout back into the pond. At the beginning of each session, we released 38 trout (instead of 32), in an attempt to ensure that, at least in principle, all individuals would be able to catch their quota of two fish each. Once a participant had caught his maximum quota, he was required to wait until the next period began to resume fishing. At the beginning of the next period, a number of trout equal to the total catch of the previous period was put into the water. Therefore, the total number of fish in the pond was the same at the beginning of each period within a given session, and this information was explained explicitly to the participants. Communication among subjects was strictly prohibited.

The above is a complete description of the FieldPI treatment; the FieldVCM treatment differed only in that a social dilemma was created by introducing group incentives for reducing the number of fish caught within each group.[5] Each fish that a participant did not catch below his maximum quota of two per period resulted in a cash payment of €2 to each of the other three group members. Therefore, a participant faced a tradeoff in the FieldVCM treatment between catching a fish for himself, or providing a surplus of €6, to be divided equally among the three other members of his group. Note that this game differs from the standard VCM game in that cooperation yields a pure externality; the decision maker does not get any private return to the investments he makes. We imposed this simplification in order to make the social dilemma more obvious to subjects. At the end of each period, participants in the FieldVCM treatment were informed of the group catch in that period, the amount of money they had earned in that period, and their cumulative earnings. The average earnings of a participant in the FieldVCM treatment over the course of a session equalled €49.60.

[5]Informing subjects that they are matched into groups is awkward in a setting in which individual outcomes are completely independent of others' actions. Nevertheless, we wanted to check whether framing the FieldPI treatment as a group exercise has an impact on behavior. Therefore, we conducted one of the FieldPI sessions without informing subjects about any matching procedures. We did not detect any differences in behavior resulting from the different framing.

One round of sessions of the FieldPI and FieldVCM treatments was carried out in June 2008, and a second round was conducted in September and October 2008. The season influences the number of fish caught. In June the water temperature is too high for trout to bite in large numbers, while this is typically not the case in September and October. Therefore, the data from each of the two seasons are analyzed separately. The data from June will be described as having been conducted in the Low season and will be designated as FieldVCML and FieldPIL. Those data acquired in September and October will be said to have been gathered in the High season and will be referred to as FieldVCMH and FieldPIH. All sessions of the field treatments were conducted between 8 AM and noon (with the instructions starting at about 7.40 AM).

2.2 Establishing the existence of a social dilemma

In the FieldVCM treatment, a social dilemma exists if the private benefit of the right to catch an extra fish is smaller than the amount of money received by the other three members if that fish is not caught. In other words, a social dilemma exists if participants value the right to catch one additional fish at less than €6.

There is market evidence that the marginal valuation of the act of catching a rainbow trout is less than or equal to €3. We identified five recreational fishing ponds within a 90 minute drive from our site, where fishermen are charged only for the number of fish caught. Thus the fee per fish can be viewed as the price for the right to catch an additional fish. The fees that are charged for each fish caught in these five facilities range from €1.95 to €3; the one that is closest to Biest-Houtakker, just 40 minutes away, charges €2.40 per fish. The fact that our participants are regular customers of the Biestse Oevers and not of these other facilities is the first piece of evidence that their marginal valuation of the act of catching a fish is less than €3.

The second piece of evidence is obtained by calculating the upper bound for the value of non-cooperation as follows. First, note that the private value of the right to catch a fish has two components: the value of the fish itself and the utility of fishing. The price of rainbow trout in local fishmongers' shops varies from €4.85 to €10 per kilo, and the average rainbow trout weighs around 400 grams. This translates into a price range from €1.95 to €4 per fish. Because an equivalent fish can be purchased nearby for at most €4, it is an upper bound for the value of a fish itself.

To place a value on the utility of fishing, recall that our subjects are regular customers at the fishing pond, so that the value of the marginal half-day of fishing is close to the market price of €12.50. This is an upper bound of the utility of the act of fishing itself, since individuals typically are able to take home some fish after four hours of fishing. Thus, a generous upper-bound for the total value of acting non-cooperatively in our experiment is then €4/fish $\times$ 12 fish + €12.50 = €60.50, though the actual private value is likely to be much lower. If we suppose that the usual fee of €12.50 is paid with an expectation of catching four fish on average, the amount typically thrown into the pond per paying customer, the experiment gives participants an opportunity to catch eight additional fish. Under this assumption, the value of acting non-cooperatively for an entire session (again assuming that the value of each fish is the highest price available in the area) is €4/fish $\times$ 8 fish + €12.50 = €44.50.

Regarding the benefits of cooperation, all subjects would each go home with €72 if they cooperate fully and catch zero fish during all six periods, which is substantially more money than the private value of fishing as calculated above.[6] Indeed, it would be enough to go fishing five times at 'De Biestse Oevers', and have €9.50 remaining, or alternatively to buy twelve

[6] We are aware of only one study that estimates the total surplus of recreational fishing (rather than the marginal value of a fishing trip), and that is the paper by Toivonen et al. (2004). They estimate the total surplus recreational fishermen in five Nordic countries obtain from all fishing trips they make per year. The estimates are fairly consistent across these five countries in that they range between 1.30 and 1.54 times actual fishing expenses. If we apply the maximum ratio (1.54, measured in Norway), to our case, the amount of compensation needed for not being allowed to fish equals €19.25 (= 1.54 times the entrance fee) plus €32 (as an upper bound for the consumption value of the eight extra fish one can catch in our experiment). The calculation indicates that, even when using total surplus of fishing rather than the marginal value, the total estimate of the private value of a half-day of fishing of €51.25, is well below the monetary returns to cooperating of €72.

fish in a fishmonger's shop and have €24 remaining.[7]

A third test of whether our game is correctly parameterized is a survey of members of our subject pool. On a day when no experiments were conducted 24 fishermen were surveyed. Using the strategy method, we asked the fishermen their maximum willingness to pay for the right to catch fish. We asked a fisherman how much fish he would like to catch, given that he would be charged €0.50 for each fish caught. If a fisherman allocated a non-zero value to this price, we asked how much he would like to catch if he would be charged €1 for each fish caught. This procedure was repeated in increments of €0.50 until a fisherman indicated that the fee exceeded his willingness to pay. The survey shows the monetary value a fisherman assigns to the act of fishing and the value of a fish combined. The data does not permit us to disentangle the two values, but that is not necessary to assess whether a social dilemma exists in our FieldVCM experiment.

The results of the survey are the following. Four fishermen indicated that they would not participate in a scheme where a fee was charged per fish caught. Therefore, we are not able to derive a maximum willingness to pay for these four fishermen. The remaining twenty fishermen had an average maximum willingness to pay for the first fish they catch of €3.50. One fisherman indicated that he was willing to pay €15 to catch one fish, while another indicated he would pay €6, and the rest indicated a willingness-to-pay lower than €6. This means that ninety percent of the fishermen had a value of less than €6 for the act of fishing and the first fish they catch. For all of the fishermen, the marginal value of each fish beyond the first was always non-increasing. Thus, we are confident that our experimental parameterization poses a social dilemma.

[7] In addition, there are various ways to decrease the opportunity cost of acting cooperatively. For example, fishermen can decide to cooperate at least partially by fishing leisurely rather than at full force, and thus enjoying the act of fishing while reducing the chances of actually catching two fish per forty-minute time period. Alternatively, they can decide to just fish for, say, four periods rather than six, or they can decide to voluntarily limit their catch to just one fish per period. We deliberately specified the strategy space as zero, one or two fish (rather than just zero or one, for example) to allow for partial cooperation.

2.3 Measuring cooperation

The measurement of cooperation in this setting raises methodological issues that do not usually appear in laboratory experiments. The number of fish caught depends on exogenous factors, such as weather conditions, as well as on the level of cooperativeness. Here, results obtained in the FieldPI treatment serve as the non-cooperative benchmark, as FieldPI provides the same incentives to catch the quota of two fish as FieldVCM does if agents are acting non-cooperatively.

Comparing catch in FieldPI and FieldVCM during a given season (High or Low) provides one measure of cooperation. Cooperation corresponds to a smaller catch of fish in FieldVCM than in FieldPI in the same season. We call the magnitude of this difference the *Catch* measure of cooperation. The level of cooperation in the FieldVCM treatment in the Low season, according to the Catch measure, is thus:

$$C = 4\sum_i x_{it}^{FieldPIL}/n - \sum_i x_{it}^{FieldVCML^j}, \tag{1}$$

where $\sum_i x_{it}^{FieldVCML^j}$ is the total catch of group j in period t of the FieldVCML treatment, and $4\sum_i x_{it}^{FieldPIL}/n$ is the average catch of 4 of the n total number of individuals in the FieldPIL treatment. An analogous measure is defined for the High season. A value of C equal to 0 would indicate zero cooperation, and a positive level would indicate the presence of cooperation.

A second measure of cooperation is the number of times an average fisherman casts his fishing rod per minute. There are several advantages of this 'input' measure of cooperation. First, casting a rod is a conscious decision of a fisherman. A fisherman can deliberately 'work harder' to catch more fish. In appendix A, we show that there is a significantly positive effect of effort on the number of fish caught. Second, the measure yields a clear measure of cooperation. Whereas catching zero fish might be a consequence of bad luck, not casting a rod cannot be reasonably interpreted in a manner other than as indicating cooperation. To measure cooperation, we take the average number of casts per minute registered by members of the group in

FieldVCM, and compare it to FieldPI in the same season. If the average is lower in FieldVCM than in FieldPI, we interpret the difference as an indication that cooperation is observed. We refer to the magnitude of the difference between treatments as the *Effort* measure of cooperation. The data on casts per minute were gathered by two experimenters continuously scoring the number of casts of the 16 fishermen at the pond, with each experimenter monitoring eight individuals. This monitoring serves to increase the level of experimenter scrutiny in both FieldVCM and FieldPI — a factor that Levitt and List (2007) have identified as one that fosters pro-social behavior.

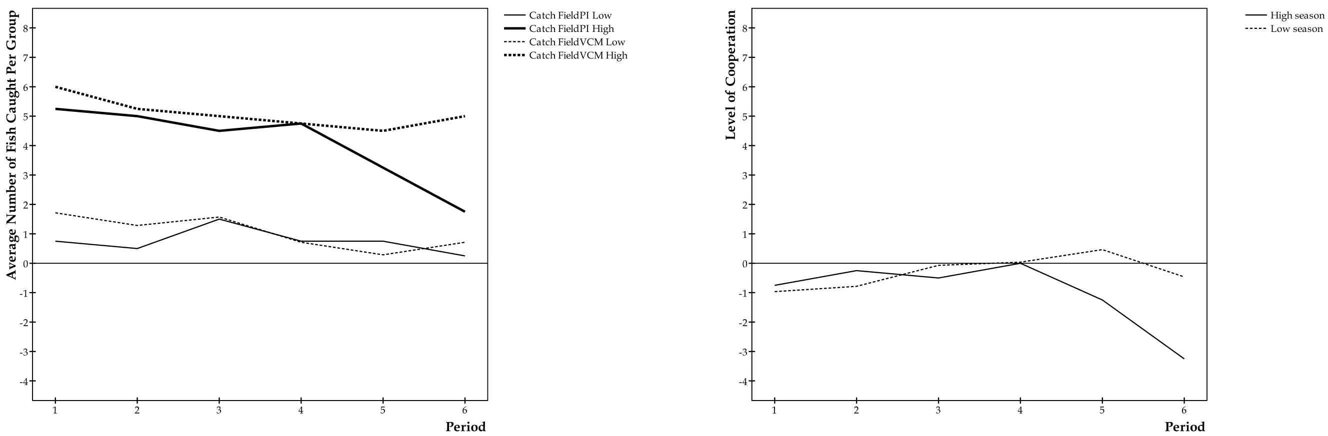
2.4 Results from the FieldVCM treatment

Table 1 illustrates the structure of the Field treatments and indicates the amount of data available. Unless noted otherwise, in the analysis of the data, we treat the activity of each group of four subjects over an entire session as one observation. This gives us a minimum of four observations per treatment.

Treatment	Groups	Main feature	Average Earnings
FieldPIH	4	Determine maximum fishing activity in the high season	–
FieldPIL	4	Determine maximum fishing activity in the low season	–
FieldVCMH	4	Diff. from FieldPIH measures cooperation in the high season	€26.63
FieldVCML	7	Diff. from FieldPIL measures cooperation in the low season	€62.71

Table 1 Number of groups, main feature, and average earnings in the Field Voluntary Contribution Mechanism treatment (FieldVCM) and Field Private Incentive treatment (FieldPI) in the Low and High season.

Figure 1(a) presents the average aggregate number of fish caught in a group, while Figure 1(b) displays the level of cooperation as calculated according to equation (1). The average in each of the two seasons is indicated as a separate series. In Figure 1(a), higher catch reflects less cooperation. Two patterns are obvious in Figure 1(a). The first is that, in a given season, the average number of fish a group catches in FieldVCM is at least as great as in FieldPI. Second, whereas the number of fish caught falls over time, the decrease is not more pronounced in FieldVCM than in FieldPI. This is shown by the relatively stable level of cooperation, as calculated according to equation (1), in all periods in Figure 1(b) (with the exception of the last period in the high season).



