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► **To cite this version:**

Hélène Serra, Juste Raimbault. Game-based tools to transmit freshwater ecology concepts. SETAC 2016, May 2016, Nantes, France. . halshs-01322860

**HAL Id: halshs-01322860**

**<https://shs.hal.science/halshs-01322860v1>**

Submitted on 27 May 2016

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# Game-based tools to transmit freshwater ecology concepts

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## INTRODUCTION

- There is an increasing awareness of the public on environmental issues
- Expert knowledge is often required to understand them
  - ➔ **A need for simple and understandable tools to explain environmental issues**
- Games provide a virtual world with given boundaries (rules) that the player needs to understand and to follow to win
- Furthermore, games are dynamic and interactive: the player engagement and its knowledge retention increase
  - ➔ **Games display interesting features to spread scientific thinking<sup>1</sup>**

## OBJECTIVE

**TO DEVELOP A BOARD GAME AND A COMPUTER-BASED GAME TO EXPLAIN THE BASIC CONCEPTS OF AQUATIC ECOLOGY**

The games aim to be **complementary**:

- ➔ in term of **player interactions** and **system dynamics**
- ➔ in the **targeted players** (groups vs isolated gamers)

## METHODOLOGY

STEP 1  
STEP 2  
STEP 3  
STEP 4

### CONTEXT

- Aim of the games
- Aquatic species and ecological concepts
- Inclusion of time and chance

### PROTOTYPES

- Design of the games (players, token, board)
- Size and layout of the board
- Coding and calibration of the model

### TEST AND EVALUATION

- Gather player feedbacks
- Refining and adapting the games

### DIFFUSION

- Identification of funding opportunities
- Construction of a diffusion network

## BOARD GAME

### DEVELOPMENT OF THE PROTOTYPE

#### Context

- The **player is a fish**, either a predator or a prey
- The **objective** of the game is to reach a **stable population of fish**
- Concepts illustrated: **feeding strategy, reproduction, predation and competition**

#### Basis of the board game

- **Species**: the **roach** (*Rutilus rutilus*) as a prey and the **pumpkinseed** (*Lepomis gibbosus*) as a predator, two **common european small fish**
- Illustration of a **native european shoal fish** (the roach) and of an **invasive species** (the pumpkinseed) with **specific life history** characteristics

### HOW TO PLAY THE GAME

- The board represents the **edge of a lake** with **plants, crustaceans, and mollusks**
- The player chooses a fish species and starts the game with 2 tokens (male + female)
- The players **use dices** to **move the tokens** on the board and to **find resources**
- Each resource provides the fish with a **given amount of energy** that he accumulates
- This energy can further be **used to reproduce** (adult fish), to **grow** (juvenile) or to **attack** a prey (predator)
- Each turn, the player takes a **card « chance »** representing the **events impacting the lake**

