# Avoiding catastrophic collapse in small-scale fisheries through inefficient cooperation: evidence from a framed field experiment

Therese Lindahl[1,2*] and Rawadee Jarungrattanapong[3]

[1]The Beijer Institute of Ecological Economics, The Royal Swedish Academy of Sciences, Stockholm, Sweden, [2] Stockholm Resilience Centre, Stockholm University, Stockholm, Sweden and [3] Sukhothai Thammathirat Open University, School of Economics, Nonthaburi, Thailand

*Corresponding author. E-email: therese.lindahl@beijer.kva.se

# ONLINE APPENDIX

## PROOFS

### Proposition 1

Assume the following strategy for each player $i \in 1,2,3,4$:

*a)* In the first period, $(t = 0)$, take (*50-X*)/4 units of the resource (to reach a stock size of *X*) and then from the second period and onwards, $t \in [1, \infty]$, take $H_X/4$ units, where $H_X$ denotes the sustainable yield to keep the stock size at *X* (i.e., the regrowth at stock size X),

*b)* If in some period *t*, someone deviates from this strategy profile (i.e., the new stock size is not *X*), then deplete the resource in the next period (*t+1)*, i.e., claim the entire remaining stock size.

Note that the maximum possible amount to claim in a specific period is the current resource stock size in that same period. Also note that in case of depletion each player gets a payoff which corresponds to his/her percentage of the sum of all claims that period (see experimental procedure). Hence, for a deviating player, the optimal deviation is to deplete the resource in period *t*.

Let $\delta_{it}$ denote the expected discounted value of 1 unit harvested, capturing the subjective probability of player *i* (in period *t*) that the game will continue for one more period. Please note that this subjective probability may change over time. Equation (A1) shows then the total payoff (in Baht), for player *i* who follows the strategy above for the entire game, given that all other players do so as well. The first term refers to the payoff in the first period (period 0) and the second term the sum of the continuation payoffs in all subsequent periods.

$$P_C = 20\left(\frac{50-X}{4} + \sum_{\tau=1}^{\infty} \delta_{it}^{\tau} \frac{H_X}{4}\right) \quad \text{(A1)}$$

Equation (A2) gives the payoff of a player *i* (in Baht) who deviates in a particular period *t* when all other players play according to the strategy profile which sustains the stock size *X*, $h_{it}$ represents the claimed harvest of the deviating player *i* in that period.

$$P_D = 20\left(\frac{X^2}{X+H_X-h_{it}}\right) \quad \text{(A2)}$$

where $h_{it} \leq X$.

From these two equations (A1)-(A2) we can derive the necessary conditions for the outcome (a stock size of *X*) to be sustained as an equilibrium outcome. In the very first period (period 0), the stock size *X* can be sustained as an equilibrium outcome if the payoff from following the cooperating strategy (equation (A1)) is bigger than the payoff from deviating (equation (A2)), i.e., if equation (A3) holds:

for all $i \in 1,2,3,4$

$$\frac{50-X}{4} + \sum_{\tau=1}^{\infty} \delta_{i1}^{\tau} \frac{H_X}{4} \geq \frac{50^2}{50+\frac{50-X}{4}(4-1)} \quad \Leftrightarrow$$

$$\frac{1}{1-\delta_{i1}} 4 \frac{H_X}{4} \geq \frac{50^2 4}{50+\frac{50-X}{4}(4-1)} - \left(50 - X - 4\frac{H_X}{4}\right) \Leftrightarrow$$

$$\frac{\left((100-X)4-(50-X)\right) H_X}{50^2 4^2-\left((100-X)4-(50-X)\right)(50-X-H_X)} \geq 1 - \delta_{i1} \Leftrightarrow$$

$$\delta_{i1} \geq \frac{50^2 4^2-\left((100-X)4-(50-X)\right)(50-X)}{50^2 4^2-\left((100-X)4-(50-X)\right)(50-X-H_X)} \ . \qquad \text{(A3)}$$