(a) **(b)**

Figure 1 **(a)** Average group catch by period for FieldVCM and FieldPI, in the High and Low season. **(b)** Average level of cooperation by period, in the High and Low season.

Our second measure of cooperation, effort as captured in the number of casts per minute, is shown in Figure 2. The figure shows that the four treatments yield similar behavior. On average, the fishermen cast their rod 0.59 times per minute in FieldPI, compared to 0.63 in FieldVCM. The Effort measure is not appreciably different between the Low and the High season. This finding is important in interpreting the catch data presented in Figure 1(a), which shows that not all fish are caught in the VCM treatments. The finding that not all fish are caught in the VCM treatments suggests cooperative play by the fishermen. However, the effort levels show that the lack of catch must be due to exogenous factors, rather than to a conscious decision of the fishermen to stop catching: fishermen in the VCM treatments try as hard as the fishermen in the PI treatments to catch fish. Thus, by both the Catch and the Effort measures, Figures 1 and 2 show no evidence of cooperation. The support for result 1 below provides the statistical basis

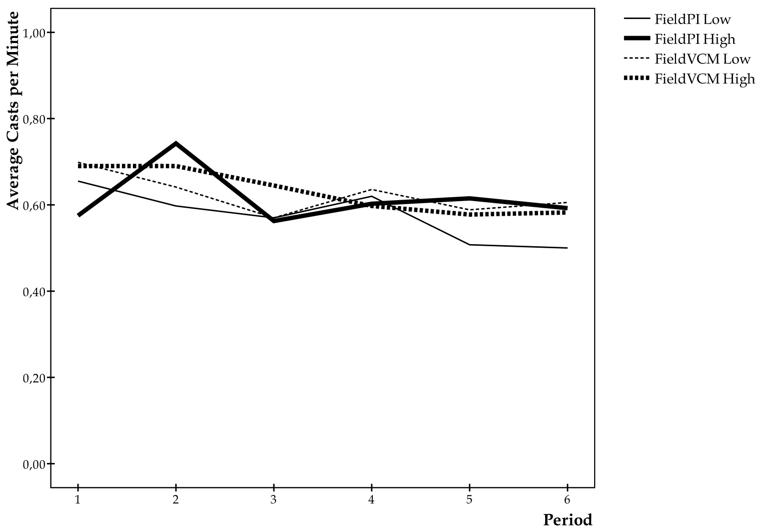


Figure 2 Average individual casts per minute by period, FieldVCM and FieldPI, High and Low season.

for this claim.

Result 1 In our social dilemma experiment conducted in the field, FieldVCM, no cooperation is observed.

Support for result 1: We first consider cooperation measured in terms of catch. On average, the catch of fish is actually higher in the FieldVCML and FieldVCMH treatments than in the corresponding FieldPIL and FieldPIH treatments. A Mann-Whitney test, taking each group's activity over a session as one observation, and comparing the catch of fish in the Low season, fails to reject the hypothesis of equal catch in the two treatments ($N_1 = 4, N_2 = 7, p = 0.164$). In the High season, the Mann-Whitney test indicates that more fish are caught in the FieldVCMH treatment than in FieldPIH ($N_1 = 4, N_2 = 4, p = 0.057$). Consider now the Effort measure. Here, the appropriate Mann-Whitney test indicates no significant differences in casts per minute between FieldVCM and FieldPI, neither in the Low season ($N_1 = 4, N_2 = 7, p = 0.412$) nor in the High season

($N_1 = 4, N_2 = 4, p = 0.886$). There is no evidence of cooperation by either of our two measures.

Another place to look for evidence of cooperation, is to consider the effort levels associated with attempting to catch a second fish, conditional on having caught one fish already in the current period. The quota of catching two fish gives the fishermen the opportunity to cooperate partially, by catching one fish — thus enjoying fishing while still earning money for the other members of one's group. Such cooperation would be revealed in lower effort in trying to catch a second fish in FieldVCM than in FieldPI. However, we find no evidence of a difference in effort to catch a second fish between FieldPI and FieldVCM (Mann-Whitney test, $N_1 = 19, N_2 = 33, p = 0.50$, taking the average effort levels of each subject over the course of the entire session as an independent observation).[8] ■

Thus, we find no evidence of cooperation in the FieldVCM treatment. We now consider whether there is a trend in cooperation over time. A downward trend in the number of fish caught is evident in Figure 1(a), which could indicate an increase in cooperation. However, the decrease is similar in the two treatments, although it is more pronounced in FieldPI than in FieldVCM in late periods of the High season. This shows that cooperation becomes even more negative over time in FieldVCMH, as can be seen from the level of cooperation depicted in Figure 1(b). The visual impression gained from Figure 2 is that there is no discernible trend in effort levels. For both Catch and Effort we test whether the relevant measure of cooperation is different between early and late periods, and the weight of the evidence favors result 2.

[8] We also test for differences in the variance of the number of casts between FieldPI and FieldVCM. A Mann-Whitney test cannot reject the hypothesis of an equal variance across the two treatments ($N_1 = 8, N_2 = 11, p = 0.60$). There is no evidence of a diminishing variance over time in either treatment. Comparing the variance in period 1 and 2 with the variance in period 5 and 6, a Wilcoxon test yields a p-value of 0.58 in the FieldPI treatment ($N_1 = N_2 = 8$) and a p-value of 0.18 in the FieldVCM treatment ($N_1 = N_2 = 11$). The similarity between the two treatments is further evidence that the incentive to cooperate does not influence behavior.

Result 2 There is no change in the level of cooperation over time.

Support for result 2: For purpose of this analysis, the *early* periods of a session consist of periods 1 and 2, while periods 5 and 6 are considered the *late* periods. The average group catch and effort over all groups in the first two periods of the FieldPI treatment in a given season are taken as the zero cooperation baselines for early periods. Similar baselines are constructed for the late periods. Using $k = \{L, H\}$ to denote the season, the early baseline is subtracted from group catch in the first two periods for each group in the FieldVCMk treatment separately, and the late baseline from group catch in periods 5 and 6 for each group in FieldVCMk. Thus, the difference between each group's catch (effort) in FieldVCMk and the average catch (effort) in FieldPIk is an observation. If the catch (effort) in an observation of FieldVCMk exceeds the average in FieldPIk, we assign the observation a cooperation level of zero. We then test whether cooperation is the same in the early and late periods in either season, treating each group's catch as a matched pair.

The number of fish caught in both early and late periods on FieldVCMk exceeds the average in the same periods of FieldPIk in every session, so the Catch measure indicates zero cooperation in both early and late periods. For the Effort measure, we find that the difference in cooperation between early and late periods is insignificant in the Low season (Wilcoxon test, $N_1 = N_2 = 7, p = 0.11$), as well as in the High season ($N_1 = N_2 = 4, p = 0.85$). ■

3 Bridging the gap between the laboratory and the field

Section 2 shows that the pattern of cooperation in FieldVCM is very different from the pattern of behavior observed in traditional VCM experiments conducted in the laboratory. However, the two conditions differ in several major aspects, and hence there are a number of candidate causes for the differences in results. These include the subject pool participating, whether the experiment is conducted within or outside the laboratory, and characteristics of the game itself, such as the decision variable (fish or money), and the framing of the task. To isolate the effect of the subject pool and the laboratory setting, we conduct three treatments, called StuLab, FisherLab and FisherPond. We will refer to these collectively as the *Lab* treatments because of their relatively close adherence to traditional laboratory experimental procedures.

In section 3.1 we describe the procedures that are common to the three treatments. Section 3.2 describes differences between the three treatments. The results are presented in section 3.3.

3.1 The laboratory version of our social dilemma game

As in the FieldVCM treatment, participants in the three lab treatments were assigned to groups of four subjects. Each group's composition remained constant throughout the six-period sessions. Sessions were conducted by hand using pen and paper. Participants were asked to decide how many virtual fish to catch in each period, with a maximum of two fish per period. Each fish that a participant decided to catch, yielded her a real cash payment of €1; each fish that the participant did not catch yielded €0.50 to each of the other three group members. The earnings of an individual are given by the following:

$$\pi_{it} = €1 \times x_{it} + €0.50 \sum_{j \neq i} (2 - x_{jt}), \tag{2}$$

where π_{it} are the earnings in Euros of subject i in period t, and $x_{it} \in \{0, 1, 2\}$ is the catch of subject i in period t. There is a dominant strategy to catch two virtual fish, yielding individual payoffs of €2 per period. The social optimum, with each group member receiving €3 per period, can be reached only if all players choose to catch zero fish. The duration of a session of the lab treatments takes about one fourth of the duration of a session of the field treatment. Therefore, earnings in the lab treatments are scaled down by a factor 4 to make the earnings comparable to the field treatments.

In contrast to the traditional laboratory experiment, the language of the instructions was contextualized to approximate a virtual implementation of the FieldVCM treatment. For example, the terms 'fish', 'catch' and 'pond' were used, rather than terms such as 'tokens', 'account', and 'project'. After the instructions were read out loud, the participants had to answer some test questions, which they answered without much difficulty.

After each period the experimenter informed all participants about the decisions of all subjects in the session by writing down all individuals' catch decisions, next to their identification numbers. This meant that each subject was able to monitor and track every other individual subject's decisions over time. However, none of the subjects were informed about which of the other session participants were in his own group, and there were either twelve or sixteen subjects in each session. This approximated the content and precision of the information available to participants in the FieldVCM and FieldPI treatments, in which individuals could observe others, but did not know who was in their group. After each period, subjects were informed, in private, of their earnings in that period as well as of the sum of the total group catch. All communication between participants was strictly forbidden, a rule that was well respected in all sessions.

3.2 Constructing the bridge from the laboratory to the field

The first treatment, StuLab, was a conventional lab treatment conducted with student participants in the CentER laboratory at Tilburg University. We specifically and exclusively invited students with a Dutch nationality to participate. This restriction was intended to control for cultural factors, which could potentially influence the results (see for example, Brandts et al. (2004), and Hermann et al. (2008)). In total, 32 students participated in the StuLab treatment, yielding eight groups of four subjects. All of the students were economics, law or psychology majors. On average, the participants in this treatment earned €12.98 in the experiment.

The second lab treatment, FisherLab, was identical to the StuLab treatment except for the subject population, who were customers of 'De Biestse

Oevers', the same subject pool sampled for the FieldVCM and FieldPI treatments. Thus, FisherLab can be classified as an artefactual field treatment according to the definitions of Harrison and List (2004). The treatment was conducted in the restaurant of De Biestse Oevers, which was temporarily transformed into an experimental lab. We rearranged the restaurant so that it closely resembled a standard experimental laboratory. We brought folding tables (normally used as exam tables for students taking large-scale written examinations at Tilburg University), and placed them in rows well apart from each other. This ensured that subjects could not read their neighbors' decision sheets. We installed a blackboard in front of the rows of tables on which decisions could be recorded. We applied the procedures customary to sessions conducted in our laboratory. In total, 32 fishermen participated in this treatment, comprising eight groups of four participants, and thus yielding eight independent observations. On average, the participants in this treatment earned €13.65.

The third lab treatment, FisherPond, was identical to the FisherLab treatment, except that the FisherPond treatment was conducted while participants were actually fishing at the pond. Recruitment took place by approaching fishermen at the pond and asking them if they would be willing to participate in a research study conducted by Tilburg University. We deliberately approached fishermen located at some distance from other participants, in order to exclude the possibility of participants contacting each other. Once we had recruited all participants, the rules were explained to all of them simultaneously at a central location. This was intended to ensure common knowledge and comprehension of the task among all participants. This was the only time during a session that the participants were not at their designated fishing spots. Participants were given a typed summary of the instructions, and listened to the experimenter reading out aloud the full version of the instructions.

After instruction, the fishermen returned to their fishing spots, and resumed fishing. An experimenter circulated among the subjects collecting their decisions and providing information about others' decisions and outcomes, while the participants continued fishing. As in StuLab and Fisher-

Lab, participants were informed in each period about the decisions of all other subjects in the session, but also (privately) about the decisions of the other members of their group and their own earnings.

After period six was completed, each participant was paid his earnings and then continued fishing for the remainder of the morning. The average earnings for the participants in this treatment were €14.30. Table 2 summarizes the number of groups, main feature and average individual earnings in each treatment.

Treatment	Groups	Main feature	Average Earnings
Students in the lab (StuLab)	8	Isolate effects of contextualization	€12.98
Fishermen in the lab (FisherLab)	8	Isolate effects of fishermen subject pool	€13.65
Fishermen at the pond (FisherPond)	7	Isolate effects of physical environment	€14.30

Table 2 Number of groups, main feature, and average individual earnings in the lab treatments.

3.3 Results in the StuLab, FisherLab and FisherPond treatments

Figure 3 shows the average levels of cooperation over time in the three lab treatments, StuLab, FisherLab and FisherPond. Cooperation is measured as the average number of fish not caught per group. That is, the level of cooperation is the maximum possible group catch in a period, eight, minus the actual (though virtual) catch. The figure shows that, as in prior controlled laboratory studies, the level of cooperation is positive in the early periods of the game, and decreases as the game progresses. We obtain the following result:

Result 3 Contribution patterns in the StuLab treatment conform to the usual patterns observed in the VCM game as typically implemented in the laboratory. The lack of cooperation in FieldVCM is therefore not due to the contextualization of the decision.

