

**Economic behavior of fishers under climate-related uncertainty: results from field experiments
in Mexico and Colombia**

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Abstract

This paper presents the results of economic experiments run among fishermen from the Mexican and Colombian Pacific. The experimental design aims at studying behavior under uncertainty concerning the possible effects of climate change on fisheries. We find that subjects' risk-aversion diminishes the level of catches and changes fishing practices (e.g. adopting marine reserves), provided that fishermen have *ex ante* information on possible climatic consequences.

Furthermore, social preferences (e.g. for cooperation and reciprocity) also play an important role regarding extraction from common-pool resources. Other factors, such as income, gender and religion are also found to have some influence. These results have important implications for adaptation actions and the management of coastal fisheries.

Highlights

Subjects' risk-aversion lowers catches and changes fishing practices (e.g. marine reserves).

Social preferences (e.g. cooperation and reciprocity) also play an important role regarding extraction from common-pool resources.

Results have important implications for adaptation actions and the management of coastal fisheries.

Keywords

Experimental economics, Uncertainty, Risk-aversion, Climate change, Cooperation and reciprocity, Coastal fisheries, Colombia, Mexico.

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14
15 **1. Introduction**

16 The livelihoods and regional development of millions of people in developing countries depend
17 to a large extent on the fishing sector. For example, several Asian and Latin American countries
18 are among the major fishing nations in the world and their populations receive up to 20% of
19 their protein intake from fish products (FAO, 2012). Furthermore fisheries and aquaculture
20 assure the livelihoods of 10-12 percent of the world's population (FAO, 2014). Nevertheless,
21 although global fish catch has stabilized during the last decades, fish stocks have been depleted
22 in a number of regions worldwide (Worm et al., 2006). A direct consequence of this situation is
23 the risk on food security in a number of regions in the developing world (Smith et al., 2011;
24 Srinivasan et al., 2010).

25
26 A changing climate is an additional factor of risk for a number of fisheries, especially for
27 livelihoods in poorer regions (Badjeck et al., 2010). Furthermore, it is well acknowledged that
28 the vulnerability of fishing livelihoods toward climate change impacts will be enhanced by poor
29 fishery management (Brander, 2007; Allison et al., 2009; McIlgorm et al., 2010).

30
31 Thus, understanding stakeholders' decisions under these risky scenarios is of paramount
32 importance for adaptation to climate change (Gowdy, 2008). Experimental economics provides

33 a powerful tool for analyzing stakeholders behavior when dealing with common-pool resources
34 (Cardenas and Ostrom, 2004) and with risky and uncertain situations in general (Sabater-
35 Grande and Georgantzis, 2002; McAllister et al., 2011; Hasson et al., 2012).

36

37 Decisions in fisheries, such as the level of harvesting, or whether or not to comply with
38 regulations, depend on a number of factors, chiefly fishermen's preferences. Among the
39 preferences which are relevant in fishing decisions, fishermen's attitudes toward risks entailed in
40 climate hazards play a major role in their actual behavior (Smith & Wilen 2005; Eggert & Lokina
41 2007; Nguyen & Leung 2009; Brick et al. 2011). Furthermore, fisheries, is a typical common-pool
42 resource extraction activity. In such a context, fishers face the dilemma of individual against
43 collective benefits. Experimental economics has proven to be a useful tool to analyze decision-
44 makers' risk attitudes and other-regarding preferences in the laboratory or in the field. Then,
45 attitudes elicited in an experiment reflect home-grown values which have been developed during
46 a subject's social or professional interaction experiences. Therefore, experimental methods can
47 be used to capture attitudes and preferences which both affect and are affected by the subject's
48 real world activity. In this sense, the experiments with populations of fishermen will capture how
49 this specific subject pool will behave in a simulated context resembling their real-life decision-
50 making environment and, consequently, real-world fishery management (Moreno-Sanchez &
51 Maldonado 2009; Revollo & Ibarra 2014; Revollo et al. 2016).

52

53 In spite of the regional importance of the fisheries sector in Latin America (Thorpe and Bennett,
54 2001), few studies in Latin America have used experimental economics for analyzing fishers'
55 behavior in controlled economic environments (for more detail see Table I). Even fewer
56 experimental studies have been carried out on adaptation to climate change (e.g. Hasson et al.,
57 2010; Hasson et al., 2012). In the case of Latin America, Bernal et al. (2013) analyzed the
58 adaptation strategies of farmers when confronted to water scarcity due to climate change.
59 Although game theory has been used for studying fisheries and climate change (Bailey et al.,
60 2010), as far as we know, no studies have been published on fisheries' adaptation to climate
61 change using experimental methodology. The aim of this paper is to report results from field
62 experiments on behavior toward climate change among fishermen. We present two studies in
63 Latin America: one deals with the artisanal fisheries of Tribugá Gulf, Colombia; and the other
64 deals with the abalone fishery, off Baja Peninsula, Mexico. We present both cases in detail in

65 the next two sections. In both experiments, real monetary rewards were used to incentivize
66 the decisions made by subjects in a controlled economic environment. In both experiments,
67 the decision-making context involves extraction decisions from a common-pool resource under
68 scenarios of external environmental change, framed as a risk affecting the returns of the
69 extraction process. This paper is divided into five sections: the introduction is followed by
70 materials and methods, results, discussion, and conclusions.

71

72 **Table I.** Summary of field experiments with fisheries in Latin America

73

74 **2. Methods**

75 **2.1. Local context and study areas**

76 **2.1.1. The abalone fishery off Natividad Island, Baja Peninsula, Mexico**

77 The abalone fishery off Baja, is one of the most valued fisheries in Mexico (25th place). In 2012,
78 the value of a ton was almost 13,000 USD (CONAPESCA, 2012). While abalone in Mexico is
79 mostly an export commodity, it indirectly contributes to domestic welfare and food security,
80 since earned money is used to buy local food. It is exploited by 22 fishing cooperatives and
81 generates about 20,000 jobs (both direct and indirect). Abalone catches have diminished to
82 about 10% of the average volume harvested during the 1950s (Revollo and Saenz-Arroyo, 2012).
83 Possible explanations for this sharp decrease are: over-exploitation, environmental changes,
84 illegal harvesting, or a combination of these. The fact is that global climatic change is expected
85 to have more impact on vulnerable fisheries. Indeed, ocean acidification will directly affect
86 species with calcium carbonate skeletons (Perry, 2011), such as abalone. Furthermore, there is
87 evidence that an increasing temperature and decreasing dissolved oxygen (i.e. hypoxia) in
88 coastal ecosystems, due to carbon dioxide absorbed by marine waters (Roessig et al., 2004),
89 provokes higher mortality rates in marine invertebrates such as abalones (e.g. Guzman del Proo
90 et al., 2003).

91

92 We present the case of the fishing cooperative that operates in Natividad Island
93 ($27^{\circ}51'09''\text{N}/115^{\circ}10'09''\text{O}$), located in mid-Baja Peninsula (Figure 1). Both the fishing
94 cooperative and the NGO Comunidad y Biodiversidad (COBI A.C.) have implemented a pilot
95 program of marine reserves around Natividad Island (Micheli et al., 2012). Under this context,
96 we designed a field experiment with the inhabitants of Natividad Island in order to study the

97 determinants of their behavior in a harvesting experiment, framed as a common-pool
98 resource in the presence of a changing climate.

99
100 **Figure 1.** Natividad Island, Baja Peninsula, Mexico

101 102 **2.1.2. The Tribugá Gulf fishery, Colombia**

103 The Tribugá Gulf is located in the northernmost Colombian Pacific, Province of Chocó
104 (N5°30'06"/W77°16'09"), dominated by a tropical rain forest climate, with 28°C mean
105 annual temperature (Figure 2). The Tribugá Gulf fishery sector is characterized by artisanal
106 fisheries that mainly use longlines (hooks) and fishing nets. The target species are snapper,
107 Pacific sierra, seashells (locally known as "piangua") and prawns. In this area, artisanal fishing is
108 the main livelihood for most coastal communities, but in recent years fish stocks have been
109 declining in both capture volume and catch size. Caicedo et al. (2008) reckon that the increase
110 in fishing effort, the use of unconventional fishing practices and climate change effects are
111 among the main causes of this decline.