In the subsequent periods, because each period is a proper subgame, we need to check that the continuation payoff at time *t* is larger than the deviation payoff. Thus, in each period $t \in [1, \infty]$, the following needs to hold:

for all $i \in 1,2,3,4$

$$\sum_{\tau=1}^{\infty} \delta_{it}^{\tau} \frac{H_X}{4} \geq \frac{(X+H_X)^2}{X + H_X + \frac{H_X(4-1)}{4}} \quad \Leftrightarrow$$

$$\frac{1}{1-\delta_{it}} \geq \frac{(X+H_X)^2 4^2}{\left((X+H_X)4 + H_X(4-1)\right)H_X} \Leftrightarrow$$

$$\frac{\left((X+H_X)4 + H_X(4-1)\right)H_X}{(X+H_X)^2 4^2} \geq 1 - \delta_{it} \Leftrightarrow$$

$$\delta_{it} \geq \frac{(X+H_X)^2 4^2-\left((X+2H_X)4-H_X\right)H_X}{(X+H_X)^2 4^2} \ . \qquad \text{(A4)}$$

In table A3 we present the critical discount factors from equations (A3) and (A4) for all stock sizes for our two treatments.

**Proposition 2**

To prove proposition 2 we also need to make some assumptions about the distribution of the discount factors of the players in the game. We denote this distribution $F(\delta i)$. We need to assume, for example, that the range of the critical values for the discount factors, which is in the range between 0.907 and 0.995, is a subset of the range of $F(\delta i)$. Moreover, the distribution $F(\delta i)$ is independent of treatment. Whereas the latter assumption is relatively straightforward, the former may need some elaboration. If the first assumption does not hold, i.e., if the discount factors of all players are below (above) the range of critical values then no (all) equilibrium(s) can be sustained in the game and we would not see a distinction between the two treatments.

**Tables for proofs**

**Table A1.** Regeneration rate for the no regime shift (NRS) treatment and the regime shift (RS) treatment

| Stock size | Growth NRS | Growth RS | Stock size | Growth NRS | Growth RS | Stock size | Growth NRS | Growth RS |
|---|---|---|---|---|---|---|---|---|
| 50 | 0 | 0 | 32 | 10 | 10 | 14 | 5 | 1 |
| 49 | 0 | 0 | 31 | 10 | 10 | 13 | 5 | 1 |
| 48 | 0 | 0 | 30 | 10 | 10 | 12 | 5 | 1 |
| 47 | 0 | 0 | 29 | 10 | 10 | 11 | 5 | 1 |
| 46 | 0 | 0 | 28 | 10 | 10 | 10 | 5 | 1 |
| 45 | 5 | 5 | 27 | 10 | 10 | 9 | 5 | 1 |
| 44 | 5 | 5 | 26 | 10 | 10 | 8 | 5 | 1 |
| 43 | 5 | 5 | 25 | 10 | 10 | 7 | 5 | 1 |
| 42 | 5 | 5 | 24 | 10 | 10 | 6 | 5 | 1 |
| 41 | 5 | 5 | 23 | 10 | 10 | 5 | 5 | 1 |
| 40 | 5 | 5 | 22 | 10 | 10 | 4 | 0 | 0 |
| 39 | 5 | 5 | 21 | 10 | 10 | 3 | 0 | 0 |
| 38 | 5 | 5 | 20 | 10 | 10 | 2 | 0 | 0 |
| 37 | 5 | 5 | 19 | 5 | 1 | 1 | 0 | 0 |
| 36 | 5 | 5 | 18 | 5 | 1 | 0 | 0 | 0 |
| 35 | 5 | 5 | 17 | 5 | 1 | | | |
| 34 | 10 | 10 | 16 | 5 | 1 | | | |
| 33 | 10 | 10 | 15 | 5 | 1 | | | |