Support for result 3: Figure 3 shows that in early periods of the StuLab treatments, students cooperate in the first period, but increasingly

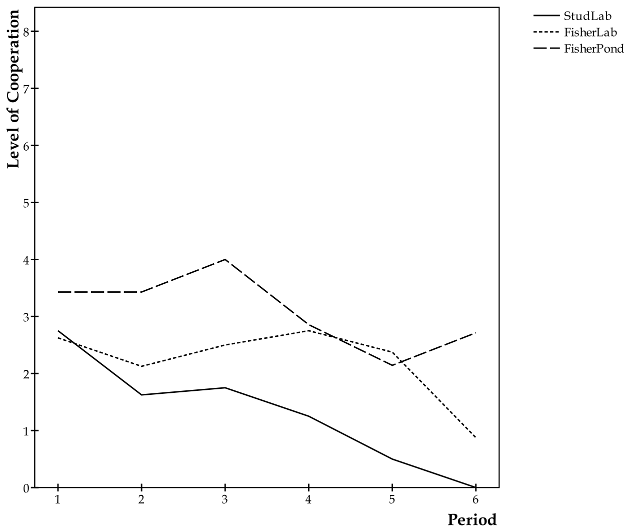


Figure 3 Levels of cooperation (maximum possible group catch minus actual catch) in the lab treatments by period, averaged over all groups.

less so in the later periods. A t-test shows that in the StuLab treatment, the cooperation level is significantly different from zero in period 1 ($N = 32, p < 0.01$). In this test, the choice of an individual, rather than a group's average contribution, is taken as an independent observation (because in the first period, there are no intragroup dependencies resulting from the history of play). A Wilcoxon test comparing 'early' and 'late' play, taking the group average contribution over periods 1 and 2 as an observation of early play and the group average over periods 5 and 6 as an observation of late play, yields a p-value of 0.01 ($N_1 = N_2 = 8$) for the StuLab treatment. Hence, cooperation decreases significantly over time. ■

Thus, we find that the lack of cooperation in the first periods of Field-VCM is not a result of contextualization itself. Next, we test whether the lack of cooperation found in the field treatments is due to differences in the subject pool. It may be the case that fishermen are systematically less cooperative than students, and that such a difference accounts for the behavior we observe in the field treatments. However, when comparing play in the StuLab and the FisherLab treatments — which are identical except for the characteristics of the subjects that participate — we find that, if anything, recreational fishermen are more cooperative than students. This is reported as result 4.

Result 4 Cooperation is greater in FisherLab than in StuLab. The lack of cooperation in FieldVCM is therefore not due to recreational fishermen being intrinsically less cooperative than students.

Support for result 4: Figure 3 shows that students exhibit a lower level of cooperation than the fishermen in the laboratory, especially in the later periods of the game. This is supported by a Mann-Whitney test ($N_1 = 8, N_2 = 8, p = 0.02$), that rejects the hypothesis of equal cooperation.[9] ■

Thus, the behavior of recreational fishermen in the laboratory experiment is not predictive of their behavior in the field. One may argue that this is not unexpected because recreational fishermen are likely to have competitive instincts: they will try to catch more fish than their peers and hence it is not surprising that we find no evidence of cooperation in the field. On the other hand, it is striking that fishermen act cooperatively, even more so than students, in a contextualized laboratory experiment. A necessary condition for laboratory experiments to be reliable tests of policy interventions is that people bring their true preferences into the laboratory; comparison of the results of FisherLab and FieldVCM suggests that this is not always the case.[10]

[9] Initial cooperation is also significantly different from zero for the FisherLab treatment. The Student t-test shows that individual cooperation levels are significantly different from zero in period 1 in the FisherLab treatment ($N = 32, p < 0.01$). In this treatment, average group cooperation decreases over time, but not significantly. A Wilcoxon test comparing the group average of period 1 and 2 to that of period 5 and 6, yields a p-value of 0.23 ($N_1 = N_2 = 8$).

[10] There is some evidence that high-sea professional fishermen, a distinct group from recreational fishermen, are particularly competitive. Two quotes illustrate this point. Analyzing the catch decisions of Norwegian fishermen targeting Blue Whiting, Gezelius

Furthermore, the above shows that subject pool composition alone does not account for the lack of cooperation in FieldVCM: both students and fishermen display positive levels of cooperation in the lab. We now consider whether the laboratory setting itself has an effect on the cooperation levels that the fishermen exhibit. We do so by comparing behavior in the FisherLab and FisherPond treatments. These two treatments are identical except that one is conducted in a synthetic environment very similar to an experimental laboratory, while the other is conducted in more natural conditions. From this comparison, we obtain result 5.

Result 5 Cooperation in the FisherPond treatment is greater than in the FisherLab treatment. Cooperation is reduced by the laboratory setting.

Support for result 5: Figure 3 shows that the average level of cooperation in the FisherPond treatment is higher than in FisherLab. A Mann-Whitney test shows that this difference is statistically significant ($N_1 = 8, N_2 = 7, p = 0.04$).[11] ■

This result suggests that the formally structured laboratory setting itself reduces cooperative behavior, at least for our subject pool of recreational fishermen. Therefore, the fact that our experiment is conducted outside of the laboratory cannot, on its own, account for the lack of cooperation we have observed in FieldVCM.

(2007) quotes a skipper stating that "[the choice of technology is not dependent so much on] a question of cost, but of fishing more than your neighbor." Similarly, in his analysis of fishing behavior by Dutch high-sea fishermen, van Ginkel (2009) states that "the deep-seated core value of the fishing game [is] the fisherman's desire to catch more than his neighbors."

[11] As in the other lab treatments, cooperation in the first round is also significantly different from zero for the FisherPond treatment, as indicated by a standard t-test, taking each individual catch decision as an independent observation ($N = 28, p < 0.01$). In this treatment there is also a significant decrease of cooperation over time. A Wilcoxon test comparing the group average cooperation of period 1 and 2 to that of period 5 and 6, yields a p-value of 0.03 ($N_1 = N_2 = 7$).

4 The FieldDyna treatment: A dynamic social dilemma

The treatments reported in section 3 show that the difference between our field results and traditional laboratory results persist when the effects of subject pool and the laboratory are removed. The source of the discrepancy in results must lie in differences between our field and the traditional laboratory implementations of the VCM. While there are several substantive differences, we believe that the most salient is the decision variable that must be modified in order to cooperate. In FieldVCM players cooperate by fishing less, while in the lab treatments, they cooperate by giving up money.

There are two separate mechanisms whereby the decision variable could affect the level of cooperation. The first is the possibility that the decision variable itself influences cooperation. It may be that if a reduction in fishing is required to achieve cooperation, individuals are less cooperative. The second is that when group benefits and private costs of cooperation are measured in different units, as in the FieldVCM treatment (money versus fish not caught rather than the money versus money trade-off in the lab treatment), individuals are less cooperative. Different units of account might introduce self-serving biases in beliefs about the tradeoffs between the two units. For example, individuals may convince themselves that other players prefer to fish rather than to have money, and thus that failure to reduce one's own fishing is compatible with attaining the social optimum.

To investigate whether the decision variable is the key factor influencing behavior, and to distinguish between the first and second possibilities of the manner in which it influences behavior, we construct an additional field treatment, called FieldDyna. In this treatment, both the private costs and group benefits of cooperation are measured in terms of fishing. If we find an absence of cooperation, we would rule out the second explanation, but not the first.

The FieldDyna treatment is a dynamic game. In the first period, fishermen are divided into groups of four. Each group has the opportunity to catch a group maximum of eight fish in the first period, as was the case in the FieldVCM treatment. In contrast to the FieldVCM treatment, however, there are no individual constraints on catching fish in FieldDyna, as long as the group as a whole does not catch more than eight fish. The total number of fish the group can catch in the second period, however, depends on the total number of fish the group catches in the first period. A quadratic (hump-shaped) growth function relates the increase in the number of fish that the group is allowed to catch in the next period to the stock remaining at the end of the current period. Hence, catching too many fish in the current period results in the group being allowed to catch fewer fish in the next. The social dilemma is entirely in terms of fish: an individual who catches a fish reduces the number of fish available to other members of his group in the current period, and typically also the number of fish available for the group in the subsequent periods — depending on the actual quantity of allowable catch remaining.

This treatment is interesting for at least three reasons. First, as stated above, it controls for the impact of the benefits and costs of cooperation being measured in different units. As such, it isolates potential factors causing the qualitative differences in play between the laboratory and the field, as captured in the difference between FisherPond and FieldVCM. Second, if there is any doubt about whether our parametrization in FieldVCM constitutes a social dilemma, it is obvious that FieldDyna unambiguously does so; fish caught by one fisherman reduces the current number of fish remaining and hence affects the fishing opportunities available to the group in both the current and future periods. Third, the FieldDyna treatment is the first experimental field test of the canonical renewable resource model used in the environmental and resource economics literature (see for example Brown (2000)).

This section is organized as follows. Section 4.1 describes the structure of the game. Section 4.2 presents the experimental design and discusses some methodological issues. Section 4.3 presents the main findings from this treatment.

4.1 Description of the game

Consider the following model, which is the basis of the FieldDyna treatment. A finite number of agents ($n \geq 2$) has access to a renewable resource. Each agent aims to maximize his net present value of resource harvesting, taking into account the dynamics of the renewable resource as well as the behavior of his $n-1$ fellow agents harvesting the resource. That is, agent i faces the following maximization problem:

$$\max_{x_i(t)} \quad V_i = \int_{t=0}^{T} \bar{p} x_i(t) e^{-rt} dt \tag{3}$$

$$\text{s.t.} \quad 0 \leq x_i(t) \leq \overline{x}, \tag{4}$$

$$\dot{S}(t) = Q(S(t)) - x_i(t), \tag{5}$$

$$Q(S(t)) = G(S(t)) - \Sigma_{j \neq i} x_j(t). \tag{6}$$

Here, T is the number of time periods ($t = 1, \ldots, T$) the game lasts, $\bar{p}$ denotes the constant net revenues of selling a unit of the resource, and $x_i(t)$ is the quantity of resource agent i harvests in period t. Next, r is the private discount rate, possibly the interest rate. $S(t)$ is the stock of the resource in period t, and $\dot{S}(t)$ denotes the change in the stock of the resource over time. $G(S(t))$ is the natural regeneration of the resource, whose rate depends only on the size of the current stock, and $Q(S(t))$ is the change in stock resulting from natural regeneration net of the amount extracted by all agents other than the decision maker. We assume that there is a maximum number of units of the resource that an agent can harvest per period ($\bar{x}$; see (4)). As constraints (5) and (6) describe, the change in the stock of the resource in period t, $\dot{S}(t)$, is equal to the natural regeneration of the resource $G(S(t))$, minus the total quantity of resource harvested by the n agents ($\Sigma_{j \neq i} x_j(t) + x_i(t)$).

In the renewable resource literature, the natural regeneration function $G(S)$ is usually specified as follows:

$$G(S(t)) \quad = \quad \gamma S(t) \left(1 - \frac{S(t)}{K}\right). \tag{7}$$

Here, $K > 0$ is the maximum possible stock of the resource, also referred to as the carrying capacity. $\gamma > 0$ is the maximum rate at which the resource regenerates, and is usually referred to as the intrinsic growth rate. Note that $G(0) = G(K) = 0$, and that the increment in population size is largest at $S = K/2$, where $dG(S)/dS = 0$. This stock level is usually referred to as the maximum sustainable yield stock (i.e., $S_{MSY} = K/2$).[12] For a sufficiently high $\bar{x}$, the total number of fish caught is maximized if aggregate effort is chosen such that the stock is kept at this level in periods $t = 1, \ldots, T-1$, while all remaining fish are caught in period T.[13] This level also maximizes group benefits in this model if and only if $r = 0$. Hence, the socially optimal steady state resource stock, S^*, is equal to S_{MSY} ($=K/2$) if $r = 0$. For any non-negative discount rate, however, the unique Nash equilibrium steady state stock is equal to zero; absent cooperation, all agents commit maximum effort until the stock is depleted. In appendix B, the social optimal and subgame perfect Nash equilibrium harvesting paths are derived and characterized.

4.2 Experimental design and parameters

As in the FieldVCM and FieldPI treatments, there were sixteen participants in a session, assigned to groups of four with fixed membership. In each period, the four fishermen in a group faced a group quota which could change from period to period. The quota for period t — also referred to as the total allowable catch in that period — is denoted by Z_t, and any fisherman in the group was allowed to catch as many fish he or she wanted (or was able

[12]Note that absent harvesting, equations (5) and (7) combined would result in the size of the resource stock growing over time according to an S-shaped function; the stock develops logistically. Starting from a very small population size, the stock increases very slowly in the first periods (in the case of fish, because the number of mating pairs is small), then increases and reaches its maximum increment at $S_{MSY} = K/2$. For stocks larger than this level, resource growth tapers off because of increased competition between individuals in the population for food and basic resources. Eventually, the resource would reach its natural equilibrium size K, where net growth is zero as the number of offspring would equal natural mortality.