112
113 In this case, the livelihoods of coastal communities are vulnerable to climate change effects due
114 to the lack of proper fisheries management, lack of both basic services (electricity, water,
115 sewage) and social security, as well as geographical isolation from the rest of the country. Such a
116 situation leads to a poverty trap, as demonstrated by Rebellón (2004), using an adapted version
117 of the model of Brander and Taylor (1998). It is shown there, that more effort by the families in
118 the Colombian Pacific generates higher levels of income by over-fishing. Thus, it is interesting to
119 assess the behavior of fishermen under this vulnerability context, looking at possible
120 improvements in fishery management in the region.

121
122 Lopez et al. (2004), Cardenas (2008), and Moreno and Maldonado (2009) have analyzed the
123 behavior of stakeholders in Colombian fisheries by means of experimental economics. We
124 present the results of a fishing-game-under-uncertainty experiment, which is adapted from
125 Ostrom et al. (1994), Cardenas and Ostrom (2004) and Sabater-Grande and Georgantzís (2002),
126 in order to assess the decision-making of artisanal fishers, under uncertainty caused by
127 potentially changing climate conditions in the Gulf of Tribugá.

129 **Figure 2.** Tribugá Gulf, Colombia

130

131 **2.2. Experimental design**

132 Due to specific contexts and logistics for each case, we adapted experimental designs for each
133 site. Thus, econometric methods (see below) somehow differ in both approach and variables. In
134 spite of these differences, the main objective of this study remains the same in both cases¹. We
135 therefore reckon that results, are nevertheless comparable for drawing valid conclusions.

136

137 **2.2.1. Natividad Island, Mexico**

138 Field experiments were carried out at Natividad Island, and included both men and women
139 older than 16 years. A public invitation was made to the whole population. It was attended by
140 37 people (N=37, 26 men and 11 women), who represented approximately 15% of the total
141 adult population in the island with an average monthly income of \$630 USD. For the baseline
142 treatment (BL), all participants played ten rounds. In the first five (rounds 1-5), they had to
143 decide on catches from one to ten resource units, knowing that their monetary rewards (in
144 accumulated points converted to real currency at the end of the session) would depend on
145 individual and group decisions.² In the setup implemented, Nash equilibrium is achieved by
146 harvesting ten units of resource, while the social optimum is obtained with one harvested unit
147 per round. Participants are told that the resource recovery rate was 50% for each round.

148

149 For the second sub-session, (rounds 6-10), participants were told that the recovery rate would
150 change for the rest of the game and that the change would depend on whether a random
151 climatic variation (e.g. El Niño Southern Oscillation -ENSO) would be present in that round³.
152 Besides, they were told to choose between either implementing a marine reserve or not,

¹ Payoffs tables and experimental protocols were tested in both Mexico and Colombia with pilot experiments. These were carried out with both students and fisheries-related colleagues for improving the experimental design before being applied in the field. This is a standard guideline in experimental economics which warrants unbiased decision-making among players. Please refer to payoffs tables and experimental protocols in the Appendix.

² In the Appendix A, we provide details on the experimental economics: decision sheets and the table of scores.

³ The stochastic component (i.e. treatment on fisheries uncertainty due to climate change effects) was not included in the baseline treatment during the first rounds of the experiment (rounds 1-5 in the Mexican experiment) in order to have a reference for comparison among treatments. Otherwise, we would not be able to disentangle the effects from climate change uncertainty from the “normal” conditions of fishermen’s decision-making.

153 according to the scenarios shown in Table II. This decision to implement or not a marine
 154 reserve is maintained for the remaining rounds and cannot change in subsequent rounds.
 155 The decision is made before starting round six and held until the end. Participants were then
 156 asked to form two groups for the rest of the game: one including those choosing a marine
 157 reserve (N=30) and another including those deciding not to implement the reserve (N=7). The
 158 last five rounds follow the same logic as the first five: participants' profits depend on both
 159 individual and group extractions. Communication among the participants was forbidden, in all
 160 cases, before, after, or during the harvesting decisions.

161

162 **Table II.** Scenarios shown to participants in the climatic change / marine reserves at Natividad
 163 Island, Baja Peninsula, Mexico

164

165 Payoffs were calculated following Cardenas and Ramos (2006), considering that fisheries
 166 resources should be considered as common-pool resources, because usually the individual
 167 interest is in contradiction of the collective interest. Hence, subject i 's earnings in round t are
 168 given by:

$$169 \quad \pi_{it} = (Price \cdot X_i) + \left(Price \cdot \frac{1}{N} \cdot Recovery\ Rate \cdot (maxQuantity - \sum_i X_i) \right)$$

170 Where:

171 X_i is harvesting level of participant i whose values range from one to ten and $Price$ denotes
 172 the price of the common-pool resource. N is the number of participants in each group and
 173 $Recovery\ Rate$ is the rate at which the remaining fish stock can regenerate at the end of each
 174 harvesting period. This depends on the scenario, as shown on Table II. $Max\ Quantity$ is the
 175 maximum level of fish stock that is recovered in each round and the sum of all extraction levels,
 176 X_i correspond to the fish stock level actually harvested at the end of each round.

177

178 It is worth noting that a subject's payoff increases in own individual extraction but
 179 decreases in the total amount harvested, indicating the existence of horizontal externality
 180 among individual decision-makers in the extraction game. In other words, the benefits of each
 181 participant depend on both individual and group extractions (Ostrom et al., 1994). Hence, the
 182 collective benefits are assumed to be the asset value of the natural resource (i.e. the value of a
 183 fish left alive in the sea).

184 **2.2.2. Tribugá Gulf, Colombia**

185 Before explaining the experimental design applied in the Gulf of Tribugá, Colombia, is important
186 to note that this design is different from that applied in Natividad Island (Mexico), due to
187 differences in fisheries management in both areas and the type of fishing practices. Natividad
188 Island (Mexico), abalone fishing (deep sea fishing) is performed, whose average prices
189 generated a high level of income for fishermen in the area and therefore there fishing
190 cooperatives that manage a vigorous productive and industrial infrastructure, including support
191 research laboratories aquaculture. Instead, in the Gulf of Tribugá (Colombia), shrimp, prawns,
192 snapper or Sierra (net and hook fishing) is performed, the average price does not allow the
193 angler to reach the minimum level of monthly income to survive, situation which does not
194 facilitate fisheries management in the area.

195
196 Field experiments were carried out in Nuquí, Coquí, Panguí, Joví, Arusí, Termales, El Valle,
197 Jurubirá and Tribugá, coastal communities in the Tribugá Gulf, Province of Chocó, Colombia,
198 including both men and women older than 16 years. A public invitation was made to the whole
199 population. It was attended by 160 people (142 men and 18 women), who represented
200 approximately 8% of the total adult population in the Gulf, with an average monthly income of
201 \$220 USD. We formed groups of five people and all groups were administered the same
202 experiment with the same treatments. Before starting, an explanation of the game context, its
203 rules, and monetary retributions were explained to all participants.⁴ They were told that their
204 individual earnings (in accumulated point convertible in real currency at the end of the session)
205 would depend on both their individual and group decisions.

206
207 They made decisions for 20 rounds of which the first ten (rounds 1-10) corresponded to the
208 baseline treatment. For the last ten rounds (rounds 11-20), participants were informed that the
209 recovery rate would change for the rest of the session, depending on the occurrence of a
210 random climatic variation (e.g. El Niño Southern Oscillation -ENSO). Besides, they were asked to
211 choose between either implementing a marine reserve or not⁵. Thus, within each group, each

⁴ In Appendix B, we provide details on the experimental economics: decision sheets and the table of scores.

⁵ The stochastic component (i.e. treatment on fisheries uncertainty due to climate change effects) was not included in the baseline treatment during the first rounds of the experiment (rounds 1-10 in the Colombian experiment) in order to

212 player must choose, individually and confidentially, whether to play 11-20 rounds under an
 213 insurance (i.e. with a marine reserve) or not (i.e. open-access fishing without marine reserve).
 214 The last 10 rounds follow the same logic of the baseline treatment, and the level of earnings
 215 depends still on both individual and group extractions. Furthermore, two more treatments were
 216 implemented during the experiment:

217

218 a) Communication treatment (n=80): all five participants within each group can communicate for
 219 five minutes before rounds 11-20, so they can share their experiences and learn from rounds 1-
 220 10 in order to set up a harvesting strategy for the rest of the game.