**Table A2.** Optimal claims for the no regime shift treatment and the regime shift treatment

| No regime shift | | | | Regime shift | | | |
|---|---|---|---|---|---|---|---|
| Stock size | Optimal claim | # rounds until 30 (R) | Harvest during R | Stock size | Optimal claim | # rounds until 30 (R) | Harvest during R |
| 50 | 30 | 1 | 30 | 50 | 30 | 1 | 30 |
| 49 | 29 | 1 | 29 | 49 | 29 | 1 | 29 |
| 48 | 28 | 1 | 28 | 48 | 28 | 1 | 28 |
| 47 | 27 | 1 | 27 | 47 | 27 | 1 | 27 |
| 46 | 26 | 1 | 26 | 46 | 26 | 1 | 26 |
| 45 | 25 | 1 | 25 | 45 | 25 | 1 | 25 |
| 44 | 24 | 1 | 24 | 44 | 24 | 1 | 24 |
| 43 | 23 | 1 | 23 | 43 | 23 | 1 | 23 |
| 42 | 22 | 1 | 22 | 42 | 22 | 1 | 22 |
| 41 | 21 | 1 | 21 | 41 | 21 | 1 | 21 |
| 40 | 20 | 1 | 20 | 40 | 20 | 1 | 20 |
| 39 | 19 | 1 | 19 | 39 | 19 | 1 | 19 |
| 38 | 18 | 1 | 18 | 38 | 18 | 1 | 18 |
| 37 | 17 | 1 | 17 | 37 | 17 | 1 | 17 |
| 36 | 16 | 1 | 16 | 36 | 16 | 1 | 16 |
| 35 | 15 | 1 | 15 | 35 | 15 | 1 | 15 |
| 34 | 14 | 1 | 14 | 34 | 14 | 1 | 14 |
| 33 | 13 | 1 | 13 | 33 | 13 | 1 | 13 |
| 32 | 12 | 1 | 12 | 32 | 12 | 1 | 12 |
| 31 | 11 | 1 | 11 | 31 | 11 | 1 | 11 |
| 30 | 10 | 1 | 10 | 30 | 10 | 1 | 10 |
| 29 | 9 | 1 | 9 | 29 | 9 | 1 | 9 |
| 28 | 8 | 1 | 8 | 28 | 8 | 1 | 8 |
| 27 | 7 | 1 | 7 | 27 | 7 | 1 | 7 |
| 26 | 6 | 1 | 6 | 26 | 6 | 1 | 6 |
| 25 | 5 | 1 | 5 | 25 | 5 | 1 | 5 |
| 24 | 4 | 1 | 4 | 24 | 4 | 1 | 4 |
| 23 | 3 | 1 | 3 | 23 | 3 | 1 | 3 |
| 22 | 2 | 1 | 2 | 22 | 2 | 1 | 2 |
| 21 | 1 | 1 | 1 | 21 | 1 | 1 | 1 |
| 20 | 0 | 1 | 0 | 20 | 0 | 1 | 0 |
| 19 | 4 | 2 | 4 | 19 | 0 | 2 | 0 |
| 18 | 3 | 2 | 3 | 18 | 0 | 3 | 0 |
| 17 | 2 | 2 | 2 | 17 | 0 | 4 | 0 |
| 16 | 1 | 2 | 1 | 16 | 0 | 5 | 0 |
| 15 | 0 | 2 | 0 | 15 | 0 | 6 | 0 |
| 14 | 4 | 3 | 4 | 14 | 0 | 7 | 0 |
| 13 | 3 | 3 | 3 | 13 | 0 | 8 | 0 |
| 12 | 2 | 3 | 2 | 12 | 0 | 9 | 0 |
| 11 | 1 | 3 | 1 | 11 | 0 | 10 | 0 |
| 10 | 0 | 3 | 0 | 10 | 0 | 11 | 0 |
| 9 | 4 | 4 | 4 | 9 | 0 | 12 | 0 |
| 8 | 3 | 4 | 3 | 8 | 0 | 13 | 0 |
| 7 | 2 | 4 | 2 | 7 | 0 | 14 | 0 |
| 6 | 1 | 4 | 1 | 6 | 0 | 15 | 0 |
| 5 | 0 | 4 | 0 | 5 | 0 | 16 | 0 |
| 4 | 4 | | | 4 | 4 | | |
| 3 | 3 | | | 3 | 3 | | |
| 2 | 2 | | | 2 | 2 | | |
| 1 | 1 | | | 1 | 1 | | |