[13]That is, in all periods $t < T$ aggregate catch should be equal to (i) zero, (ii) the maximum amount ($n\bar{x}$), or (iii) $G(S)/n$, if the current stock is smaller than, larger than, or equal to S_{MSY}. In period T, $\Sigma_i x_i(T) = S_{MSY}$

to) in that period as long as $X_t \equiv \Sigma x_{it} \leq Z_t$. The total allowable catch remaining for the group at the end of period t, $S_t \equiv Z_t - X_t$, determined the number of new fish the group was permitted to catch, $G(S_t)$. Therefore, the available quota for period $t+1$ was equal to $Z_{t+1} = S_t + G(S_t)$. Thus, a group's total allowable catch remaining at the end of period t satisfied:

$$S_t = S_{t-1} + G(S_{t-1}) - X_t. \tag{8}$$

In order to facilitate the implementation of the experiment, we modified the model of section 4.1 as follows. First, the model (3)–(5) assumes that there are constant benefits of catching fish (equal to $\bar{p}$). However, in the field, the marginal utility of fish may be declining. In the experiment, we ensured that the benefits of catching fish were always strictly positive, by not only allowing fishermen to keep any fish caught, but also by paying them an additional €5 for every fish they caught.[14] Second, the rate of time preference, r, was set equal to zero.[15] Third, in the experiment, the continuous growth function (7) of the model was approximated by a discrete function. The values chosen are represented by the solid line in Figure 4; they were such that $K = 8$ and $S_{MSY} = 4$. Fourth, we set the number of periods equal to four ($t = 1, \ldots, 4$), and, as in the FieldVCM treatment, we set the total allowable catch for period 1 equal to eight fish for each group ($Z_1 = 8$).[16]

For the parameter values we use, the socially optimal harvesting path is the following. Because $r = 0$, the group's benefits are largest if the group harvest is maximized. To do this, a group should catch four fish in the first three periods, and it should catch the remaining eight fish in the fourth

[14]Note that because harvesting costs are zero and independent of the size of the stock, neither the socially optimal nor the Nash equilibrium harvesting paths are affected by the level of $\bar{p}$ as long as it is positive.

[15]In a four hour experiment the natural value of r is zero. Participants may prefer to catch fish sooner than later because of strategic considerations, but for any given number of fish caught during a session, participants are not likely to prefer to catch them all in the first few periods. We could have induced $r > 0$ by paying interest, but at the cost of (i) longer instructions, and (ii) a lower probability of subjects being able to infer the correct level of S^*.

[16]Hence, we implicitly assume that the group's fish stock was initially equal to the carrying capacity, K.

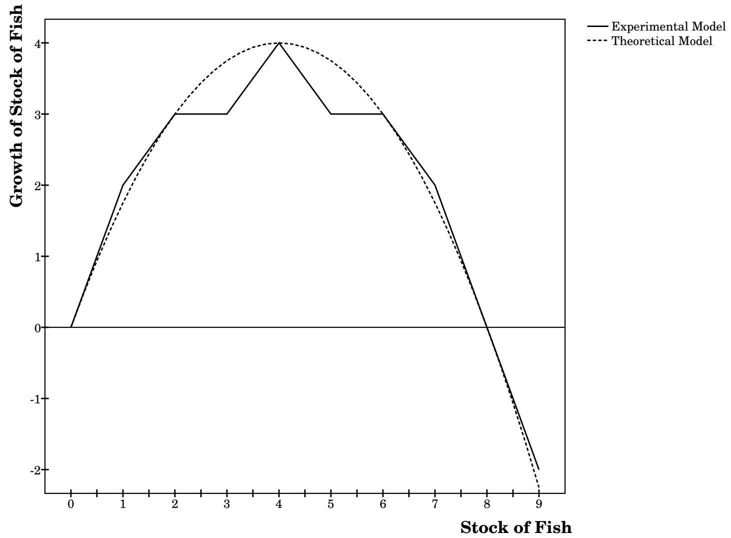


Figure 4 Theoretical specification of the regeneration function (with $\gamma = 2$ and $K = 8$) and the discrete experimental parametrization thereof.

(that is, $X_t^* = K - S^* = K/2$ in periods $t = 1, 2, 3$, and $X_4^* = K$). Note that the discrete parameterization of the logistic growth function as shown in Figure 4 is chosen to increase the salience of the maximum sustainable yield stock as the cooperative solution — the fit of the discrete function would have been better if we had set $G(S) = 4$ for $S = \{3, 4, 5\}$ rather than just for $S = \{4\}$. The subgame perfect equilibrium path is $x_{i,t} = \bar{x}$ for all i, t as long as $Z_t > 0$. That is, the equilibrium outcome is that the entire allowable catch is taken in the first period, and there are no fish available to the group afterwards. Since $G(0) = 0$, the session would end after the first period, and the members of the group would be required to leave the pond area. Because each period is one hour long, in the social optimum, a group can fish for four hours, catch twenty fish and receive €100. In the subgame perfect Nash equilibrium harvesting path, a group receives eight fish and €40, and can fish for at most one hour.[17]

[17]The reader may argue that it is no surprise that there is no cooperation in FieldVCM because 'fishing is fun'. If anything, this argument should result in more cooperation in FieldDyna because the more cooperative the group's fishing behavior, the longer one is

In all sessions of FieldDyna, 16 subjects participated, divided into four groups of four participants. At the beginning of the first period 38 rainbow trout were released into the pond (two per participant, plus an additional six, as was the case in FieldVCM). At the beginning of each subsequent period, a quantity of fish was released equal to the number caught in the previous period by all groups in the session that were still active in the current period. Hence, the actual number of fish in the pond, per fisherman still participating, was the same at the beginning of each period, while the dynamics of the total allowable catch remaining for each of the four groups are described by equation (8). Replacing the fish caught avoids the possibility that one group's harvesting path affected the feasibility of other groups in the same session following their intended path.

In the FieldDyna treatment, participants were aware of which other individuals were in their group. Fishermen wore colored ribbons identifying their group. We gave this information because the model presented in section 4.1 has a closed-loop solution (see appendix B), which requires fishermen to be aware of the size of the remaining quota (Z_t) at any moment. We believe that if this feature of the design affects behavior, it would enhance cooperativeness. If fishermen are able to monitor the development of the remaining quota over time, it may induce them to cease fishing when they see that the remaining quota is getting too small. Hence, if we do not find any evidence of cooperation, the results would be even more convincing than in the absence of the group affiliation information.

At the end of each period, subjects were informed of (i) their total earnings in the period, (ii) total group catch in the period, X_t, (iii) the total group quota still remaining, S_t, (iv) the increase in the group's quota, $G(S_t)$, and (v) the size of the resulting allowable catch for the next period, $Z_{t+1} = S_t + G(S_t)$.

As in FieldPI and FieldVCM, the instructions were read out aloud by the experimenter at a central location, participants were provided with a handout summarizing the instructions, and communication was strictly for-

allowed to fish, the larger the number of fish caught, and the larger the amount of money earned.

bidden. We explicitly tested the participants' understanding of the dynamic game by having them answer test questions before the start of the session. The sessions of the FieldDyna treatment were conducted in April 2009. Average earnings of the participants in this experiment were €15.30.

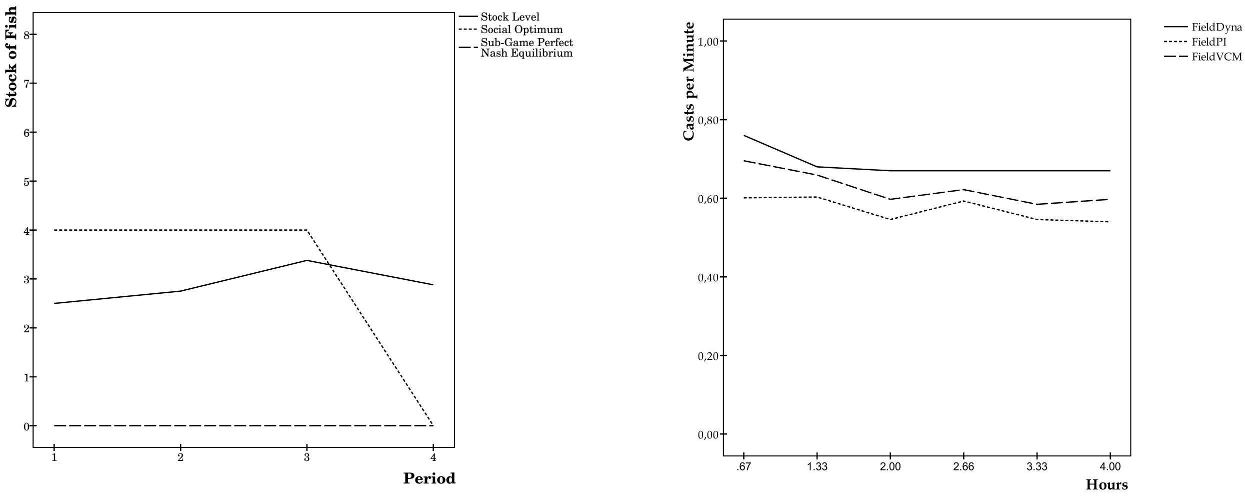
4.3 Results of the FieldDyna treatment

There are two patterns that we use to distinguish cooperation from non-cooperation in this treatment.[18] The first is that, under non-cooperative behavior, there would be no difference in behavior over the four periods. Players would fish with the same, maximal, effort in all periods. Under the social optimum, however, effort would be greater in the last period, relative to the first three periods. This would indicate an attempt to reduce catch in periods 1–3 to below the maximum feasible level. The second pattern is that, under cooperative behavior, effort would exhibit a dependence on the number of fish remaining in the group's quota. If individuals fish less intensely when there are fewer fish in the pond in periods 1–3, it is consistent with cooperation. If they exert less effort when the stock of fish is below the socially optimal level than when it is above, it is consistent with a targeting of the social optimum. If they fish with the same intensity regardless of the social cost, we interpret it as evidence of non-cooperative behavior.

The results of the FieldDyna treatment are presented in Figure 5, where panel (a) shows the stock of fish remaining at the end of each period (S_t), and panel (b) shows the associated effort, averaged over all active groups, in the four periods. For comparability we have also included the average effort levels observed in FieldPI and FieldVCM in Figure 5(b).

At first glance, Figure 5(a) seems to suggest that participants acted fairly cooperatively; the size of the remaining stock at the end of each of the first three periods is positive. Indeed, of the eight groups participating

[18]Because it may not be feasible to catch the subgame perfect equilibrium quantity of fish in a one hour period, comparing the absolute stock of fish remaining with the point predictions of the two models may give a misleading impression of support for either model. In particular, if the remaining allowable catch is close to the socially optimal level, it may be a consequence of a binding feasibility constraint rather than an intention to cooperate.



(a) **(b)**

Figure 5 **(a)** Amount of allowable catch remaining (ACR) at the end of a period in the FieldDyna treatment, averaged over all groups. **(b)** Casts per minute in the FieldDyna treatment, averaged over all active groups.

in this treatment, only two actually depleted their quota before the final period, and only one group caught the total allowable catch in the first period. However, there is evidence from the catch data that the stock was not depleted in most sessions because catching the full quota in a period of one hour was not feasible. The allowable catch remaining at the end of the fourth period, Z_4, is greater than zero in six of eight groups. Furthermore, the allowable catch remaining (ACR) at the end of periods 1-3 is on average very close to the ACR at the end of period 4.

If cooperation is occurring, the average level of effort should be at a similar level in periods 1 to 3, and then increase in period 4. Figure 5(b), however, shows that effort starts at a high level in the first period, decreases slightly in the second, and remains approximately constant between the second, third and fourth periods. Furthermore, as the figure illustrates, effort in FieldDyna is not lower than effort in the FieldPI treatment, further suggesting that participants did not voluntarily limit their effort.

We also find that effort is independent of the current stock of fish. The model in section 4.1 and appendix B suggests that if players are cooperating, effort in periods 1–3 would be as great as possible if $S > S^* = 4$, and zero if $S \leq S^* = 4$. The relationship between the number of casts and the ACR is shown in Figure 6. The figure shows the average individual number of casts in the five minute intervals during which a specific stock level is reached.[19]

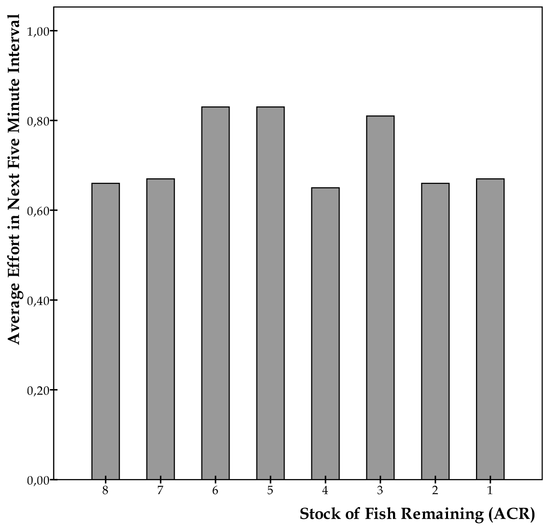


Figure 6 Average individual effort conditional on the allowable catch remaining (ACR) in period $1-3$. Each 5 minute interval is an observation.