221

222 b) Voluntary enforcement treatment (n=80): the monitor explains the negative effects of
 223 overfishing and therefore suggests a minimum level of extraction (one unit) in each round. It is
 224 also noted that harvesting over this recommended level will be enforced. However,
 225 participants can vote on whether each player's harvesting levels should be inspected in each
 226 round. If the inspection mechanism is voted, participants harvesting above the socially optimal
 227 unit, are fined with minus 100 points for each additional unit extracted from the common pool.

228 Both the experimental designs and hence, the models, presented differences between both
 229 countries in order to adjust for local and institutional realities. Thus, the theoretical model for
 230 the economic experiment applied in Colombia is presented as follows.

231

232 Payoffs were calculated following Cárdenas (2010)⁶, with a model that simulates the social
 233 dilemma of Common Pool Resource (CPR) Hence, the individual harvesting level that maximizes
 234 the private benefit of each participant (x_i); in other words, the agent's objective function is
 235 defined by his own effort x_i , and aggregate efforts by other agents, $\sum x_j$. Formally, the private
 236 profit Y_i of the agent is given by the expression:

237

$$Y_i = ax_i - \frac{1}{2}bx_i^2 + \frac{1}{N} \sum_{j=1}^N x_j$$

have a reference for comparison among treatments. Otherwise, we would not be able to disentangle the effects from climate change uncertainty from the "normal" conditions of fishermen's decision-making.

⁶ The theoretical model implemented is adapted from Cardenas (2010) and extensively described in Georgantzis et al. (2013).

238 where, a is the income from each harvested unit, b is the decreasing marginal parameter, φ is
 239 the externality cost due to stock depletion and n is the number of players φ represents the cost
 240 that each agent i incurs due to the externality emerging from the aggregate extraction by all
 241 other agents. The Nash solution obtained is given by:

$$242 \quad x_i^N = \frac{a - n\varphi}{h}$$

243 Cárdenas (2010) suggests that $a=60$, $b=5$, $\varphi = 20$ and that the minimum harvesting quantity = 1.
 244 It follows that in the Nash equilibrium,

$$245 \quad x_i^N = \frac{a - n\varphi}{h} = \frac{60 - 20}{5} = 8$$

246 Thus, a player maximizing own profits, and taking others' individual extraction levels as given,
 247 harvests eight units in each round. For this reason, this model, as suggested Ostrom, Garner and
 248 Walker (1994), shows that this situation will result in a social dilemma associated with over-
 249 exploitation of CPR. In order to incorporate the possibility of adopting a marine reserve insurance
 250 against climate change, we follow Sabater-Grande and Georgantzis (2002) and Georgantzis et al.
 251 (2009). It is important to note that this is a type of economic experiment, which studies the
 252 behavior of fishers (Tribugá Gulf, Colombia) confronted to risky economic decisions. For this
 253 reason, the experiment implements a design where fishermen can decide whether or not get
 254 assurance⁷ against unexpected events (e.g. climatic change) that possibly, affects fisheries and
 255 consequently social welfare.

256

257 Following this approach, in rounds 11-20 players are faced with a lottery (q, X) giving a payoff X
 258 with a probability q . The scheme is designed to compensate the risk of obtaining $X=0$ (with a
 259 probability of $1-q$) with a risk premium which is an increasing (linear) function of the probability
 260 of the unfavorable outcome, as implied in:

261

$$262 \quad q \cdot X(q) = c + (1 - q) \cdot r \rightarrow X(q) = \frac{c + (1 - q) \cdot r}{q} \quad (4)$$

263

263 The experiment assumes a continuum of lotteries (c, r), that for the fishing game under
 264 uncertainty is represented by a continuum of Nash Equilibria, compensating riskier options with
 265 an increase in the expected payoff; in other words, if the player decides not to buy the insurance

⁷ The assurance is associated with the meaning of a protected area or marine reserve thanks to the application of economic experiments in Colombia, 2015: <http://www.eltiempo.com/estilo-de-vida/ciencia/nueva-area-marina-golfo-de-tribuga-cabo-corrientes/15474539>

266 and fishing is adversely affected by climate change, the expected payoff for the player will be low
267 or even negative. In summary, the experiment shows that fishermen may have negative payments
268 if their decision was not to get insurance (i.e. a protected marine reserve) in the presence of
269 unexpected events (i.e. climate variations) that affect fishing. This experimental design is
270 consistent with the suggestion by Micheli F, Saenz-Arroyo A, Greenley A, Vazquez L, Espinoza
271 Montes JA, Rossetto M, et al. (2012), who successfully demonstrate that under future scenarios of
272 frequent and/or persistent disturbance, increasing resilience to climatic impacts through
273 networks of marine reserves may be the most effective tool that local communities and nations
274 worldwide have to combat the negative impacts of global climate change on marine ecosystems
275 and livelihoods.

276

277 **3. Results**

278 **3.1. Natividad Island, Baja Peninsula, Mexico**

279 In the first stage (baseline treatment) of the experiment, the average catch was 4.6 units of the
280 resource. In the second stage, where a treatment is applied under climate change uncertainty,
281 the average catches decrease (3.3 units). Interestingly, when analyzing the evolution of the
282 average catches before and after the implementation of marine reserves, along with the
283 presence of the hypoxia phenomenon, it is observed that the level of catches for the whole group
284 (both with and without reserves), is reduced in about 38%. In contrast, when the experiment
285 treatment change, the group without marine reserves reduced their harvesting level in 20% (p-
286 value<0.01), while the group with marine reserves reduced catches in 46% (p-value<0.01). Hence,
287 both groups, after learning the possibility of a climatic event, decided to reduced their average
288 catch (Figure 3).

289

290 About 75% of participants decided to implement a marine reserve during the second stage of the
291 experiment. Besides, when asked the percentage that they would devote to creating marine
292 reserve with or without a scenario of climatic variability (i.e. hypoxia), they responded that a 41-
293 50% of the fishing ground would be converted into marine reserve in the presence of hypoxic
294 conditions, and 21-30% otherwise.

295

296 **Figure 3.** Average harvesting levels for the baseline (left panel) and climatic variability (right
297 panel) treatments (p-value < 0.01). ANOVA to test whether the normality and heteroskedasticity

298 assumptions are accepted. It is verified that harvesting levels are significantly different across
299 treatments.

300

301 **3.2. The Tribugá Gulf, Colombia**

302 The results show that the average extraction for 11-20 rounds (control treatments
303 communication and voluntary-enforcement) in context of climate change uncertainty, are always
304 lower compared to those obtained in rounds 1-10 (baseline). Particularly, the results show an
305 average decrease from 4.55 extraction units (baseline treatment) to 3.55 units under the
306 communication treatment, and an even further decrease to 2.55 units under the voluntary-
307 enforcement treatment (Figure 4) (p -value <0.05).

308

309 The results suggest that the average extraction decisions of fishermen, who participated in the
310 common-pool resource game, are clearly influenced by the treatments as evidenced by
311 Cardenas et al. (2002), Cardenas et al. (2003), Cardenas and Ostrom (2004), Cardenas (2010),
312 Lopez et al. (2009), Maldonado and Moreno (2010), Ostrom et al. (1994), Ostrom (2005) and
313 Velez et al. (2008).

314

315 In other words, to interpret the behavior of participants during 11-20 rounds, under the
316 inclusion of treatments (communication and regulation) and the possibility that fishing is
317 affected by unexpected events, such presence of natural changes (water heating, migration of
318 species, seasonality of the resource), or defection in commitments set by the community, the
319 results show that the extraction levels fall.

320

321 Additionally, most participants (152 out of 160) chose to adopt a marine reserve as insurance
322 against uncertain climatic variation in each round (rounds 11-20).

323

324 **Figure 4.** Average harvesting levels for the baseline (left panel), communication and voluntary-
325 enforcement (right panel) treatments (p -value < 0.05). ANOVA to test whether the normality and
326 heterocedasticity assumptions are accepted. It is verified that harvesting levels are significantly
327 different across treatments.