**Table A3.** Critical discount factors for the no regime shift (NRS) treatment and the regime shift (RS) treatment

| Stock size | Critical discount factor, first round, NRS | Critical discount factor, first round, RS | Critical discount factor, continuation periods, NRS | Critical discount factor, continuation periods, NRS |
|---|---|---|---|---|
| 50 | 1 | 1 | 1 | 1 |
| 49 | 1 | 1 | 1 | 1 |
| 48 | 1 | 1 | 1 | 1 |
| 47 | 1 | 1 | 1 | 1 |
| 46 | 1 | 1 | 1 | 1 |
| 45 | 1 | 1 | 1 | 1 |
| 44 | 0.972601 | 0.972601 | 0.972537 | 0.972537 |
| 43 | 0.972066 | 0.972066 | 0.971924 | 0.971924 |
| 42 | 0.971522 | 0.971522 | 0.971282 | 0.971282 |
| 41 | 0.970966 | 0.970966 | 0.970611 | 0.970611 |
| 40 | 0.970399 | 0.970399 | 0.969907 | 0.969907 |
| 39 | 0.96982 | 0.96982 | 0.969170 | 0.969170 |
| 38 | 0.969229 | 0.969229 | 0.968395 | 0.968395 |
| 37 | 0.968625 | 0.968625 | 0.967581 | 0.967581 |
| 36 | 0.968008 | 0.968008 | 0.966724 | 0.966724 |
| 35 | 0.967377 | 0.967377 | 0.965820 | 0.965820 |
| 34 | 0.935604 | 0.935604 | 0.933497 | 0.933497 |
| 33 | 0.934367 | 0.934367 | 0.931720 | 0.931720 |
| 32 | 0.933102 | 0.933102 | 0.929847 | 0.929847 |
| 31 | 0.931807 | 0.931807 | 0.927870 | 0.927870 |
| 30 | 0.930481 | 0.930481 | 0.925781 | 0.925781 |
| 29 | 0.929124 | 0.929124 | 0.923570 | 0.923570 |
| 28 | 0.927733 | 0.927733 | 0.921226 | 0.921226 |
| 27 | 0.926307 | 0.926307 | 0.918736 | 0.918736 |
| 26 | 0.924845 | 0.924845 | 0.916088 | 0.916088 |
| 25 | 0.923345 | 0.923345 | 0.913265 | 0.913265 |
| 24 | 0.921805 | 0.921805 | 0.910251 | 0.910251 |
| 23 | 0.920223 | 0.920223 | 0.907025 | 0.907025 |
| 22 | 0.918597 | 0.918597 | 0.903564 | 0.903564 |
| 21 | 0.916925 | 0.916925 | 0.899844 | 0.899844 |
| 20 | 0.915205 | 0.915205 | 0.895833 | 0.895833 |
| 19 | 0.954759 | 0.990612 | 0.939779 | 0.987031 |
| 18 | 0.953762 | 0.990397 | 0.936791 | 0.986323 |
| 17 | 0.952732 | 0.990175 | 0.933497 | 0.985532 |
| 16 | 0.951668 | 0.989945 | 0.929847 | 0.984645 |
| 15 | 0.950567 | 0.989706 | 0.925781 | 0.983643 |
| 14 | 0.949429 | 0.989459 | 0.921226 | 0.982500 |
| 13 | 0.948249 | 0.989203 | 0.916088 | 0.981186 |
| 12 | 0.947027 | 0.988937 | 0.910251 | 0.979660 |
| 11 | 0.94576 | 0.98866 | 0.903564 | 0.977865 |

| | | | | |
|---|---|---|---|---|
| 10 | 0.944444 | 0.988372 | 0.895833 | 0.975723 |
| 9 | 0.943078 | 0.988072 | 0.886798 | 0.973125 |
| 8 | 0.941657 | 0.98776 | 0.876109 | 0.969907 |
| 7 | 0.940177 | 0.987434 | 0.863281 | 0.965820 |
| 6 | 0.938637 | 0.987094 | 0.847624 | 0.960459 |
| 5 | 0.93703 | 0.986738 | 0.828125 | 0.953125 |
| 4 | 1 | 1 | 1 | 1 |
| 3 | 1 | 1 | 1 | 1 |
| 2 | 1 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 0 | 1 | 1 | 1 | 1 |

## INSTRUCTIONS (no regime shift)

Normal text: read out loud the participants
*Italics: Things you should do*

Welcome and thank you for coming and participating in this activity!

It will take approximately 2 hours of your time.

During this activity we will play a game. After the game we would also like you to stay for some short interviews.

In this game you will be asked to take some decisions. You will receive 200 Baht for your participation in this activity. Depending on the decisions you make in the game. you can earn extra money. You will receive the money after the experiment (paid in private).