The figure reveals that the average effort level in a group is independent of the allowable catch remaining. There is no evidence that effort is greater for $S > 4$ than for $0 < S \leq 4$. The following result summarizes our findings with regard to cooperation in FieldDyna:

[19]Data from the first ten minutes of a period are not included in the figure. During the first ten minutes of each period fishermen have the tendency to put in more effort than in the subsequent time intervals within a period. An explanation for this effect could be that fishermen are more eager to fish at the start of a new period. Alternatively, given their new spot at the pond, fishermen have to adjust the optimal settings of their rods by trial and error. Since all groups begin with a stock of eight fish in the first period, effort levels for this particular stock of fish are higher when the first ten minutes are included. Inclusion of the first ten minutes causes the average effort at a stock size of eight to equal 0.88 rather than 0.66. Excluding the first ten minutes of each period does not appreciably change the average effort at the other stock levels.

Result 6 In the dynamic social dilemma treatment, FieldDyna, no cooperation is observed. The lack of cooperation in FieldVCM is not specific to that particular treatment nor to a setting in which private and group gains are denominated in different units.

Support for result 6: Consider the differences in effort levels over the four one-hour periods (see Figure 5(b)). A Wilcoxon test indicates no difference in effort between the fourth period and the first period ($N_1 = N_2 = 6, p = 0.75$), taking the average effort levels of each group as an independent observation. Similar results are found when the fourth period is compared with either the second period ($N_1 = N_2 = 6, p = 0.67$), or the third period ($N_1 = N_2 = 6, p = 0.60$). Six observations are used, because two groups caught their allowable catch in a period before the fourth (one in period 1 and one in period 3).

Now consider the allowable catch remaining at the end of each of the four periods (see Figure 5(a)). A series of Wilcoxon tests indicate that a group's allowable catch remaining at the end of period 4 does not differ from that remaining at the end of each of the first three periods. The allowable catch remaining at the end of period 4 does not differ from that in period 1 ($N_1 = N_2 = 8, p = 0.60$), period 2 ($N_1 = N_2 = 8, p = 0.89$), or period 3 ($N_1 = N_2 = 8, p = 0.40$).

The difference in effort between the range of allowable catches remaining where it is in a group's interest to catch more fish (if the ACR is 5 or higher), and where it is socially harmful to catch fish (at four and lower), is investigated with a fixed effects panel data regression model. We only use the data for periods 1-3 because effort should be maximal in period 4, independently of the allowable catch remaining. The Fixed Effects estimates, which show no significant differences in effort between these two ranges of ACR, are presented in Table 3.

Effort levels in period 1, 2 and 3 are estimated as a function of ACR. Each period is divided into twelve five-minute intervals. We regress the amount of effort exerted by fisherman i in time interval $s+1$ on the ACR in interval

Dependant Variable: Effort in interval $s+1$	
$I(\text{ACR}=4)$	-0.052
	(0.042)
$I(\text{ACR}=3)$	0.012
	(0.089)
$I(\text{ACR}=2)$	-0.062
	(0.082)
$I(\text{ACR}=1)$	-0.147
	(0.128)
Time	-0.014^{**}
	(0.005)
$I(\text{Period}=2)$	-0.090^{**}
	(0.038)
$I(\text{Period}=3)$	-0.097
	(0.069)
Constant	0.871^{***}
	(0.053)
N	937

Table 3 Impact of amount of allowable catch remaining (ACR) on individual effort.
Standard errors, clustered at the group level, are reported between parentheses. ***: significant at the 1%-level, **: significant at the 5%-level.

s. The ACR is captured by a series of dummy variables capturing whether it is equal to 4, 3, 2, or 1. We use an indicator function $I(\text{ACR} = h), h \in \{1, 2, 3, 4\}$ which has value 1 if $S_s = h$, and zero otherwise. Therefore, the baseline against which each dummy variable should be interpreted is the range at which the ACR is five or greater. In addition, we insert a within-period time interval variable (Time) and dummies accounting for the influences of between-period effects. The variable Time is included to correct for the natural decline in effort within a period due to the fishermen becoming tired.

All ACR dummy variables are insignificant. Hence, irrespective of the amount of allowable catch remaining, fishermen fish with the same intensity as they do so when it is both individually and socially desirable to exert full effort. They make no attempt to replenish the resource when ACR levels are critically low. The only significant variables in this model are the variable Time and the dummy variable for the second period. The negative sign of Time indicates that fishermen exert less effort later in the one hour period, controlling for the amount of allowable catch remaining. Overall, we find that our subject pool of recreational fishermen displays a similar lack of cooperation in the FieldDyna treatment as in the FieldVCM treatment. ■

5 Conclusion

Our data are consistent with the predictions of classical game theory. In FieldVCM and FieldDyna, behavior conforms to the subgame perfect equilibria of the games that we created. Accordingly, we find no evidence of cooperative behavior in our framed field social dilemma experiment. We can detect no difference in behavior between a situation in which refraining from fishing yields a large positive externality to the group (the FieldVCM treatment) and when it does not (the FieldPI treatment). This conclusion contrasts sharply with results from studies of the VCM game when it is implemented in the laboratory. In such laboratory settings, cooperation is typically positive at the outset of a group's interaction, and declines over time. Therefore, our results shed doubt on the external validity of behavior observed in this type of laboratory experiment. While the behavior of recreational fishermen may not be not of special economic interest in itself, it is striking to see the difference in their behavior in the field compared to a contextualized laboratory environment.

Additional treatments allow us to explore potential causes of the difference between the results we have observed and those from previous laboratory studies. The treatments permit us to rule out four would-be explanations: (i) differences in contextualization between the game we implemented in the field and the standard VCM implemented in the laboratory, (ii) differences in the subject pool (students versus recreational fishermen), (iii) differences between the settings in which the experiments are conducted (the laboratory versus a more natural environment, the recreational fishing pond), and (iv) differences in the units in which the benefits and costs of cooperation are measured (money versus money, or money versus fish).

When implementing our modified version of the VCM game in the laboratory using student subjects, we find a pattern of behavior very similar to that typically observed in standard VCM lab experiments. In addition, we find that using students as participants lowers cooperation compared to our subject pool of recreational fishermen. Therefore, the use of students alone cannot account for the greater cooperation observed in received laboratory experiments than in FieldVCM. Conducting the experiments in the structured and formal setting of an experimental laboratory decreases cooperation among our subjects. They are more cooperative when participating in a voluntary contributions game while they are fishing than when they are in the laboratory. Therefore, the fact that the experiment is conducted outside the laboratory, cannot on its own account for the lack of cooperation.

The most plausible remaining explanation of the poor external validity of our laboratory experiments is the nature of the decision variable. Our subjects are unwilling to forego fishing to yield benefits to the group, even when group benefits are also in terms of fishing. Nevertheless, subjects from the same pool are willing to cooperate if it involves sacrificing own monetary earnings for the benefit of the group. Taken together, our data are consistent with the assertion that cooperativeness depends on the decision variable, the activity that must be modified in order to yield a benefit to the group. This statement is not to deny the importance of other factors; for example, whether similar results would apply to professional high sea fishermen is an open question.

Some readers of this paper have suggested that a demand effect may exist in the experiment, in that 'fishermen participate in the experiment to fish', and that when individuals find themselves at the fishing pond, the desire to fish overwhelms the money that we offer the group not to fish. However, we note that a similar effect exists with students who participate in traditional laboratory experiments: students presumably participate in such experiments with the primary motivation of earning money for themselves. While fishermen might be disposed to feel that the pond is a place to fish, subjects in the laboratory presumably are disposed to view it as a place to earn money for themselves. Furthermore, in the FieldDyna treatment, payoffs are entirely in terms of fishing. Reducing one's own fishing increases the overall fishing opportunities available to the group. Thus, the tradeoff is fully in terms of the reward medium that is typically associated with the venue. As described earlier, we find no cooperation in FieldDyna, in agreement with standard economic theory, indicating that a demand effect of the type described above could not account for the lack of cooperation that we observe.

It has been shown in some field experiments that decentralized cooperation can be successful (see for example Erev et al. (1993) and Bandiera et al. (2005)). Cooperation can be found in naturally-occurring social dilemma situations as well (see for example Ostrom (1990)). However, our results suggest that this successful cooperation does not spontaneously arise. When there is no contact possible between agents facing a social dilemma, the mere presence of potential group-level gains resulting from the sacrifice of private payoffs does not guarantee cooperation — even if the group concerned is small in number. The propensity to cooperate appears to depend on the nature of the activity that individuals must undertake, or refrain from, in order to increase group payoffs. It may be the case that to reliably achieve cooperation in a setting such as ours, some additional structure is required. This structure might be an effective avenue of communication between individuals (Isaac and Walker (1988a)), a system of punishment of non-cooperators (Fehr and Gächter (2000)), or a mechanism for increasing and maintaining social cohesion (Gächter and Fehr (1999); Masclet et al. (2003)). All of these factors have been found to increase the level and sustainability of cooperation in laboratory social dilemmas. It is thus reasonable to conjecture that presence of one or more of these instruments may be necessary, or at least make it more likely, to achieve cooperation in some inhospitable field settings, such as the one we have studied here. On the other hand, cooperation may be so difficult to achieve in our setting that even these instruments may not be effective.

References

Alpizar, F., Carlsson, F., and Johansson-Stenman, O. (2008). Anonymity, reciprocity, and conformity: Evidence from voluntary contributions to a national park in Costa Rica. *Journal of Public Economics*, *92*, 1047–1060.

Andreoni, J. (1988). Why free ride? Strategies and learning in public goods experiments. *Journal of Public Economics*, *37*, 291–304.

Andreoni, J. (1995). Cooperation in public-goods experiments: Kindness or confusion? *The American Econonomic Review*, *85*(4), 891–904.

Andreoni, J. and Samuelson, L. (2006). Building rational cooperation. *Journal of Economic Theory*, *127*, 117–154.

Bandiera, O., Barankay, I., and Rasul, I. (2005). Social preferences and the response to incentives: Evidence from personnel data. *Quarterly Journal of Economics*, *120*(3), 917–962.

Barr, A. (2001). Social dilemmas and shame-based sanctions: Experimental results from rural Zimbabwe. *Working Paper*.

Benz, M. and Meier, S. (2008). Do people behave in experiments as in real life? Evidence from donations. *Experimental Economics*, *11*(3), 268–281.

Bolton, G. E. and Ockenfels, A. (2000). Erc: A theory of equity, reciprocity, and competition. *The American Economic Review*, *90*(1), 166–193.

Brandts, J., Saijo, T., and Schram, A. (2004). How universal is behavior? A four country comparison of spite and cooperation in voluntary contribution mechanisms. *Public Choice*, *119*, 381–424.

Brandts, J. and Schram, A. (2001). Cooperation and noise in public goods experiments: applying the contribution function approach. *Journal of Public Economics*, *79*, 399–427.

Brown, G. (2000). Renewable natural resource management and use without markets. *Journal of Economic Literature*, *38*, 875–914.

Cardenas, J. C. (2003). Real wealth and experimental cooperation: Experiments in the field lab. *Journal of Development Economics*, *70*, 263–289.

Cardenas, J. C. (2004). Norms from outside and from inside: An experimental analysis on the governance of local ecosystems. *Forest Policy and Economics*, *6*, 229–241.

Cardenas, J. C. and Ostrom, E. (2004). What do people bring into the game? Experiments in the field about cooperation in the commons. *Agricultural Systems*, *82*, 307–326.

Carpenter, J. and Seki, E. (2005). Do social preferences increase productivity? Field experimental evidence from fishermen in Toyama bay. *Working Paper.*

Clark, C. (1980). Restricted access to common-property fishery resources: A game-theoretic analysis, Lui, P. (ed.). *Dynamic Optimization and Mathematical Economics*, Plenum Press, New York, 117–132.

Croson, R. and Shang, J. Y. (2008). The impact of downward social information on contribution decisions. *Experimental Economics*, *11*(3), 221–233.

Dockner, E., Jorgensen, S., Long, N. V., and Sorger, G. (2000). Differential games in economics and management science. Cambridge: Cambridge University Press.

Erev, I., Bornstein, G., and Galili, R. (1993). Constructive intergroup competition as a solution to the free rider problem: A field experiment. *Journal of Experimental Social Psychology*, *29*, 463–478.

Fehr, E. and Gächter, S. (2000). Cooperation and punishment in public goods experiments. *The American Economic Review*, *90*(4), 980–994.

Fehr, E. and Leibbrandt, A. (2008). Cooperativeness and impatience in the Tragedy of the Commons. *Working Paper.*

Fehr, E. and Schmidt, K. (1999). A theory of fairness, competition and cooperation. *The Quarterly Journal of Economics*, *114*, 817–868.

Frey, B. S. and Meier, S. (2004). Social comparisons and pro-social behavior: Testing "conditional cooperation" in a field experiment. *American Economic Review*, *94*(5), 1717–1722.

Gächter, S. and Fehr, E. (1999). Collective action as a social exchange. *Journal of Economic Behavior and Organization*, *39*, 341–369.