#### Ecological characteristics of each player:

#### PLAYER 1: PREY



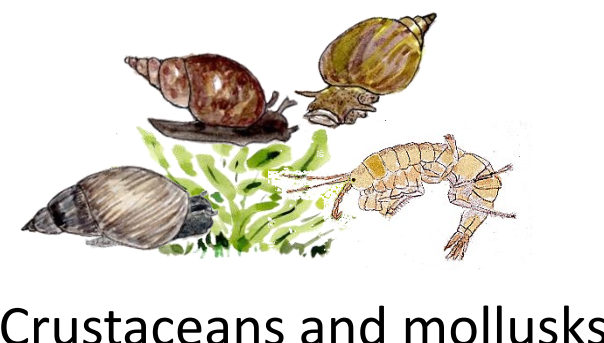
The roach

#### PLAYER 2: PREDATOR



The pumpkinseed

#### RESSOURCES



Crustaceans and mollusks

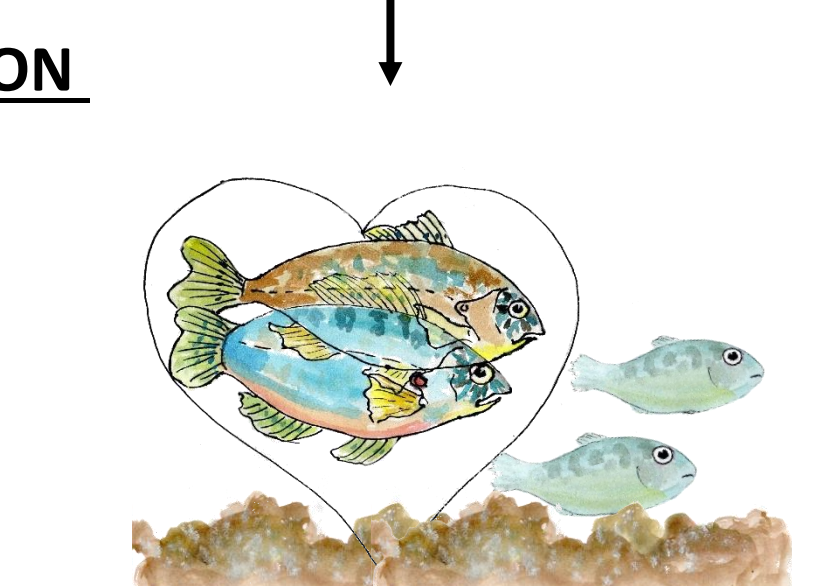
#### REPRODUCTION



The eggs stick to the plants



Roach juveniles and crustaceans



The eggs are layed in a nest done by the male

#### EXAMPLE OF « CHANCE » CARD

*A solitary pike is swimming around... Watch out! You just lost one fish*

*Tonight is full moon. You see as well as in day light: play again*

*The forestry guards cut trees near the lake: plants become much more light! Snails eat more: they bring twice more energy for 2 turns*

*A fisherman put his boat onto the water. He repainted it with antifouling: no mollusk for 2 turns*

*Opening of a fishing contest. The introduced fish destroyed the whole bottom of the lake: no more resources in the area for 2 turns*