Why do we use money? We do not expect that the money you earn is a payment for taking part in the activity. nor the reason for you to be here. We use money because the exercise requires that you make some economic decisions that have consequences. It is to make the game realistic.

Before we start we want you to sign a consent form. The consent form says you are here voluntarily. It also informs you that the decisions that you take today will be anonymous. It will not be known to the other participants. Also when we analyze the results we will use numbers and color coding to identify you.

You will now be divided into groups of 4 people and thereafter we will explain the procedure more in detail.

### Group division

*Make group division. Each subject randomly picks a note which tells which group (color assigned) he will be assigned to and which number (1-4) he will be identified in that group (1-4). So for example if we have three groups playing at the same time we could have something like Blue (1.2.3.4); Green (1.2.3.4) and Brown (1.2.3.4)*

*Think about how to deal with people from the same family (e.g. siblings. cousins) or close friends. Avoid putting in the same group if possible.*

**Explain common access to a fishing water (e.g., the sea)**

In this game. we want you to imagine that you in this group have common access to a fishing ground (e.g., the sea).

*Place the fish on the table. represented by the 'fake fish'*

Although in reality it is impossible to know exactly how much fish there is in the sea. in this game we ask you to pretend that we can know how much fish there is.

Each of you can catch this fish from this common resource.

**Explaining the game. catch. procedure etc**

The game we will play lasts several rounds and in each round you take an individual and anonymous decision of how much fish to catch in that particular round.

For each fish you catch you get 20 Baht. So for example if you catch 20 fish you will earn 20*20 = 400 Baht.

So how do we keep track of you catch?

*Introduce the records. Explain the procedure.*

*Show the decision protocol (which should be foldable to ensure anonymity)*
In each round/period you mark how much fish you want to catch (the assistants are here to help you with this if you need). You can choose a number between 0 and the current number of fish available (that is in the pool). These protocols will be collected by the assistants after each decision round. The assistants will give them to the experimental leader after each decision round.

*Make sure that decisions are anonymous by for example using dividers or let them sit with their back towards each other's back.*

The experimenter leader will in each round sum up the fish catch of the whole group. He/she will calculate the new stock size. You will get this information from the assistants (plus total catch in each round and earnings) on your protocol.

**Explain that the resource is dynamic and grows**

Now we will explain how the fish grows. which will be indicated by these symbols. *Show with the symbols*

The fish reproduce/grows between each new round. How much the fish stock grows depends on how many fish your group left in the previous round. We start with 50 fish in the first round. After the catch. if there is 46-50 fish left the stock does not grow. If there is 35-45 fish in the stock (big pool/pond/stock). there will be 5 more fish in the next round
*Show with the magnets on the board how the stock grows from the biggest stock sizes.*

If there is so much fish in the sea as in this "hypothetical" case– they may compete for food and have a hard time of finding each other to reproduce with the result that the fish stock does not grow so much.

If there is 20-34 fish in the stock (middle pool/pond/stock). there will be 10 more fish in the next round.

*Show with the magnets on the board how the stock grows from the middle stock.*
Here there is enough fish so that they can find mating partners and not too much so they compete for food.

If there is 5-19 fish in the stock (small pool/pond/stock). there will be 5 more fish in the next round.
*Show with the magnets on the board how the stock grows from the small stock.*
*Reference to fish site: if there is too little fish they don't find enough partners and cannot reproduce.*

For stock sizes below 5. the fish stock doesn't grow at all.

As long as there is fish to catch. the game continues for a number of rounds and you can earn money. We will not tell you the exact number of rounds. If there is no fish the game ends and you will not earn any more money.

*If someone asks about how to share a harvest that is larger than the stock. answer: we will share proportionally according to your catch claim.*

**Examples**
There are 50 fish in the beginning of the experiment. If you. for example. catch together 20 fish (for example 3+4+6+7) there are 30 fish left and the stock will then grow with 10 more fish. Then the fish stock will consist of (50-20+10) = 40 fish in round 2.

So now there is 40 fish. If you then catch 25 fish in total (10+5+5+5) there are 15 fish left and the stock will then grow with 5 more fish. Then the fish stock will consist of (40-25+5) = 21 fish in round 3.