Gezelius, S. (2007). The social aspects of fishing effort: Technology and community in norways blue whiting fisheries. *Human Ecology*, *35*, 587–599.

Gneezy, U., Haruvy, E., and Yafe, H. (2004). The inefficiency of splitting the bill. *The Economic Journal*, *114*, 265–280.

Harrison, G. and List, J. (2004). Field experiments. *Journal of Economic Literature*, *42*(4), 1009–1055.

Hartl, R. and Feichtinger, G. (1987). A new sufficient condition for most rapid approach paths. *Journal of Optimization Theory and Applications*, *54*(2), 403–411.

Henrich, J., Boyd, R., Bowles, S., Camerer, C., Fehr, E., and Gintis, H. (2004). *Foundations of Human Sociality: Economic Experiments and Ethnographic Evidence from Fifteen Small-Scale Societies.* Oxford University Press, New York.

Hermann, B., Thöni, C., and Gächter, S. (2008). Antisocial punishment across societies. *Science*, *319*, 1362–1367.

Houser, D. and Kurzban, R. (2002). Revisiting kindness and confusion in public goods experiments. *The American Economic Review*, *92*(4), 1062–1069.

Isaac, R., McCue, K., and Plott, C. (1985). Public goods provision in an experimental environment. *Journal of Public Economics*, *26*(1), 51–74.

Isaac, R. M. and Walker, J. M. (1988a). Communication and free-riding behavior: The voluntary contribution mechanism. *Economic Inquiry*, *26*(4), 585–608.

Isaac, R. M. and Walker, J. M. (1988b). Group size effects in public goods provision: The voluntary contributions mechanism. *The Quarterly Journal of Economics*, *103*(1), 179–199.

Karlan, D. S. (2005). Using experimental economics to measure social capital and predict financial decisions. *The American Economic Review*, *95*(5), 1688–1699.

Laury, S. K. and Taylor, L. O. (2005). Altruism spillovers: Are behaviors in context-free experiments predictive of altruism toward a naturally occurring public good? *Journal of Economic Behavior and Organization*, *65*, 9–29.

Ledyard, J. (1995). *Public Goods: A Survey of Experimental Research.* Princeton University Press.

Levitt, S. D. and List, J. A. (2007). What do laboratory experiments measuring social preferences reveal about the real world? *Journal of Economic Perspectives*, *Volume 21*(2), 153–174.

Levitt, S. D. and List, J. A. (2008). Homo economicus evolves. *Science*, *319*(5865), 909–910.

List, J. A. (2006). The behavioralist meets the market: Measuring social preferences and reputation effects in actual transactions. *Journal of Political Economy*, *114*(1), 1–37.

List, J. A. and Lucking-Reiley, D. (2002). The effects of seed money and refunds on charitable giving: Experimental evidence from a university capital campaign. *Journal of Political Economy*, *110*(1).

Martiny, R. and Randal, J. (2005). Voluntary contributions to a public good: A natural field experiment. *Working Paper.*

Masclet, D., Noussair, C., and Tucker, S.and Villeval, M. (2003). Monetary and nonmonetary punishment in the voluntary contributions mechanism. *The American Economic Review*, *93*(1), 366–380.

Neugebauer, T., Perote, J., Schmidt, U., and Loos, M. (2007). Selfish-biased conditional cooperation: On the decline of contributions in repeated public goods experiments. *Kiel Working Papers*, *1376*.

Ostrom, E. (1990). *Governing the Commons: The Evolution of Institutions for Collective Actions*. Cambridge University Press.

Palfrey, T. and Prisbey, J. (1996). Altruism, reputation and noise in linear public goods experiments. *Journal of Public Economics*, *61*, 409–427.

Rabin, M. (1993). Incorporating fairness into game theory and economics. *The American Economic Review*, *83*(5), 1281–1302.

Rodriguez-Sickert, C., Andrs Guzmn, R., and Cardenas, J. C. (2008). Institutions influence preferences: Evidence from a common pool resource experiment. *Journal of Economic Behavior and Organization*, *67*, 215–227.

Ruffle, B. J. and Sosis, R. (2007). Does it pay to pray? Costly ritual and cooperation. *The B.E. Journal of Economic Analysis and Policy*, *7*(1), 1–37.

Sonnemans, J., Schram, A., and Offerman, T. (1999). Strategic behavior in public good games: when partners drift apart. *Economics Letters*, *62*, 35–41.

Toivonen, A., Roth, E., Navrud, S., Gudbergsson, G., Appelblad, H., Bengtsson, B., and Tuunainen, P. (2004). The economic value of recreational fisheries in Nordic countries. *Fisheries Management and Ecology*, *11*, 1–14.

van Ginkel, R. (2009). *Braving Troubled Waters: Sea Change in a Dutch Fishing Community*. Amsterdam: Center for Maritime Research and Amsterdam University Press.

A Statistical analysis of the effect of effort on catch

This appendix shows that the number of casts per minute, our Effort measure of cooperation, is correlated with the number of fish caught, which is used to calculate our Catch measure of cooperation. Thus, we establish that casts per minute is a legitimate measure of cooperation: a higher casting frequency increases expected private payoff and decreases expected group payoff.

An Ordered Probit model is used to estimate the effects of fishing effort on the number of fish caught, as presented in Table 4. The dependent variable is an individual's catch of fish in a period. Table 4 contains estimates of the pooled data from the FieldVCM and FieldPI treatments.

The model shows a clear positive and significant effect of our measure of effort, casts per minute, on the catch of fish. The dummy variable I(HighSeason) has a value of 1 when an observation is taken from the high season. The quadrant fixed effects are dummy variables that capture the position at the pond at which a fisherman is fishing. The quadrant dummy variables are insignificant, indicating that the position at which an individual fishes has no influence on his catch of fish.

Dependent variable: Number of fish caught in a period	
Effort	0.739***
	(0.301)
I(High Season)	1.522***
	(0.127)
Quadrant Fixed Effects	Yes
N	456
pseudo-R^2	0.1928

Table 4 Relationship between individual effort and individual catch.
Standard errors, clustered at the subject level, are reported between parentheses. ***: significant at the 1%-level.

B The socially optimum and subgame perfect equilibrium extraction paths of the dynamic game

In this appendix we derive the socially optimal and closed-loop Nash equilibrium harvesting paths for the theoretical model in section 4.1. Assuming homogenous agents, we have a social dilemma if $\bar{X} \equiv n\bar{x} > G(S_{MSY})$; that is, if $\bar{X} > G(S)$ for all $0 \leq S \leq K$. This can be shown as follows. Consider first the social optimum in case of an infinite time horizon problem. The social welfare function can be derived by inserting (6) into (5), noting that this implies that $X \equiv \sum_{i=1}^{n} x_i = G(S) - \dot{S}$, and then summing V_i over all $i = 1, \ldots, n$:

$$\max_{X(t)} V = \int_{t=0}^{\infty} \bar{p} \left(G(S) - \dot{S}(t) \right) e^{-rt} dt. \tag{9}$$

Integrating by parts allows us to rewrite the objective function as:

$$\max_{X(t)} \left[\bar{p} S_0 + \bar{p} \int_{t=0}^{\infty} \left(G(S) - rS(t) \right) e^{-rt} dt \right]. \tag{10}$$

Objective function (10) is maximized if $dG(S)/dS$ and r are equated as quickly as possible. Using (7), we find that the socially optimal steady state stock is equal to $S^* = \max[0, K(\gamma - r)/(2\gamma)]$ and that the socially optimal harvesting levels equal $X = \bar{X}$ if $S > S^*$, $X = G(S)$ if $S = S^*$, and $X = 0$ if $S < S^*$.[20] In our dynamic field experiment r is equal to zero, and hence $S^* = K/2$ $(= S_{MSY})$. Also, if the time horizon is limited to T periods and assuming that $\bar{X} > K$, the socially optimal stock is $S^* = K/2$ in periods $1, \ldots, T - 1$ and 0 in period T; to maximize group welfare, regeneration should be maximized in all periods apart from the last one, and the stock should be depleted in that terminal period.

Next we derive the unique Nash equilibrium harvesting path. The solution is straightforward: all $n \geq 2$ agents harvest the resource at maximum effort level $(\bar{x})$ until it is depleted, even if $\gamma > r$. This can be shown as follows. Consider $\widetilde{S}$ as a candidate interior equilibrium stock size (i.e.,

[20] Hence, the socially optimal transition path towards the steady state is a so-called Most Rapid Approach Path (see for example Hartl and Feichtinger (1987)).

$\widetilde{S} \in \langle[0, K])$, which may or may not be equal to S^*. For $\widetilde{S}$ to be an interior steady state, all agents $j = 1, \ldots, n$ must harvest at $x_j = G(\widetilde{S})/n$ if $S = \widetilde{S}$, and choose $x_j = 0$ ($x_j = \bar{x}$) if $S < \widetilde{S}$ ($S > \widetilde{S}$).

That means that the amount of net regeneration agent i faces for any stock level S, $Q(S)$, equals:

$$\begin{aligned}
Q(S) &= G(S) - (n-1)\bar{x} \text{ if } S > \widetilde{S};\\
Q(S) &= G(\widetilde{S})/n \text{ if } S = \widetilde{S};\\
Q(S) &= G(S) \text{ if } S < \widetilde{S}.
\end{aligned}$$

That means that if agent i decreases the stock infinitesimally below $\widetilde{S}$, she would increase the regeneration she faces ($Q(S)$) by almost a factor n (from $G(\widetilde{S})/n$ to infinitesimally less than $G(\widetilde{S})$). Forever harvesting at a rate such that the stock remains infinitesimally below $\widetilde{S}$ would then yield a present value of (almost) $\bar{p}G(\widetilde{S})/r$ for agent i and a zero payoff for all other agents $j \neq i$ in an infinite time horizon model. Clearly, this holds for all agents $i = 1, \ldots, n$ and for all $\widetilde{S} \in \langle 0, K]$, and hence the only steady state equilibrium stock is $S = 0$ for all $t = 1, \ldots, \infty$. This means that if one or more of the $n-1$ agents are greedy and harvest at maximum rate, no individual agent is able to keep the resource stock at the desired level, and hence each agent's best response is to harvest at maximum rate too (see also Clark (1980), or Dockner et al. (2000), pp. 333-335). Because $G(S) = 0$ if $S = 0$, the game ends in period 1. And if the unique closed-loop Nash equilibrium path is to deplete the resource in one period in the infinite time horizon model, it is also the unique subgame perfect equilibrium path in the finite time horizon model implemented in the field.

C Promotional material

NOT FOR PUBLICATION

This appendix contains a translation of the flyer, which we used to recruit participants in the Field treatments.[21] The original flyer is available upon request from the authors.

TILBURG UNIVERSITY REQUESTS YOUR PARTICIPATION IN A STUDY

DATE: ...

TIME: PRESENT AT 7.15 A.M., START OF THE STUDY AT 7.45 A.M.

- Duration: 4 hours.
- Participation is free.
- You can earn money during the study.
- Each participant can catch at most twelve fish.
- You can take home all of the fish you catch.
- You should use your own fishing equipment and bait.
- We will use pond 3.
- You will fish according to the standard rules of the trout fishing facility plus some modifications.
- You will be allocated more than one spot.
- You are not allowed to talk during the session.

[21] Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

D General rules at the trout fishing facility

NOT FOR PUBLICATION

This appendix gives the rules for fishing which apply at the trout fishing facility.[22] They are copied from their website, and translated into English.

Rules and regulations at the trout fishing facility

Everyone is cordially invited to fish at our recreational fishing facility. You are obliged to abide by the following rules.

- Entering the site is at your own risk.
- Do not cause unnecessary noise nuisance.
- Each person fishes with one only rod at a time.
- Fly-fishing is only allowed when there is enough space (we decide if this is so).
- Feeding the fish, in any way or form, is prohibited.
- Fishing is only allowed with natural bait and/or Trout Dough (no fish).
- Fishing with artificial bait, twister, dreg, jigs, shiner, etc..., is not allowed.
- Throwing back trout (rainbow trout and salmon trout) into the pond is not allowed.
- All trout caught (rainbow trout and salmon trout) must be taken home.

[22] Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

- Using a keepnet is not allowed.
- Using a scoopnet to catch fish is not allowed.
- Any grass carp or catfish caught should be thrown back into the pond.
- Fishing at a different pond than the one you have selected upon entering is not permitted.
- You are allowed to clean fish only at the designated cleaning area.
- Everyone should keep the area clean, including the fish cleaning area.
- Damage to rented material due to incompetent use must be compensated for.
- We cannot be held accountable for theft, accidents, etc. which take place on our property.

E Instructions for the FieldPI treatment

NOT FOR PUBLICATION

This appendix contains a translation of the instructions for the FieldPI treatment.[23] Part (a) is the summary of the rules handed out to participants, who could reread it throughout the session. Part (b) is the text of the instructions read aloud at the beginning of the session.

a) Summary of the rules

Group formation

- You are placed in groups of 4 persons.
- The groups will remain the same throughout the entire session.
- We do not tell you who belongs to your group and you are not allowed to exchange information with other participants.