328

329

330 **3.3. Econometric estimation**

331 **3.3.1. Natividad Island⁸**

332 An econometric model was applied for assessing the socioeconomic and social capital
333 variables that influence decisions on common-pool resources and climatic variability among
334 islanders at Natividad Island. Table III shows the variables introduced in our model. The model
335 takes the form:

336

$$CATCH_{i,t+1} = \beta_0 + \beta_1 \cdot CATCHI_{i,t} + \beta_2 \cdot CATCHJ_{i,t} + \beta_3 \cdot POINTS_{i,t} + \beta_4 \cdot CLIMATE_{t+1} \\ + \beta_5 \cdot TREAT_t + \beta_6 \cdot GENDER_i + \beta_7 \cdot FISH_i + \beta_8 \cdot RESERVE_{i,t} + V_i$$

337

338

339 The dependent variable is harvesting level in the reference period, while all other independent
340 variables are introduced with a lag, assuming that what is decided in a given period depends on
341 strategies and feedback from past rounds, except climatic variations.

342

343 **Table III.** Variables introduced in the econometric model

344

345 Table IV shows the results of the econometric estimation. Among the statistically significant
346 variables ($p < 0.1$), the ones that measure the harvesting behavior of participant i ($CATCHI$) and
347 participant j ($CATCHJ$) reveal that, for each fish stock unit away from the social optimum in
348 the previous round, participant i will harvest about 0.53 additional units of the resource stock.
349 Furthermore, for every unit extracted by other players away from the social optimum,
350 participant i will harvest 0.48 units in the next round. Another significant variable was $GENDER$,
351 indicating that women's extractions are 0.70 units lower than men's. Besides, changing
352 treatment from a baseline to a random climatic event ($TREAT$) in the following round, leads to
353 reductions of 0.44 fish stock units under a marine reserve treatment, while this reduction is of

⁸ We applied a balanced panel data model since we had both cross-section information (i.e. harvesting levels of participants in each round) and a time series (ten rounds). After comparing the estimates of two panel- data methods (fixed and random effects) and with the results of a Hausman test, we decided to use a random-effects panel-data model. We decided to use a random-effects model since it included variables that do not change within individuals, but that do change among individuals. Breusch-Pagan, Hausman and F-tests were performed. Besides, auto-correlation and heterocedasticity tests were used in order to choose the best model specification (for more detail see: Revollo, 2012).

354 0.22 without a marine reserve. The possibility of climatic variations (*CLIMATE*) induced
355 participants to lower their extraction in 0.24 of resource units.

356

357 **Table IV.** Econometric estimations for explaining the individual harvesting decisions (CATCH) of
358 participants in the Natividad Island experiment

359

360 **3.3.2. Tribugá Gulf, Colombia⁹**

361 An econometric model was applied for assessing the decision-making of artisanal fishers, under
362 uncertainty caused by potential climate change conditions in the Gulf of Tribugá. Table V shows
363 the variables introduced in our model. The model takes the form:

364

$$CATCH_{i,t+1} = \beta_0 + \beta_1 \cdot EXPER_i + \beta_2 \cdot CIVIL_i + \beta_3 \cdot INCOME_i + \beta_4 \cdot SCHOOL_i + \beta_5$$

365 $\cdot RELIGION_i + \beta_6 \cdot GENDER_i + \beta_7 \cdot CLIMATE_{t+1} + V_i$

366

367

Table V. Variables introduced in the econometric model

368

369 Table VI shows the results of the econometric estimation. So, for the variable EXPERIENCE, it
370 suggests that more years of fishing experience do not necessarily lead to decreases in the levels
371 of extraction by the fisher (p-value<0.01). Hence, the average behavior of fishermen
372 remains invariant to their experience. Furthermore, the negative sign of the SCHOOL variable
373 indicates that a higher education level implies a greater commitment to sustainable fishing
374 decisions (p-value<0.01). With respect to income, the result suggests that for every percentage
375 point increase in the level of income resulting from fishing activities, extraction decisions are
376 increased by 5.7% (p-value<0.01). AGE was not statistically significant.

377

⁹ Like in the empirical evidence of Natividad Island, we applied a balanced panel data model since we had both cross-section information (i.e. harvesting levels of participants in each round) and a time series (twenty rounds). After comparing the estimates of two panel-data methods (fixed and random effects) and with the results of a Hausman test, we decided to use a random-effects panel-data model. We decided to use a random-effects model since it included variables that do not change within individuals, but that do change among individuals. Furthermore, following the recommendations of Baltagi (2008) and Hsiao (2003), the estimates are correct, as there is no autocorrelation, nor heteroskedasticity (for more detail see: Arroyo, 2013).

378 Now, consider the change in the second part of the session with respect to baseline, introducing
379 uncertainty in the decision-making context and two treatments (communication and
380 enforcement), this then affects the levels of captures in rounds 11-20. In fact, the fishermen
381 reduce their levels of catch by 0.08 of common-pool resource units. Particularly, as explained
382 above, there is a clear effect of communication and enforcement on catch decisions.

383

384 **Table VI.** Econometric estimations for explaining the individual harvesting decisions (CATCH) of
385 participants in the Tribugá Gulf experiment

386

387 **4. Discussion**

388 We provide evidence of behavior in controlled environments by Mexican and Colombian fishing
389 communities under a scenario of climatic variability. In the case of Mexico, the average
390 extraction decrease from the baseline treatment to the climate change treatment was 46%;
391 while in Colombia the decrease ranged between 22% (communication treatment) to 44%
392 (voluntary-enforcement treatment). These results could be explained under the light of
393 three types of factors: the subjects' aversion towards an external risky influence (i.e. climate
394 change), social preferences (e.g. cooperation and reciprocity), and other demographic elements
395 (e.g. income, gender and religion).

396

397 **4.1. Climate-related risk aversion**

398 When confronted with a treatment where harvesting levels depended on a climatic influence
399 in the second stage of the experiments, most participants in both countries (95% in Colombia
400 and about 83% in Mexico) decided to adopt an insurance against climatic risks, in the form of a
401 marine reserve. Such a scenario implies that fishers would be willing to change fishing practices
402 in order to secure a less risky flow of future income. These results suggest that information
403 on climatic variability inhibits common-pool resource over-exploitation. In this case, fishers
404 would adopt sustainable fishing practices, like lowering their extractions towards a social
405 optimum or implementing marine reserves before a climate change scenario, not necessarily
406 because of pro-environmental preferences, but in order to minimize their expected disutility.
407 This is a standard result as fishermen frequently are confronted with decision-making in the
408 presence of uncertainty (Smith and Wilen, 2005; Eggert and Lokina, 2007; Nguyen and Leung,
409 2009).

410 Adaptation to climate variability in fisheries could be helped by information on the risks of
411 climate change in fishing productivity and therefore in their future livelihoods. Furthermore,
412 adaptation actions could include the encouragement for implementing marine reserves among
413 coastal communities. In fact, Micheli et al. (2012) have demonstrated that marine reserves
414 enhance resilience under climatic variability, acting as an ecological insurance against climate
415 change. This is important because, to date, no specific actions or programs are aimed at
416 adapting the Mexican fishery sector to climate change impacts (Ibarra et al., 2013). Similar
417 situations can be found elsewhere in Latin America, including Colombia.

418

419 Now, as in the experiment, fishermen face certain types of uncertainty for decisions that ignore
420 other fishermen. For this reason, each participant had to privately decide whether she would
421 overharvest and how many additional units she would overharvest as it happens in usual
422 fisheries operations (Gelcich et al., 2013). Finally, as pointed out by Gelcich et al. (2013), an
423 additional source of uncertainty faced by each fisherman, both in the experiment and in the real
424 world, is due to the horizontal externality emerging from the extraction decisions of other
425 fishermen.

426

427 **4.2. Social preferences**

428 Apart from the subject's attitude towards the risk of climate change, social preferences are also
429 important in determining participants' behavior. Indeed, when managing common-pool
430 resources, such as fisheries, it is always useful to remind that the willingness to cooperate of one
431 agent will depend on the behavior of other agents (Keser and Van Winden, 2000). In fact,
432 Cardenas and Ostrom (2004) point out that the empirical evidence of experimental economics
433 on common-pool resources, show that groups who can effectively communicate (i.e.
434 possibility of cooperation), establish a set of social norms, reducing, consequently, over-
435 exploitation.