*Use the material (wooden fish and fish symbols when going through this example)*

**Communication?**

What can you talk about?
You should not show the catch decision on balance sheet or the protocol to the other people in your group *(point to the balance sheet and protocol again)*.

However. you can talk to each other. You can talk about the game. the rules and your decisions but you cannot make any threats or arrangements for side-payments during or after this activity.

In case you have any questions just ask any of the assistants
Summary:

- The four of you share this fishing ground
- In each round you will take an individual decision of how many fish to catch
- As long as there is fish left the game continues (until the experimenter leader stops)
- The fish recovery depends on how much fish there is (point to magnets)
- Each fish is worth 20 Baht.
- We do not tell you how many rounds we will play.

***Do practice rounds***

*During the practice round(s). they do not earn money. We do not reveal who took what. only that "someone took" We calculate the total catch openly. growth and the new fish stock. Illustrating also with the magnets and the fake fish on the table.*

Questions?

If not we can start the game which means that from now you earn money based on your decisions.

*Remind them that they can ask questions*
*Remind them about the communication rules and then say we start the game.*

**Table to illustrate resource dynamics**

| **Size of fish stock/pool** | **Growth rate** |
|---|---|
| # fish between 0 – 5 | 0 |
| # fish between 5 - 19 (small pool) | 5 |
| # fish between 20 - 34 (medium pool) | 10 |
| # fish between 35 - 45 (large pool) | 5 |
| # fish between 46-50 | 0 |

## INSTRUCTIONS (regime shift)

Normal text: read out loud the participants
*Italics: Things you should do*

Welcome and thank you for coming and participating in this activity!

It will take approximately 2 hours of your time.

During this activity we will play a game. After the game we would also like you to stay for some short interviews.

In this game you will be asked to take some decisions. You will receive 200 Baht for your participation in this activity. Depending on the decisions you make in the game. you can earn extra money. You will receive the money after the experiment (paid in private).

Why do we use money? We do not expect that the money you earn is a payment for taking part in the activity. nor the reason for you to be here. We use money because the exercise requires that you make some economic decisions that have consequences. It is to make the game realistic.

Before we start we want you to sign a consent form. The consent form says you are here voluntarily. It also informs you that the decisions that you take today will be anonymous. It will not be known to the other participants. Also when we analyze the results we will use numbers and color coding to identify you.

You will now be divided into groups of 4 people and thereafter we will explain the procedure more in detail.

### Group division

*Make group division. Each subject randomly picks a note which tells which group (color assigned) he will be assigned to and which number (1-4) he will be identified in that group (1-4). So for example if we have three groups playing at the same time we could have something like Blue (1.2.3.4); Green (1.2.3.4) and Brown (1.2.3.4)*

*Think about how to deal with people from the same family (e.g. siblings. cousins) or close friends. Avoid putting in the same group if possible.*

**Explain common access to a fishing water (e.g., the sea)**

In this game. we want you to imagine that you in this group have common access to a fishing ground (e.g., the sea).

*Place the fish on the table. represented by the 'fake fish'*

Although in reality it is impossible to know exactly how much fish there is in the sea. in this game we ask you to pretend that we can know how much fish there is.

Each of you can catch this fish from this common resource.

**Explaining the game. catch. procedure etc**

The game we will play lasts several rounds and in each round you take an individual and anonymous decision of how much fish to catch in that particular round.

For each fish you catch you get 20 Baht. So for example if you catch 20 fish you will earn 20*20 = 400 Baht.

So how do we keep track of you catch?

*Introduce the records. Explain the procedure.*

*Show the decision protocol (which should be foldable to ensure anonymity)*
In each round/period you mark how much fish you want to catch (the assistants are here to help you with this if you need). You can choose a number between 0 and the current number of fish available (that is in the pool). These protocols will be collected by the assistants after each decision round. The assistants will give them to the experimental leader after each decision round.

*Make sure that decisions are anonymous by for example using dividers or let them sit with their back towards each other's back.*

The experimenter leader will in each round sum up the fish catch of the whole group. He/she will calculate the new stock size. You will get this information from the assistants (plus total catch in each round and earnings) on your protocol.