Timing

- The session lasts four hours, from around 8.00 a.m. until noon.
- If we begin later, we will stop later.
- The four hours will be divided into 6 periods of 40 minutes.

Stocking of the pond

- In the first period, we will put (16 x 2) + 6 = 38 rainbow trout into the pond.
- You are allowed to take home each fish you catch.

[23] Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

- We make sure that an equal number of rainbow trout is in the pond at the beginning of each period. We do this by putting in a new rainbow trout at the beginning of a new period for each fish that is caught in the previous period.
- In each period of 40 minutes, you are allowed to catch at most 2 fish. If you catch a salmon trout, it also counts as one fish.

In each period

- The number of rainbow trout put into the pond is equal to the number of fish caught in the previous period.
- You are not allowed to talk with the other participants.

In periods 1, 3 and 5:

- The fishing spots are determined by participants picking a numbered spot tag from a black linen bag.

At the end of the session:

- You will receive 5 euro for your participation.

b) Introduction

Welcome to this study by Tilburg University. Before we start, we want to point out two things. Firstly, this study is independent of the owners of the trout fishing facility. We are grateful that we are allowed to conduct this study here, but the owners have nothing to do with this project. All responsibility lies with Tilburg University. Secondly, we want to make clear that this study has nothing to do with animal welfare issues or the like. As researchers, we accept the rules and habits of recreational fishing as practiced at the trout fishing facility. We cannot tell you the exact aim of this study. We do want to stress that your privacy is guaranteed; none of the results we report can be traced back to individual participants.

As you know, you do not have to pay to take part in this study. The entrance fees are paid by Tilburg University. You are allowed to take home all fish you catch.

We ask you to abide strictly by the rules which we impose.

The session

In the next four hours, we ask you to adhere to the following rules. First, all rules that normally apply at the trout fishing facility remain in place. This means that it is not permitted to throw fish you catch back into the pond, you are only allowed to fish with one rod, you are only allowed to use a scoop net to set fish ashore, you are only allowed to use the usual types of bait, etc.

You are placed in a group with 3 other participants during the session. A group therefore consists of 4 persons. Your group remains the same for the whole session, but we do not inform you about who is in your group, and who is not. We urgently ask you not to talk to other people during the study. This is so important to us that we will exclude you from the session if you violate this rule.

The session takes a total of four hours, from about 8.00 a.m. until noon. If we start a little later, we will stop a little later. The study consists of 6 periods of 40 minutes. In the first period, we will put 2 rainbow trout into the pond for each participant. In addition, we put another 6 rainbow trout into the pond. There are 16 participants, and hence we will put (16 x 2) + 6 = 38 rainbow trout into the pond. You are allowed to take home all fish that you catch. We make sure that, at the beginning of each period, the number of trout in the pond is always equal to that at the beginning of all other periods. We do this by putting in a number of rainbow trout, at the beginning of a new period, equal to the total number of trout caught in the previous period.

In each 40 minute period you are allowed to catch a maximum of 2 fish. Any trout caught counts as one fish, whether it is a rainbow trout or a salmon trout. Whenever you have caught 2 fish and the period is not finished yet, you have to take your fishing line out of the pond. You then have to wait until the next period begins. You are not allowed to talk with others while you wait.

The spot at which you are located may influence the number of fish you can catch. Fishing spots are assigned in periods 1, 3 and 5. That means that you will be located for two periods of 40 minutes at each of your three spots. Spots are assigned by having participants pick a numbered spot tag out of a black linen bag.

Questions

If you have any questions regarding the session, you can ask them now, but also during the session. We do not answer questions about how to act in this study — all decisions you take are yours. We also do not answer questions about the purpose of this study. When we have analyzed the data, we will inform you about its results.

F Instructions for the FieldVCM treatment

NOT FOR PUBLICATION

This appendix contains a translation of the instructions for the FieldVCM treatment.[24] Part (a) is the summary of the rules handed out to the participants, who could reread it throughout the session. Part (b) is the text of the instructions read aloud at the beginning of the session.

a) Summary of the rules

Group formation

- You are placed in groups of 4 persons.
- The groups will remain the same throughout the entire session.
- We do not tell you who belongs to your group and you are not allowed to exchange information with other participants.

Timing

- The session lasts four hours, from around 8.00 a.m. until noon.
- If we begin later, we will stop later.
- The four hours will be divided into 6 periods of 40 minutes.

Stocking the pond

- In the first period, we will put $(16 \times 2) + 6 = 38$ rainbow trout into the pond.
- You are allowed to take home each fish you catch.

[24] Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

- We make sure that an equal number of rainbow trout is in the pond at the beginning of each period. We do this by putting in a new rainbow trout at the beginning of a new period for each fish that is caught in the previous period.
- In each period of 40 minutes, you are allowed to catch at most 2 fish. If you catch a salmon trout, it also counts as one fish.
- If you (decide to) catch less than two fish, we give money to the other three participants of your group.
- If you catch fewer fish than the two you can catch maximally, we divide 6 euro equally among the other 3 participants in your group for each fish you did not catch.
- Hence, for each fish you do not catch (or decide not to catch), each of the other 3 participants in your group receives 2 euro. This means that:
  - If you catch 2 fishes, the other 3 participants in your group do not receive any money.
  - If you catch 1 fish, each of the other 3 participants in your group receives 2 euros.
  - If you catch 0 fishes, each of the other 3 participants in your group receives 4 euros.
- This holds for all participants. This means that you will receive 2 euro for each fish that is left in the pond by the other participants in your group.

In each period

- The number of rainbow trout put into the pond is equal to the number of fish caught in the previous period.
- You are not allowed to talk with the other participants.

In periods 1, 3 and 5:

- The fishing spots are determined by participants picking a numbered spot tag from a black linen bag.

At the end of the session:

- You receive €2 for every fish not caught by the other three members of your group over the 6 periods.

b) Introduction

Welcome to this study by Tilburg University. Before we start, we want to point out two things. Firstly, this study is independent of the owners of the trout fishing facility. We are grateful that we are allowed to conduct this study here, but the owners have nothing to do with this project. All responsibility lies with Tilburg University. Secondly, we want to make clear that this study has nothing to do with animal welfare issues or the like. As researchers, we accept the rules and habits of recreational fishing as practiced at the trout fishing facility. We cannot tell you the exact aim of this study. We do want to stress that your privacy is guaranteed; none of the results we report can be traced back to individual participants.

As you know, you do not have to pay to take part in this study. The entrance fees are paid by Tilburg University. You are allowed to take home all fish you catch. In addition, you can earn money.

We ask you to abide strictly by the rules which we impose.

The session

In the next four hours, we ask you to adhere to the following rules. First, all rules that normally apply at the trout fishing facility remain in place. This means that it is not permitted to throw fish you catch back into the pond, you are only allowed to fish with one rod, you are only allowed to use a scoop net to set fish ashore, you are only allowed to use the usual types of bait, etc.

You are placed in a group with 3 other participants during the session. A group therefore consists of 4 persons. Your group remains the same for the whole session, but we do not inform you about who is in your group, and who is not. We urgently ask you not to talk to other people during the study. This is so important to us that we will exclude you from the session if you violate this rule.

The session takes a total of four hours, from about 8.00 a.m. until noon. If we start a little later, we will stop a little later. The study consists of 6 periods of 40 minutes. All the money you earn during the study is paid to you at the end. In the first period, we will put 2 rainbow trout into the pond for each participant. In addition, we put another 6 rainbow trout into the pond. There are 16 participants, and hence we will put $(16 \times 2) + 6 = 38$ rainbow trout into the pond. You are allowed to take home all fish that you catch. We make sure that, at the beginning of each period, the number of trout in the pond is always equal to that at the beginning of all other periods. We do this by putting in a number of rainbow trout, at the beginning of a new period, equal to the total number of trout caught in the previous period.

In each 40 minute period you are allowed to catch a maximum of 2 fish. Any trout caught counts as one fish, whether it is a rainbow trout or a salmon trout. If you catch fewer than 2 fish, or decide to catch fewer than 2 fish, the other members of your group receive money. For each fish you catch fewer than 2, the other members of your group receive, in total, 6 euros, to be divided equally among the three of them; they thus receive 2 euros each.

This means that if you catch 2 rainbow trout, the other 3 participants in your group do not receive any money. If you catch 1 rainbow trout, each of the other 3 participants in your group receives 2 euro. If you catch 0 rainbow trout, each of the other 3 participants in your group receives 4 euro. This rule holds for all participants. Hence, you receive 2 euro for every fish anyone of your three group members decides to catch fewer than 2 in any period.

The spot at which you are located may influence the number of fish you can catch. Fishing spots are assigned in periods 1, 3 and 5. That means that you will be located for two periods of 40 minutes at each of your three spots. Spots are assigned by having participants pick a numbered spot tag out of a black linen bag.

Questions

If you have any questions regarding the session, you can ask them now, but also during the session. We do not answer questions about how to act in this study — all decisions you take are yours. We also do not answer questions about the purpose of this study. When we have analyzed the data, we will inform you about its results.

G The instructions for the StuLab, FisherLab and FisherPond treatments

NOT FOR PUBLICATION

Part (a) of this appendix presents the translation of the instructions for the StuLab treatment. Part (b) indicates how the instructions for the FisherLab and FisherPond treatments differed from those of the StuLab treatment.[25]

a) Instructions for the StuLab treatment

Introduction

Welcome to this study by Tilburg University. You can earn money during the study. The amount of money you can earn depends on your decisions during the session and on the decisions of others. We will read out aloud the instructions now, and you are invited to read along.

The session

In this session you are placed in a group with 3 other participants during the session. A group therefore consists of 4 persons. Your group remains the same for the whole session, but we do not inform you about who is in your group, and who is not. We urgently ask you not to talk with others during the study. This is so important to us that we will exclude you from the session if you violate this rule.

The study consists of 6 periods in which we mimic a scenario at a fishing pond. However, instead of really catching fish, you are requested to decide how many fish you would like to catch. The rules of the study are as follows. In each of the 6 periods, you are allowed to catch a maximum of 2 fish. You receive 1 euro for each fish you catch. For each fish you catch fewer than

[25] Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

2, the other members of your group receive, in total, €1.50, to be divided equally among the three of them; they thus receive €0.50 each.

That means that if you catch 2 fish, you receive €2 and the other three members of your group do not receive any money. If you catch 1 fish, you receive €1 and the other three members of your group receive 1 × €0.50 = €0.50 each. If you catch 0 fish, you receive €0 and the other three members of your group receive 2 × €0.50 = €1 each. This rule holds for all participants. Hence, you receive €0.50 for every fish anyone of your three group members decides to catch fewer than 2 in any period.

Examples

Suppose that you and all your other group members catch 0 fish. You will earn €3. This amount consists of the 2 × €0.50 = €1 as a consequence of the choice of each of your other group members. Because there are 3 other group members, you will earn 3 × €1 = €3. Because you have not caught a fish yourself, you will earn nothing due to your own fishing activities.

If you catch 2 fish while all of your other group members catch 0, you will earn €5. This amount consists of the 3 × €1 as a consequence of no catch of your other group members plus the earnings from your own fishing activities, 2 × €1 = €2.

Suppose that you and all your other group members catch 2 fish. You will earn €2. This amount consists of the 2 × €1 of the two fish you have caught. Because all your other group members have also caught 2 fish, you will earn no money.

If you catch 0 fish and all of your other group members catch 2 fish, then you will earn €0. You will earn nothing as a consequence of your own fishing activities. Because no other group member leaves a fish, you will earn nothing.

Filling in the form

You can indicate your choices for each of the 6 periods on the form we handed out. We will now explain how you can do this. Please have a look at the form now.

In the upper right corner please fill in your participant number. This number is the one marked on the sticker on your table. Please make sure to fill in the correct number; we need this in order to make the payments at the end of the session.

On the form you find the choices you can make. Below these options, we have printed the numbers 0, 1, and 2 next to each period. We ask you simply to circle your choice for each period.

When you have made your choice for period 1, please put the form, face down, on your desk, so that we know you are done making your decision for the period. When all participants have made their choice, we collect all of the forms. We calculate how much you receive in this period, and fill the information out on the form. We then return the form to you, so that you know how much you have earned. On the form, we also write the total number of fish your group has caught. In addition, we write down the decisions of all participants in the session on the white board in front of you. Note that the white board does not provide information on who is in your group.

After this procedure, period 2 starts. We ask you to make your choice for this period by circling the appropriate number, and place your form face down on top of your desk. When everyone has made their choice, we collect the forms, and calculate how much money each participant receives in period 2. We inform each participant about the decisions of their group members, and how much money he/she receives. Also, we again write the decisions of all participants on the white board. This procedure is repeated until all 6 periods are finished. Note that you should not make a choice for a period that has not yet begun.

At the end of the session, we give all participants their receipts in private by inviting them, one by one, to the adjacent room. When you have collected your earnings, the session is finished. There is no reason for you to return to this room, so please take all your belongings when your name is called.

Questions

If you have any questions regarding the session, you can ask them now, but also during the session. We do not answer questions how to act in this study — all decisions you take are yours. We also do not answer questions about the purpose of this study. When we have analyzed the data, we will inform you about the results.

Test questions

We now proceed with a short test. Once all participants have answered these questions correctly, the session will begin.