436

437 In our experiments, we found that participants presented a more sustainable behavior in
438 common-pool resources extraction after participating in the baseline treatment. This result can
439 be explained also by a certain degree of cooperation, trust, and reciprocity. According to Fehr
440 and Leibbrandt (2011), cooperation and low impatience are drivers for such a behavior.
441 Moreover, social preferences such as altruism and cooperation might enhance productivity

442 (Carpenter and Seki, 2011), but in contrast, competition may lead to lower cooperation
443 (Carpenter and Seki 2006; Stoop et al. 2010). In the experiment carried out in Natividad Island,
444 the fact that variables CATCHI (difference between social optimum harvest and the participant's
445 i actual harvest in the previous round. In other words, it measures the willingness to cooperate
446 of participant i) and CATCHJ (difference between social optimum harvest and the participant's j
447 actual harvest in the previous round. It measures the willingness to cooperate of the rest of
448 participants) were statistically significant, implies that cooperation was an important factor in
449 determining the harvesting levels. In this way, a participant conditioned her catch to the
450 harvesting level of the rest of the group.

451

452 Trust and reciprocity were, therefore, other important factors among participants' behavior. The
453 importance of trust has been highlighted by McAllister et al. (2011), who found that, under a
454 risky treatment, trust depended on reciprocity, that is to say, participants reckoned that it was
455 riskier not to reciprocate among trusting individuals than in a do-nothing treatment. Revollo and
456 Ibarra (2013) found in a common-pool resource lab experiment among Mexican students, that
457 players showed a certain degree of reciprocal punishment (i.e. higher harvesting levels) if
458 they noticed that the rest of the group did not cooperate on resource conservation. In fact,
459 Kraak (2011) reviewed the evidence that reciprocity is an important factor to fishermen in non-
460 anonymous treatments for more sustainable practices.

461

462 Important considerations for fisheries management can be drawn from our results, given the
463 fact that real-world stakeholders showed reciprocity and willingness to cooperate (Gowdy,
464 2008; Venkatachalam, 2008). Indeed, the success of external (i.e. governmental) regulations
465 depends on the existence of informal rules or local ecological knowledge among stakeholders.
466 For example, Velez et al. (2008) argue that external regulation should complement existing
467 informal regulations for fisheries management in Colombia. A similar result was found by Vollan
468 et al. (2013) for Namibian and South African rural herders. Such results suggest that co-
469 management regimes should be seriously considered for managing common-pool resources,
470 such as fisheries. Indeed, Moreno-Sanchez and Maldonado (2009) found that experiments under
471 a co-management treatment showed more sustainable harvesting levels in a marine protected
472 area off Colombia. In fact, co-management could offer effective sustainability results when

473 dealing with small-scale fisheries, as demonstrated by Defeo and Castilla (2005) for several Latin
474 American examples.

475

476 **4.3. Other factors**

477 Other factors explaining fisher's decisions on lowering their harvest after the baseline treatment
478 were income and religion in the Colombian experiment, and gender in both cases. First, income
479 is a standard result in experimental economics. Second, in the Tribugá Gulf study, although the
480 number of male participants outnumbered those of women (12%) the GENDER variable
481 was statistically significant. This result was also observed in Natividad Island, with a larger
482 percent of female participants (29%). Thus, women presented more sustainable catches than
483 men. Indeed, there is empirical evidence that women are more risk-averse in general (Eckel and
484 Grossman, 2008; Croson and Gneezy, 2009), and have more sustainable attitudes than men
485 (Davidson and Black, 2001; Agarwal, 2009; Revollo, 2012). And third, religion was statistically
486 significant for the Colombian experiment (this variable was not tested in the Mexican
487 experiment) explaining the decrease in harvesting levels. Few studies have demonstrated the
488 actual influence of a belief in decision-making towards the environment, but in general, these
489 show that it does have a positive influence (Chermak and Krause, 2002; Owen and Videras,
490 2007), although in other public-good experiments this relationship was not evident (Anderson
491 and Mellor, 2009).

492

493 **5. Conclusion**

494 We have studied the behavior of fishermen communities in a controlled experimental harvesting
495 environment of common-pool resources. The subjects were familiar with the decision-making
496 problem they faced in the experiment. Thus, their reactions to our treatment factors had
497 the expected sign. The vast majority would react to climate change through risk-reducing
498 mechanisms like a marine reserve or any sort of insurance. Also, depending on their social and
499 educational background, learning from past experience leads them to more sustainable
500 harvesting levels, avoiding common-pool resource depletion. Climate-related risk-aversion is an
501 idiosyncratic behavioral reaction to an external factor leading to lower catches or changes in
502 fishing practices (e.g. adopting marine reserves), provided that fishermen have information in
503 advance of possible climatic consequences.

504

505 We suggest that the results from both experiments support the conclusion that the behavior for
506 sustainable fishing is likely to be achieved, if and only if, control mechanisms are
507 established to encourage both fisheries management and improvement of life quality to
508 inhabitants in both studied areas. For example, as suggested by González, G., Díaz, Y. and
509 Puentes, V. (2015), the work done in Tribugá Gulf-Colombia reveals that regulation of less
510 selective fishing gear may be a possible alternative in the region, because the tendency is
511 towards a drastic reduction in fishing. Either way, the Exclusive Zone for Artisanal Fisheries in
512 the Tribugá Gulf, which is the result of a process of community and government participation,
513 shows that it is necessary to work on marketing chains for the fishermen for improving their
514 income and hence their quality of life. Furthermore, social preferences (e.g. cooperation and
515 reciprocity) also played an important role in determining a more sustainable attitude in
516 common-pool resources extraction. Other factors, such as income, gender and religion had also
517 some influence.

518

519 Additionally, it is important to note that in both countries, the results of the experiments were
520 complemented by a survey that sought to strengthen governance processes of local communities
521 for the collective construction of sustainable fishery agreements. In case of Colombia and Mexico,
522 we asked the fishermen if they agreed to implement an area of fisheries reserves, which could be
523 either an exclusive artisanal fishing zone, a closed area or an area where responsible fishing is
524 carried out. In other words, the question involves the possibilities for fishermen to establish
525 agreements for sustainable fisheries.

526

527 Finally, this paper presents empirical evidence on the economic behavior of fishermen and their
528 behavior on the management of common pool resources, in a context of uncertainty (climate
529 events). For this reason, the results of economic experiments applied to fishing groups in Mexico
530 and Colombia, concluded on the importance of the implementation of marine reserves. Thus, this
531 paper attempts to collaborate and complement the few studies in this field of experimental
532 economic methods and climatic phenomena that have developed in developing countries, such as
533 Latin America.

534

535

536

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Table I

Table I. Summary of field experiments with fisheries in Latin America

Fishery	Region of study	Main results	Reference
Artisanal fisheries, Clam fisheries, and Trout fishery	Caribbean, south Pacific, and Andean region, all in Colombia	Cooperation under a low regulation penalty, and free-riding under a high regulation penalty; opposition to externally imposed regulations	(Cardenas 2005)
Artisanal fisheries (lobster, conch, snapper) and crab hunting	Providencia Island, Colombia	Crab hunters were more willing to cooperate than fishers under tax and communication treatments.	(Castillo and Saysel 2005)
Artisanal fisheries	Baru Island, Colombia	High harvesting rate chosen with varying fish stock levels.	(Cardenas et al. 2008)
Artisanal fisheries	Caribbean coast, the Pacific coast and the Magdalena river (all in Colombia).	External regulation should complement existing informal regulations.	(Velez et al. 2008)
Fish or water extraction	Five villages in Colombia	Absence of enforcement conditioned the compliance of a regulation on the behavior of others.	(Rodriguez-Sickert et al. 2008)
Artisanal fisheries	Caribbean coast, Colombia.	Experiments under a co-management treatment showed more sustainable	(Moreno-Sanchez and Maldonado 2009)

Fishery	Region of study	Main results	Reference
		harvesting levels in a marine protected area.	
Artisanal fisheries	Caribbean coast, the Pacific coast and the Magdalena river (all in Colombia).	Altruism, conformity and reciprocity featured the harvesting decisions of fishers.	(Velez et al. 2009)

Table II

Table II. Scenarios shown to participants in the climatic change / marine reserves at Natividad Island, Baja, Mexico

Game stages	SCENARIOS			
First round (Baseline R:1-5)	Recovery rate (RR) = 50% (Nº = 37)			
Second round (Treatment) (R: 6-10)	Marine reserve implementation (Nº = 30)		No marine reserve implementation (Nº = 7)	
	Climatic variation	No climatic variation	Climatic variation	No climatic variation
	RR = 40%*	RR = 60%*	RR = 20%*	RR = 80%*

* The recovery rates were chosen according to the information of Guzmán del Proo et al. (2003) who found the changes in recruitment (presumably due to a higher level of hypoxia) for marine invertebrates before and after the 1997-1998 ENSO event at Bahía Tortugas, Baja peninsula, Mexico.