**Explain that the resource is dynamic and grows**

Now we will explain how the fish grows. which will be indicated by these symbols. *Show with the symbols*

The fish reproduce/grows between each new round. How much the fish stock grows depends on how many fish your group left in the previous round. We start with 50 fish in the first round. After the catch. if there is 46-50 fish left the stock does not grow. If there is 35-45 fish in the stock (big pool/pond/stock). there will be 5 more fish in the next round
*Show with the magnets on the board how the stock grows from the biggest stock sizes.*

If there is so much fish in the sea as in this "hypothetical" case– they may compete for food and have a hard time of finding each other to reproduce with the result that the fish stock does not grow so much.

If there is 20-34 fish in the stock (middle pool/pond/stock), there will be 10 more fish in the next round.

*Show with the magnets on the board how the stock grows from the middle stock.*
Here there is enough fish so that they can find mating partners and not too much so they compete for food.

If there is 5-19 fish in the stock (small pool/pond/stock), there will be 1 more fish in the next round.
*Show with the magnets on the board how the stock grows from the small stock.*
*Reference to fish site: if there is too little fish they don't find enough partners and cannot reproduce.*

For stock sizes below 5. the fish stock doesn't grow at all.

As long as there is fish to catch. the game continues for a number of rounds and you can earn money. We will not tell you the exact number of rounds. If there is no fish the game ends and you will not earn any more money.

*If someone asks about how to share a harvest that is larger than the stock. answer: we will share proportionally according to your catch claim.*

Note there is an abrupt drop in the fish growth. If the number of fish is below 20. the fish stock can only grow by one fish per round. *Point to the small pool in the magnet board and in the table.*
If you want to be in the middle pool where the fish stock grows by 10 fish per round. the total catch of the group must be zero for some rounds. *Show example on the board.*

**Examples**

There are 50 fish in the beginning of the experiment. If you. for example. catch together 20 fish (for example 3+4+6+7) there are 30 fish left and the stock will then grow with 10 more fish. Then the fish stock will consist of (50-20+10) = 40 fish in round 2.

So now there is 40 fish. If you then catch 25 fish in total (10+5+5+5) there are 15 fish left and the stock will then grow with 1 more fish. Then the fish stock will consist of (40-25+1) = 16 fish in round 3.

*Use the material (wooden fish and fish symbols when going through this example)*

**Communication?**

What can you talk about?

You should not show the catch decision on balance sheet or the protocol to the other people in your group *(point to the balance sheet and protocol again)*.

However. you can talk to each other. You can talk about the game. the rules and your decisions but you cannot make any threats or arrangements for side-payments during or after this activity.

In case you have any questions just ask any of the assistants

Summary:

- The four of you share this fishing ground
- In each round you will take an individual decision of how many fish to catch
- As long as there is fish left the game continues (until the experimenter leader stops)
- The fish recovery depends on how much fish there is (point to magnets)
- Each fish is worth 20 Baht.
- We do not tell you how many rounds we will play.

***Do practice rounds***

*During the practice round(s). they do not earn money. We do not reveal who took what. only that "someone took" We calculate the total catch openly. growth and the new fish stock. Illustrating also with the magnets and the fake fish on the table.*

Questions?

If not we can start the game which means that from now you earn money based on your decisions.

*Remind them that they can ask questions*

*Remind them about the communication rules and then say we start the game.*

**Table to illustrate resource dynamics**

| **Size of fish stock/pool** | **Growth rate** |
|---|---|
| # fish between 0 - 5 | 0 |
| # fish between 5 - 19 (small pool) | 1 |
| # fish between 20 - 34 (medium pool) | 10 |
| # fish between 35 - 45 (large pool) | 5 |
| # fish between 46-50 | 0 |

**PROTOCOL**

Participant no_____

| **Round** | **Catch** | **Earning Baht** | **Round** | **Catch** | **Earning Baht** | **Round** | **Catch** | **Earning Baht** |
|---|---|---|---|---|---|---|---|---|
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