1. With how many other participants will you be placed in a group?

2. How much money will you earn due to your own fishing activity when you decide to catch 2 fish in a period?

3. How much money will you earn when the following decisions are made in a period?

- You catch 1 fish,
- Two other members of your group catch 0 fish,
- One other member of your group catches 2 fish.

The form

The session consists of 6 periods. In each period, we ask you to choose one of the following options.

(0) You catch 0 fish. You receive €0 and the other members of your group receive 2 × €0.50 = €1 each;
(1) You catch 1 fish. You receive €1 and the other members of your group receive 1 × €0.50 each);
(2) You catch 2 fish. You receive €2 and the other members of your group each receive €0.

	Your choice			Total group catch	Your earnings
Period 1	0	1	2		
Period 2	0	1	2		
Period 3	0	1	2		
Period 4	0	1	2		
Period 5	0	1	2		
Period 6	0	1	2		

b) Instructions for the FisherLab and FisherPond treatments

The instructions for the FisherLab treatment are identical to those for the StuLab treatment. The instructions for the FisherPond treatment only differ from those of StuLab and FisherLab treatments with respect to the mechanics of the experiment's implementation. In the FisherPond treatment decisions sheets were to be handed back to the experimenter (rather than put on the participant's table for the experimenter to collect) and information about the decisions of the other participants in the session were shown on a paper sheet for the participant to peruse rather than recorded on a white board.

H Survey about the value of fishing

NOT FOR PUBLICATION

Dear participant,

We are conducting a study on behalf of Tilburg University. We would like you to answer the following questions. What we ask of you, is to answer the following questions, which relate to a hypothetical scenario we describe now.

Suppose that you are fishing for rainbow trout. However, there is an additional rule to the usual rules that apply here at the Biestse Oevers: you have to pay for each rainbow trout that you catch. You are not allowed to put fish that have been caught back into the pond. What price would be the most you would pay to catch rainbow trout?

Price per rainbow trout caught	I would like to catch ... fish
€0.50	> 10/9/8/7/6/5/4/3/2/1/0
€1	> 10/9/8/7/6/5/4/3/2/1/0
€1.50	> 10/9/8/7/6/5/4/3/2/1/0
...	...
€15	> 10/9/8/7/6/5/4/3/2/1/0

The figure below shows the frequency of subjects who state each level of maximum willingness to pay to catch a rainbow trout.

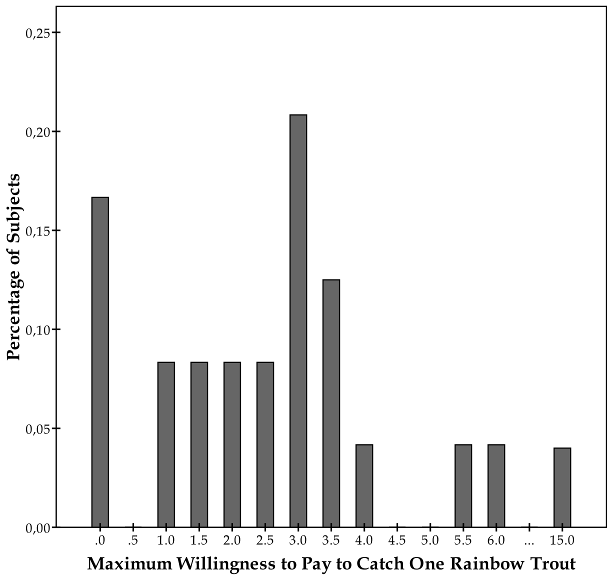


Figure 7 Maximum willingness to pay to catch one rainbow trout: percentage of subjects choosing each level

I Instructions of the FieldDyna treatment

NOT FOR PUBLICATION

This appendix is a translation of the instructions for the FieldDyna treatment.[26] Part (a) is the summary of the rules handed out to participants, who could reread it throughout the session. Part (b) is the text of the instructions read aloud at the beginning of the session. Part (c) is the quiz that participants took before their session began.

(a) Summary of the rules of the study

Group formation

- You are placed in groups of 4 persons.
- These groups remain the same throughout the entire session.
- The other members of your group wear a ribbon of the same color as you do.
- You are not allowed to talk to other people during the study.

Timing

- The session lasts four hours, from around 8.00 a.m. until noon.
- If we begin later, we will stop later.
- The four hours are divided into 4 periods of 1 hour each.

Stocking the pond

- In the first period, we will put $(4 \times 8) + 6 = 38$ rainbow trout into the pond.

[26]Not to be included in the final paper. Now included for the reviewers' convenience; available upon request from the authors in the final version.

- You are allowed to take home each fish you catch.
- At the beginning of each new period, we put fish into the pond equal to the total number of fish caught by the present participants in the previous period.
- The number of fish in the pond per active participant is therefore equal at the start of each period.

Catching fish

- Each fish you catch is yours to take home. For every fish you catch, you also receive €5. Rainbow trout and salmon trout count both as one fish.

Available fish for your group

- Each period, you and your other group members allowed to catch at most the number of fish available to your group.
- In the first period this is 8 fish.
- The number of fish available for your group does NOT depend on the number of fish caught by other groups.
- The number of available fish for your group in the current period depends ONLY on the number of fish your group left in the pond at the end of the previous period. See the table below.
- Whenever a group catches all fish that were available to that group, all members of that group have to stop fishing and are requested to leave the pond area.
- We pay your earnings at the end of the period in which your session ends.
- Example:

- In the first period the total number of fish available to your group equals 8.
  * The maximum number of fish that your group is allowed to catch in the first period, is 8 fish.
  * When 8 fish are caught, all members of your group have to take their fishing lines out of the water and have to leave the pond area.
- Suppose your group catches 6 fish in the first period.
  * At the beginning of the second period, there are 2 fish left from the first period and 3 new fish are put into the pond; see the table.
  * Your group is then allowed to catch 2 + 3 = 5 fish in the second period.
  * If your group catches all 5 fish in the second period, all members of your group have to take their fishing lines out of the water and have to leave the pond area.
- If your group catches less than 5 fish, new fish will be placed into the pond, as indicated in the table.
  * Suppose your group catches 1 fish in the second period.
  * Then, at the end of the period there are 5 − 1 = 4 fish left for your group.
  * The available number of fish for your group in the next period is then raised by 4 fish (see the table), and the total number of available fish in period 3 is 4 + 4 = 8.
- Etc.

Your fishing spot

- Each group has four spots, each member of the group fishes for one period at each of these four spots.
- You draw a numbered spot tag out of a black linen bag which indicates your spot for the first period.

- You receive a ribbon at the beginning of the session.
- At the end of each period of one hour, we inform you at what spot you will be fishing in the next period.
- You are not allowed to talk to other people during the session.

Number of fish left at the end of the previous period by your group	Increase in the number of fish available to your group	Number of fish available to your group in the coming period
0	0	0
1	2	3
2	3	5
3	3	6
4	4	8
5	3	8
6	3	9
7	2	9
8	0	8
9	2 fish subtracted	7

(b) Test questions

1. How many other group members are in your group, besides you?

2. Suppose your group catches 6 fish in the first period.
a. What is the number of fish still available to your group at the end of the first period?
b. The number of fish available to your group is then increased by how many fish in period 2?
c. What is the maximum number of fish your group is allowed to catch in period 2?
Suppose next that you and the other participants of your group catch all available fish in period 2.
d. What is the maximum number of fish your group is allowed to catch in the third period?

e. What is the maximum number of fish your group is allowed to catch in the fourth period?

3.

a. What is the maximum number of fish your group is allowed to catch in the first period?
b. How many fish should your group have left at the end of the first period in order to have the largest increase in fish available to your group at the start of period 2?
c. How much is this increase?
d. What is the total number of fish available for your group in the next period?

(c) Instructions

Introduction

Welcome to this study by Tilburg University. Before we start, we want to point out two things. Firstly, this study is independent of the owners of the trout fishing facility. We are grateful that we are allowed to conduct this study here, but the owners have nothing to do with this project. All responsibility lies with Tilburg University. Secondly, we want to make clear that this study has nothing to do with animal welfare issues or the like. As researchers, we accept the rules and habits of recreational fishing as practiced at the trout fishing facility. We cannot tell you the exact aim of this study. We do want to stress that your privacy is guaranteed; none of the results we report can be traced back to individual participants.

As you know, you do not have to pay to take part in this study. The entrance fees are paid by Tilburg University. You are allowed to take home all fish you catch. In addition, you can earn money.

We ask you to abide strictly by the rules which we impose.

The session

In the next four hours, we ask you to adhere to the following rules. First, all rules that normally apply at the trout fishing facility remain in place. This means that it is not permitted to throw fish you have caught back into the pond, you are only allowed to fish with one rod, you are only allowed to use a scoop net to set fish ashore, you are only allowed to use the usual types of bait, etc.

You are placed in a group with 3 other participants during the session. A group therefore consists of 4 persons. The group remains the same throughout the study. Each participant receives a ribbon. The members of your group have the same color ribbon as you have. We urgently ask you not to talk to other people during the study. This is so important to us that we will exclude you from the session if you violate this rule.

The session consists of four periods of one hour. The session therefore takes four hours, from 8.00 a.m. until 12.00 a.m. If we start a little later, we will stop a little later.

In the first period, we put 8 rainbow trout into the pond for each of the four groups. In addition, we put another 6 rainbow trout into the pond, and hence we put $(4 \times 8) + 6 = 38$ rainbow trout into the pond. At the beginning of period 2, 3, and 4 we put a number of fish into the pond equal to the number of fish caught in the previous period by all active participants. This means that the number of fish in the pond for each active fisherman is the same at the beginning of each period.

Each fish you catch is yours to take home. In addition, you receive €5 for each fish you catch. During the study, rainbow trout and salmon trout both count for 1 fish.

Although the number of fish per participant remains constant over all periods, you are not allowed to catch fish without limit. Each period of one hour, you and your group members are not allowed to catch more than the maximum number of fish available to your group. In the first period, this maximum number of fish available is 8 fish, and you and your group members are not allowed to catch more than 8 fish in this period. Keep in mind that each fisherman is allowed to catch as many fish he or she can or wants to, as long as the total number caught by the group in the first hour is not more than 8 fish.

In the second period, the number of fish available to your group changes. The number of fish available to your group does not depend on the number of fish caught by participants of other groups. The number of fish available to your group in the next period depends only on the number of fish still available to your group at the end of the current period.

The way in which this works is indicated in the table.

Whenever the number of fish caught is such that the number of fish available to your group at the end of the period equals zero, the number of available fish is not increased and your group is not allowed to catch any more fish. The session is over for your group. We pay you your earnings at the end of the period in which your group has caught its maximum available fish.

Whenever the number of fish caught is such that at the end of a period 1 fish is left to your group, the number of fish available to your group is raised by 2, and your group is allowed to maximally catch 3 fish in the next period.

Whenever the number of fish caught is such that at the end of a period the number of fish available to your group equals 4, the number of fish available to your group is raised by 4, and your group is allowed to maximally catch 8 fish in the next period.

Whenever the number of fish caught is such that at the end of a period the number of fish available to your group equals 6, the number of fish available to your group is raised by 3, and your group is allowed to maximally catch 9 fish in the next period.

Let us consider an example. In the first period, the total number of fish available to your group equals 8. This means that your group is allowed to catch at most 8 fish in this period. When the 8th fish is caught, all members of the group have to take their fishing lines out of the water. The session is then over for your group and you have to leave the pond area.

Suppose your group does not catch 8 fish in the first period, but rather 6. In that case there are $8-6=2$ fish still available to your group at the end of the first period. The table shows that when 2 fish are left to a group at the end of a period, the total number of fish this group is allowed to catch is increased by 3 fish at the beginning of the second period. At the beginning of the second period there are hence $2+3=5$ fish available for your group. Once again, the number of fish caught by other groups has no influence on the number of fish your group is allowed to catch.

When your group catches 5 fish in the second period, all members of your group have to take their fishing lines out of the water at the moment the fifth fish is caught. If your group catches fewer than five fish in the second period, the number of fish available to your group is again increased. The increase in the number of fish available for your group depends on the number of fish left at the end of the second period, as indicated in the table. Suppose your group catches one fish in period 2, then the total number of fish still available to your group at the end of that period is $5-1=4$ fish. In the table you can see that in that case, the number of available fish is raised by 4 fish. The number of available fish for your group is 8 in period 3, in this example.

Each group of fishermen is allocated 4 fishing spots. You will be located for one period at each of those group spots. You will draw a number out of a bag which indicates the spot at which you will be located during the first period. You will receive a ribbon before the session starts. At the end of each period we inform you at which spot you will be located in the next period. We want to stress again that it is important that you are not allowed to talk during the session. This is of such importance, that we will exclude you from the session if you violate this rule.

Questions

If you have any questions regarding the session, you can ask them now, but also during the session. We do not answer questions about how to act in this study — all decisions you take are yours. We also do not answer questions about the purpose of this study. When we have analyzed the data, we will inform you about its results.

Before the session starts, we ask you to answer some test questions. You can do this at the spot at which you will be fishing in the first period. Only when all participants have answered all questions correctly, will the session start.