Table III

Table III. Variables introduced in the econometric model

Variable	Description	Expected sign
<i>Dependent</i>		
<i>CATCH</i>	Harvesting level of participant i in round t+1	
<i>Independent</i>		
<i>CATCHI</i>	Difference between social optimum harvest and the participant's i actual harvest in the previous round. It measures the willingness to cooperate of participant i.	(+,-)
<i>CATCHJ</i>	Difference between social optimum harvest and the participant's j actual harvest in the previous round. It measures the willingness to cooperate of the rest of participants.	(+,-)
<i>POINTS</i>	Difference in absolute value between the points of participant i and the rest of participants in the previous round. It measures the inequity aversion.	(+,-)
<i>CLIMATE</i>	Dichotomous variable for indicating whether (1) or not (0) a climatic event takes place in that round.	(-)
<i>TREAT</i>	Count variable for indicating the type of treatment: 1 for the baseline treatment, 2 for no marine reserve implemented, and 3 for marine reserve implemented.	(-)
<i>GENDER</i>	Dichotomous variable for indicating gender of participant: 1 for man and 0 for woman.	(+)
<i>FISH</i>	Dichotomous variable for indicating whether (1) or not (0) the participant is actually a fisher in real life.	(-)
<i>RESERVE</i>	Count variable for indicating the percent area that the participant would implement as marine reserve: 0-10%=1, 11-20%=2, 21-30%=3, 31-40%=4, 41-50%=5, 51-60%=6, 61-70%=7, 71-80%=8, 81-90%=9, 91-100%=10.	(-)

Table IV

Table IV. Econometric estimations for explaining the individual harvesting decisions (*CATCH*) of participants in the Natividad Island experiment

	Coefficient	Std. Err.	p > Z 	
<i>CATCHI</i>	0.528	0.078	0.000	*
<i>CATCHJ</i>	0.481	0.259	0.064	*
<i>POINTS</i>	-0.001	0.001	0.377	
<i>GENDER</i>	0.701	2.03	0.043	*
<i>TREAT</i>	-0.223	0.314	0.077	*
<i>CLIMATE</i>	-0.241	0.446	0.091	*
<i>RESERVE</i>	-0.159	0.126	0.205	
<i>FISH</i>	-0.355	0.375	0.344	
<i>CONSTANT</i>	1.917	1.466	0.191	

* p < 0.10
 R-squared = 0.458
 Wald chi2(8) = 146.68
 Prob > chi2 = 0.0000
 N = 333

Table V

Table V. Variables introduced in the econometric model

Variable	Description	Expected sign
<i>Dependent</i>		
<i>CATCH</i>	Harvesting level of participant i in round t+1	
<i>Independent</i>		
<i>EXPER</i>	Continuous variable reflecting individual behavior based on years of fishing	(+)
<i>CIVIL</i>	Categorical variable indicating civil status of participant: 1 for free-union, 2 for married, 3 for single, 4 for divorced	(+,-)
<i>INCOME</i>	Monthly income from fishing activities	(+)
<i>SCHOOL</i>	Continuous variable indicating years of formal education	(-)
<i>RELIGION</i>	Categorical variable indicating religion: 1 for Catholic, 2 for Christian Evangelical or Pentecostal, 3 for agnostic	(+,-)
<i>GENDER</i>	Dichotomous variable for indicating gender of participant: 1 for man and 0 for woman.	(+)
<i>CLIMATE</i>	Dichotomous variable for indicating whether (1) or not (0) a climatic event takes place in that round	(-)

Table VI

Table VI. Econometric estimations for explaining the individual harvesting decisions (CATCH) of participants in the Tribugá Gulf experiment

	Coefficient	Std. Err.	p > Z
<i>EXPER</i>	0.0041	0.00127	0.074 *
<i>SCHOOL</i>	-0.2382	0.01844	0.000 *
<i>INCOME</i>	0.0568	0.01589	0.000 *
<i>AGE</i>	0.0004	0.00131	0.720
<i>CIVIL</i>	0.1206	0.02366	0.000 *
<i>RELIGION</i>	0.4195	0.0542	0.000 *
<i>GENDER</i>	0.4212	0.05390	0.000 *
<i>CLIMATE</i>	-0.07953	0.08907	0.000 *

* p < 0.10
 R-squared = 0.445
 Prob > chi2 = 0.000
 N = 1500

A.1.1. Baseline: Recovery Rate = 50% - Rounds 1-5

TABLE OF POINTS (PROFIT EXTRACTION + CONSERVATION)										
My level of extraction										
	1	2	3	4	5	6	7	8	9	10
0	1,593	1,685	1,778	1,870	1,963	2,055	2,148	2,240	2,333	2,425
1	1,585	1,678	1,770	1,863	1,955	2,048	2,140	2,233	2,325	2,418
2	1,578	1,670	1,763	1,855	1,948	2,040	2,133	2,225	2,318	2,410
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
50	1,218	1,310	1,403	1,495	1,588	1,680	1,773	1,865	1,958	2,050
51	1,210	1,303	1,395	1,488	1,580	1,673	1,765	1,858	1,950	2,043
52	1,203	1,295	1,388	1,480	1,573	1,665	1,758	1,850	1,943	2,035
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
100	843	935	1,028	1,120	1,213	1,305	1,398	1,490	1,583	1,675
101	835	928	1,020	1,113	1,205	1,298	1,390	1,483	1,575	1,668
102	828	920	1,013	1,105	1,198	1,290	1,383	1,475	1,568	1,660
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
189	175	268	360	453	545	638	730	823	915	1,008
190	168	260	353	445	538	630	723	815	908	1,000

The level of extraction of them

A.1.2.1. Marine Reserve: Recovery Rate = 40% - Rounds 6-10

TABLE OF POINTS (PROFIT EXTRACTION + CONSERVATION)											
My level of extraction											
	1	2	3	4	5	6	7	8	9	10	
The level of extraction of them	0	1,493	1,586	1,679	1,772	1,865	1,958	2,051	2,144	2,237	2,330
	1	1,486	1,579	1,672	1,765	1,858	1,951	2,044	2,137	2,230	2,323
	2	1,479	1,572	1,665	1,758	1,851	1,944	2,037	2,130	2,223	2,316
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	50	1,143	1,236	1,329	1,422	1,515	1,608	1,701	1,794	1,887	1,980
	51	1,136	1,229	1,322	1,415	1,508	1,601	1,694	1,787	1,880	1,973
	52	1,129	1,222	1,315	1,408	1,501	1,594	1,687	1,780	1,873	1,966
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	100	793	886	979	1,072	1,165	1,258	1,351	1,444	1,537	1,630
	101	786	879	972	1,065	1,158	1,251	1,344	1,437	1,530	1,623
	102	779	872	965	1,058	1,151	1,244	1,337	1,430	1,523	1,616
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	189	170	263	356	449	542	635	728	821	914	1,007
	190	163	256	349	442	535	628	721	814	907	1,000

A.1.2.2. Marine Reserve: Recovery Rate = 60% - Rounds 6-10

TABLE OF POINTS (PROFIT EXTRACTION + CONSERVATION)											
My level of extraction											
	1	2	3	4	5	6	7	8	9	10	
The level of extraction of them	0	1,692	1,784	1,876	1,968	2,060	2,152	2,244	2,336	2,428	2,520
	1	1,684	1,776	1,868	1,960	2,052	2,144	2,236	2,328	2,420	2,512
	2	1,676	1,768	1,860	1,952	2,044	2,136	2,228	2,320	2,412	2,504
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	50	1,292	1,384	1,476	1,568	1,660	1,752	1,844	1,936	2,028	2,120
	51	1,284	1,376	1,468	1,560	1,652	1,744	1,836	1,928	2,020	2,112
	52	1,276	1,368	1,460	1,552	1,644	1,736	1,828	1,920	2,012	2,104
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	100	892	984	1,076	1,168	1,260	1,352	1,444	1,536	1,628	1,720
	101	884	976	1,068	1,160	1,252	1,344	1,436	1,528	1,620	1,712
	102	876	968	1,060	1,152	1,244	1,336	1,428	1,520	1,612	1,704
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	189	180	272	364	456	548	640	732	824	916	1,008
	190	172	264	356	448	540	632	724	816	908	1,000