**QUESTIONNAIRE (used for the interviews)**

## Section 1: Background data

1. Gender:_____ 1. ☐ Female 2. ☐ Male
2. Marital status: 1. ☐ Single 2. ☐ Married 3. ☐ Divorced/Widow
3. Age: (specify) _____ years old
4. Education:
   1. ☐ No formal education 2. ☐ Primary school
   3. ☐ Secondary school 4. ☐ Vocational school
   5. ☐ Bachelor degree 6. ☐ Higher than bachelor degree (specify) …….
5. Size of Household:_____persons (including yourself)
6. No. of working household members (also includes unpaid work such as housework): _____ persons (including yourself)
7. Household income (Baht/month): (If anyone has more than one source of income. please specify by source of income separately. Unit of household means they share their income)

| Household member | Source of income | Monthly income (Baht) |
|---|---|---|
| 1. Yourself | Fishery | |
| 2. Yourself | Daily worker | |
| 3. Your wife | | |
| 4. Your son | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| Total household income | | |

8. Household expenditure:_____ Baht/month
9. Were you born in Tha Chat Chai village?
   1. ☐ Yes 2. ☐ No. I was born in (specify province) _____
10. When have you lived in Tha Chat Chai village? Which years? (specify) _____
11. Are children and women involved in the fishing activities?
    1. ☐ No
    2. ☐ Yes. 1. ☐ Only women
       2. ☐ Only children
       3. ☐ Both women and children
    3. ☐ Others (specify)_____

12. Do you expect your children continue working on fishery?
    1. ☐ yes. I expect them continue working on fishery
    2. ☐ No. I want them to work other jobs
    3. ☐ Others (specify) _____
13. Do you want to have side income from other sources?
    1. ☐ yes. because _____
       Specify what kind of job you want _____
    2. ☐ No. because _____
    3. ☐ I already have side income from (specify) _____
    4. ☐ Others (specify) _____
14. Do you think you will change to work in another job in the future?
    1. ☐ yes. because _____
       Specify what kind of job you want _____
    2. ☐ No. because _____
    3. ☐ Others (specify) _____

## Section 2: Description of fishing activities

15.How long have you been as a fisherman? _____ years.
16. Do you have your own boat?
    1. ☐ No  2. ☐ Yes. I have _____ boats
17. Describe briefly the gear you use for fishing you have (access to):
    _____
    _____
    _____

18. How many hours per day (approx.) or how many day per week do you spend on fishing activities?
    _____ hours/day or _____ day/week
19. How do you know where you can catch fish/sea animals?
    _____
20. How do you normally catch fish/sea animals?
    1. ☐ by yourself
    2. ☐ together with other fishermen and sharing income
    3. ☐ others (specify) _____
21. How much percentage of the sea animals you consume and sell of your total catch?
    1. Consume _____% of your total catch and sell _____% of your total catch
    2. Others (specify) _____

## Section 3: Knowledge and attitudes about the fish abundance in the area

*To what extent do the respondents agree with the following statements? Mark on the scale 1-5 (where 5 means agree completely and 1 disagree completely)*

22. I have a good knowledge about variations in fish abundance. e.g. where and when to expect fish:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Comments: _____

23. I believe that our current fishing (generally in the community/in Thailand) will affect the abundance of fish in the future:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Comments: _____

24. I think that I will be able to make a good living from fishing in the next 10 years.

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Reason that you **agree**: _____

Reason that you **disagree**: _____

25. Have you ever experienced a sudden (more dramatic) change in fish abundance? This would be something more dramatic then a seasonal variation. where you really notice that a particular specie(s) seems to have disappeared:

Yes_____ No_____

If yes. describe how you noticed. which specie. when it was (approx year). if the change persisted for a long time (how long). what you think caused the change etc:

| Which species that disappeared? | How long have you noticed it disappeared? | What caused they disappeared? |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |

26. I think we will experience such dramatic/sudden and persistent changes in fish abundance in the future:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

If yes. what do you think will be the main cause?:_____

_____

**Section 4: Cooperative and communication activities**

27. In the community we (fishermen) often discuss about fish and fishing (e.g. potential problems) with each other:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Comments _____

28. In the community we (fishermen) share our knowledge and experience with each other about fishing (e.g. where and when to fish):

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Comments: _____

29. I believe that cooperation between the fishermen is something that is good/necessary for sustaining our livelihood:

| 1 | 2 | 3 | 4 | 5 |
|---|---|---|---|---|
| Completely disagree | Disagree | Neither agree nor disagree | Agree | Completely agree |

Reason that you **agree**: _____
Reason that you **disagree**: _____

30. Other comments (e.g. about fishing. about the game. advice to you children/grandchildren):

_____
_____
_____
_____