A.1.2.3. No Marine Reserve: Recovery Rate = 20% - Rounds 6-10

TABLE OF POINTS (PROFIT EXTRACTION + CONSERVATION)											
My level of extraction											
	1	2	3	4	5	6	7	8	9	10	
The level of extraction of them	0	1,294	1,388	1,482	1,576	1,670	1,764	1,858	1,952	2,046	2,140
	1	1,288	1,382	1,476	1,570	1,664	1,758	1,852	1,946	2,040	2,134
	2	1,282	1,376	1,470	1,564	1,658	1,752	1,846	1,940	2,034	2,128
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	50	994	1,088	1,182	1,276	1,370	1,464	1,558	1,652	1,746	1,840
	51	988	1,082	1,176	1,270	1,364	1,458	1,552	1,646	1,740	1,834
	52	982	1,076	1,170	1,264	1,358	1,452	1,546	1,640	1,734	1,828
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	100	694	788	882	976	1,070	1,164	1,258	1,352	1,446	1,540
	101	688	782	876	970	1,064	1,158	1,252	1,346	1,440	1,534
	102	682	776	870	964	1,058	1,152	1,246	1,340	1,434	1,528
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	189	160	254	348	442	536	630	724	818	912	1,006
	190	154	248	342	436	530	624	718	812	906	1,000

A.2. Individual Decision Sheet (Baseline and Treatments): Rounds 1-10

Rounds	My nevel the extraction	The level of extraction of them	Score
Practice 1			
Practice 2			
Practice 3			
1			
2			
3			
:			
10			
Total			

Appendix B1

B.1. Individual Score Table

Aggregated amount of other participants	My own amount of yield							
	1	2	3	4	5	6	7	8
4	758	790	818	840	858	870	878	880
5	738	770	798	820	838	850	858	860
6	718	750	778	800	818	830	838	840
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
10	638	670	698	720	738	750	758	760
11	618	650	678	700	718	730	738	740
12	598	630	658	680	698	710	718	720
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
20	438	470	498	520	538	550	558	560
21	418	450	478	500	518	530	538	540
22	398	430	458	480	498	510	518	520
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
30	238	270	298	320	338	350	358	360
31	218	250	278	300	318	330	338	340
32	198	230	258	280	298	310	318	320

Appendix B2

B.2. Individual Decision Sheet - Baseline: Rounds 1-10

Rounds	A: Individual Amount of Yield	B: Aggregated Amount of Yield of Group	C (B-A): Aggregated Amount of Yield from other participants	D: Score
Practice 1				
Practice 2				
Practice 3				
1				
2				
3				
⋮				
10				
Total				

B.3.1. Internal Regulation

Rounds	Vote for regulation*		A: Individual Amount of Yield	B: Aggregated Amount of Yield of Group	C (B-A): Aggregated Amount of Yield from other participants	D: Score	E: Regulation Fine	F (D-E): Final Score	Fishing under unexpected conditions	
11	Y	N							Y	N
12	Y	N							Y	N
13	Y	N							Y	N
:										
20	Y	N							Y	N

* The regulation applies only when the majority votes YES in the group; i.e. if there are at least 3 for YES votes, regulation is applied.

B.3.2. Random Regulation

Round	A: Individual Amount of Yield	B: Aggregate Amount of Yield of Group	C (B-A): Aggregated Amount of Yield from other participants	D: Score	E: Regulation Fine	F (D-E): Final Score	Fishing under unexpected conditions
11							Y N
12							Y N
13							Y N
:							
20							Y N

A.1.2.4. No Marine Reserve: Recovery Rate = 80% - Rounds 6-10

		TABLE OF POINTS (PROFIT EXTRACTION + CONSERVATION)									
		My level of extraction									
		1	2	3	4	5	6	7	8	9	10
The level of extraction of them	0	1,891	1,982	2,073	2,164	2,255	2,346	2,437	2,528	2,619	2,710
	1	1,882	1,973	2,064	2,155	2,246	2,337	2,428	2,519	2,610	2,701
	2	1,873	1,964	2,055	2,146	2,237	2,328	2,419	2,510	2,601	2,692
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	50	1,441	1,532	1,623	1,714	1,805	1,896	1,987	2,078	2,169	2,260
	51	1,432	1,523	1,614	1,705	1,796	1,887	1,978	2,069	2,160	2,251
	52	1,423	1,514	1,605	1,696	1,787	1,878	1,969	2,060	2,151	2,242
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	100	991	1,082	1,173	1,264	1,355	1,446	1,537	1,628	1,719	1,810
	101	982	1,073	1,164	1,255	1,346	1,437	1,528	1,619	1,710	1,801
	102	973	1,064	1,155	1,246	1,337	1,428	1,519	1,610	1,701	1,792
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮	⋮
	189	190	281	372	463	554	645	736	827	918	1,009
	190	181	272	363	454	545	636	727	818	909	1,000

Figure 1
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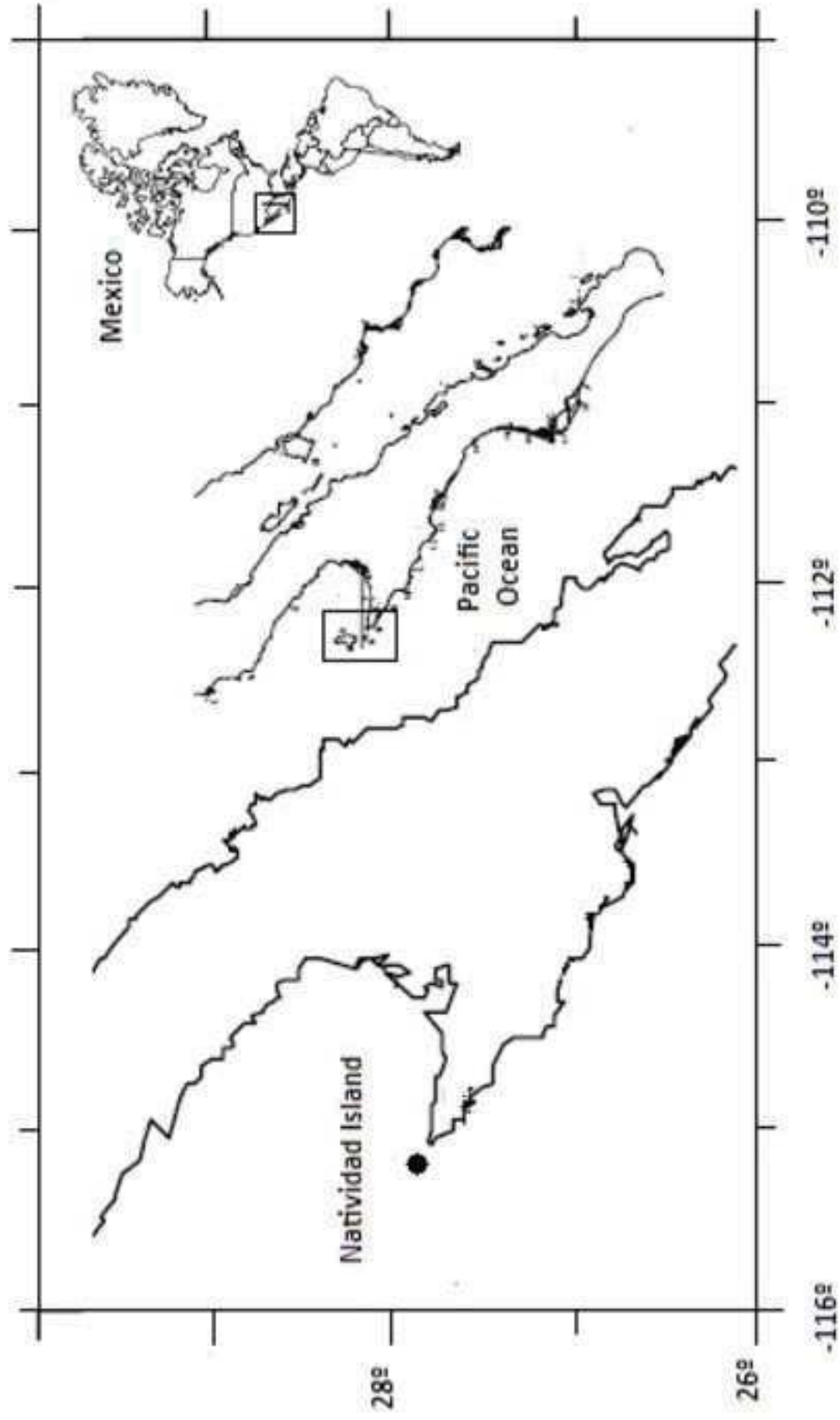


Figure 2
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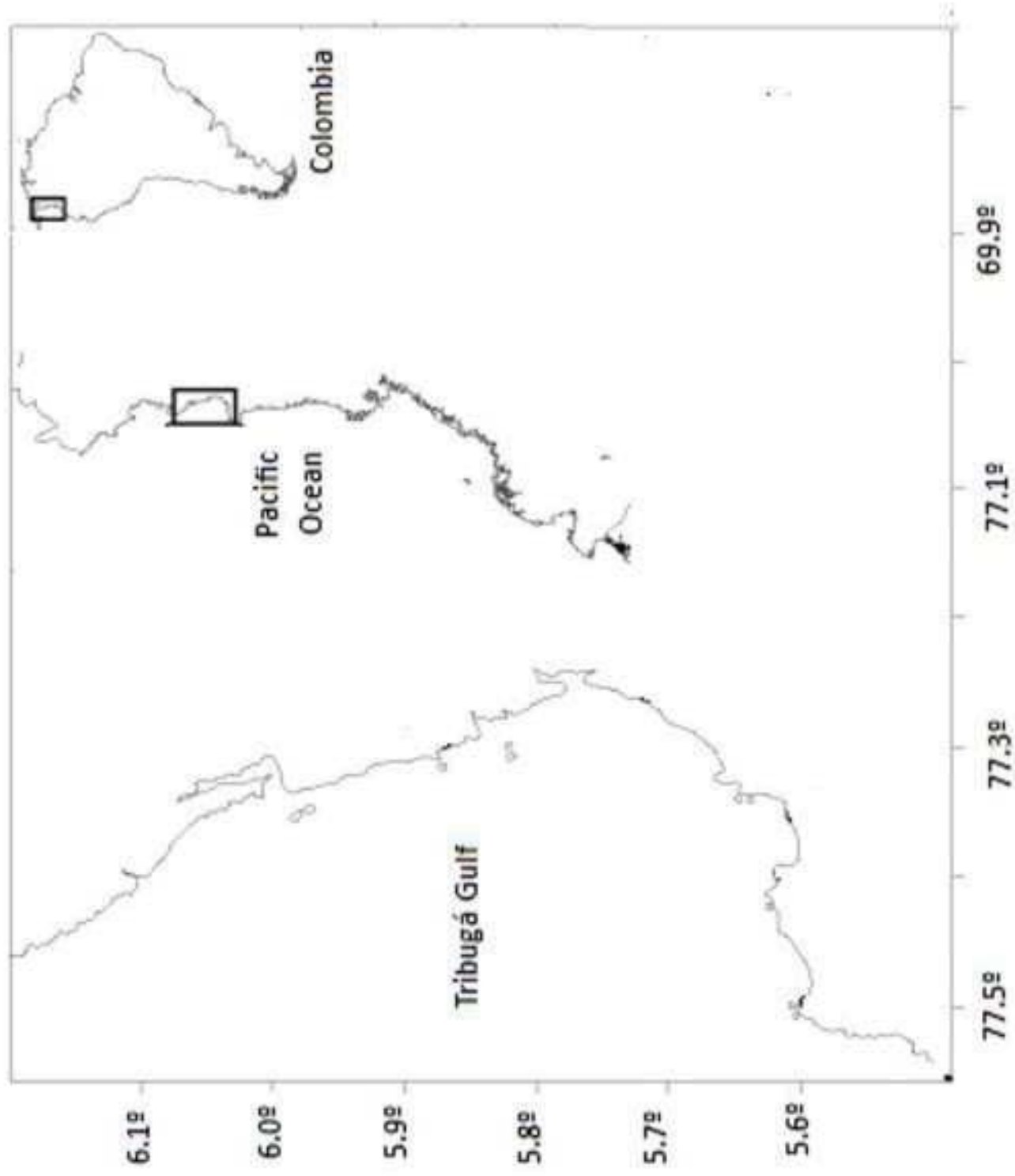


Figure 3
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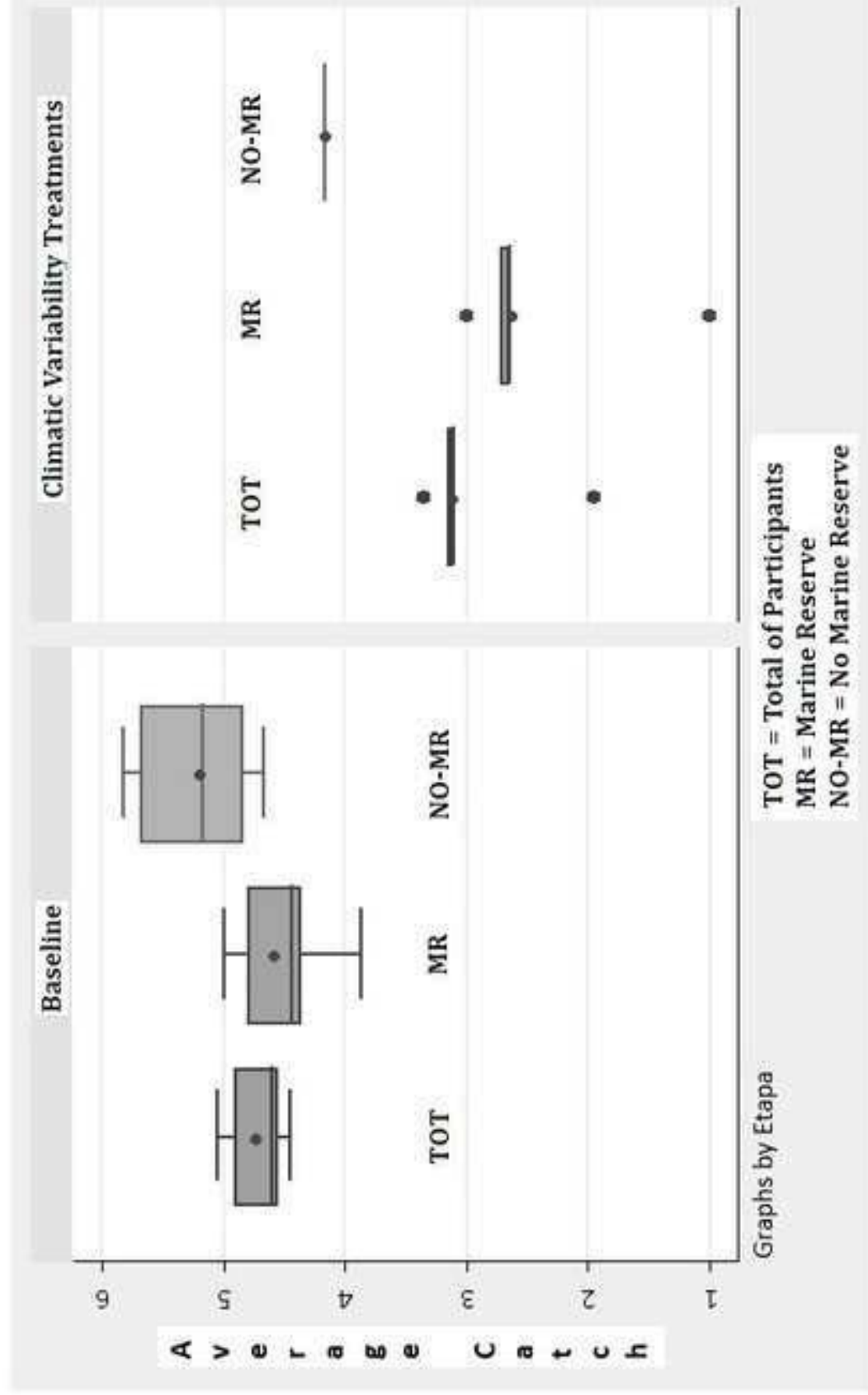


Figure 4
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