## COMPUTER-BASED GAME

### DEVELOPMENT OF THE PROTOTYPE

#### Context

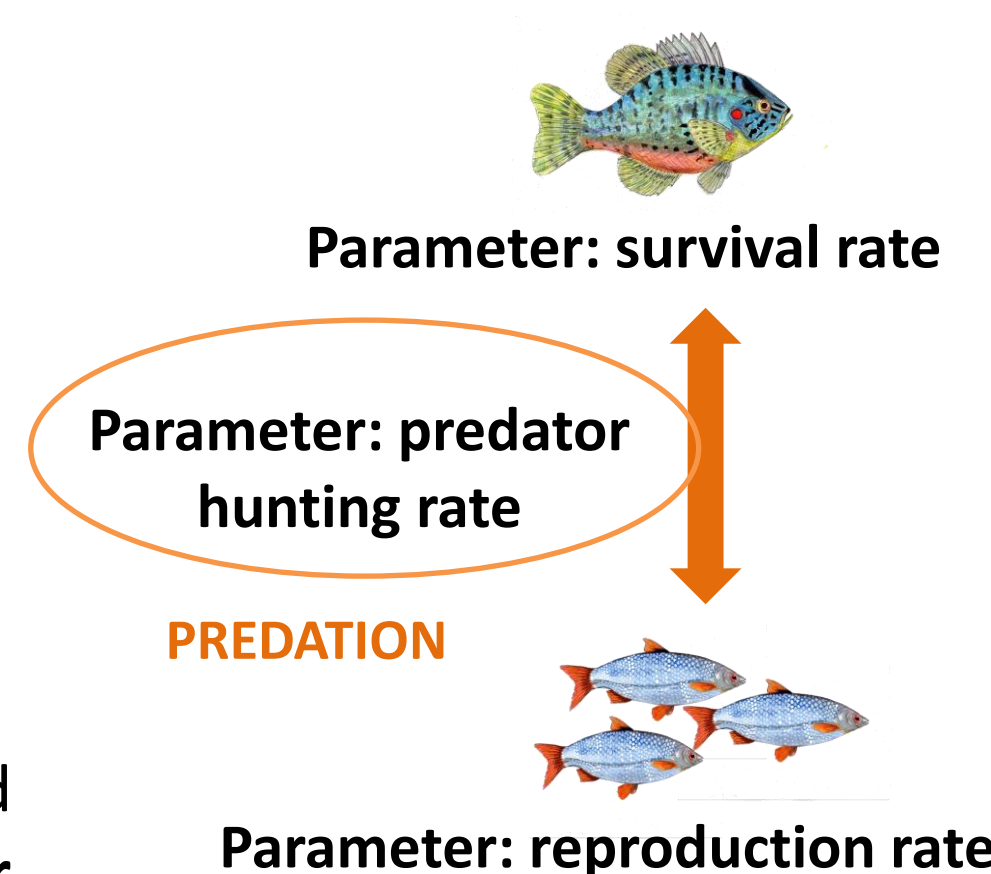
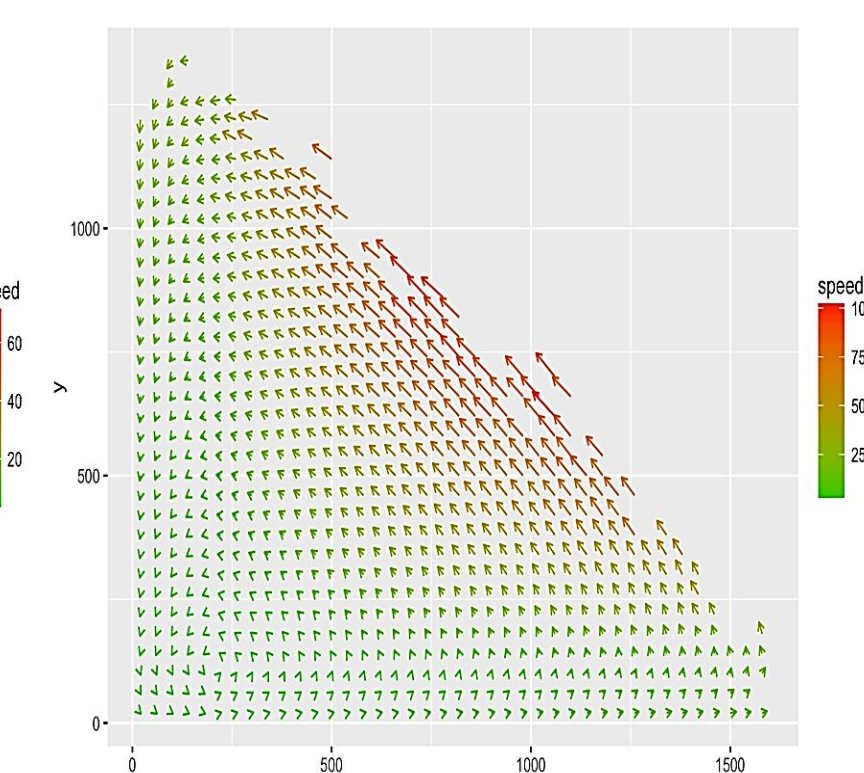
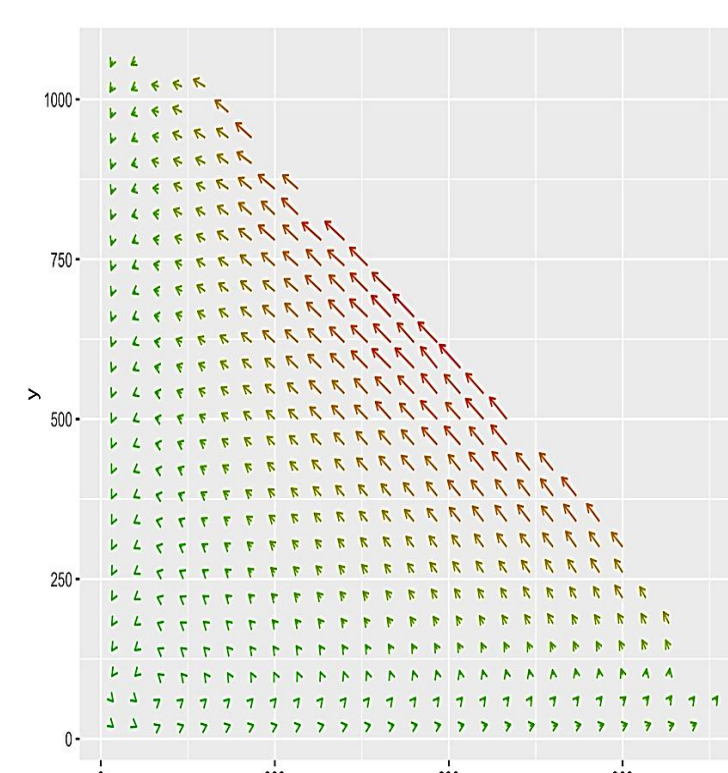
- The **player controls an ecosystem** with **preys** (the roach) and **predators** (the pumpkinseed)
- The **objective** of the game is to **maintain the stability of the ecosystem**
- Concepts illustrated: **population dynamic** and **ecosystem resilience**

#### Basis of the computer-based game:

- An **agent-based model<sup>2</sup>** (ABM) for a simple prey-predator system is proposed as a basis of the computer game (Netlogo software)
- ABM **simulate the behavior and interactions between agents** (fish) to reconstruct the **population dynamic** (bottom-up approach)
- **Stochasticity** is included with spatialized interactions (smoothed brownian motions), illustrating the **randomisation of prey-predator interactions**

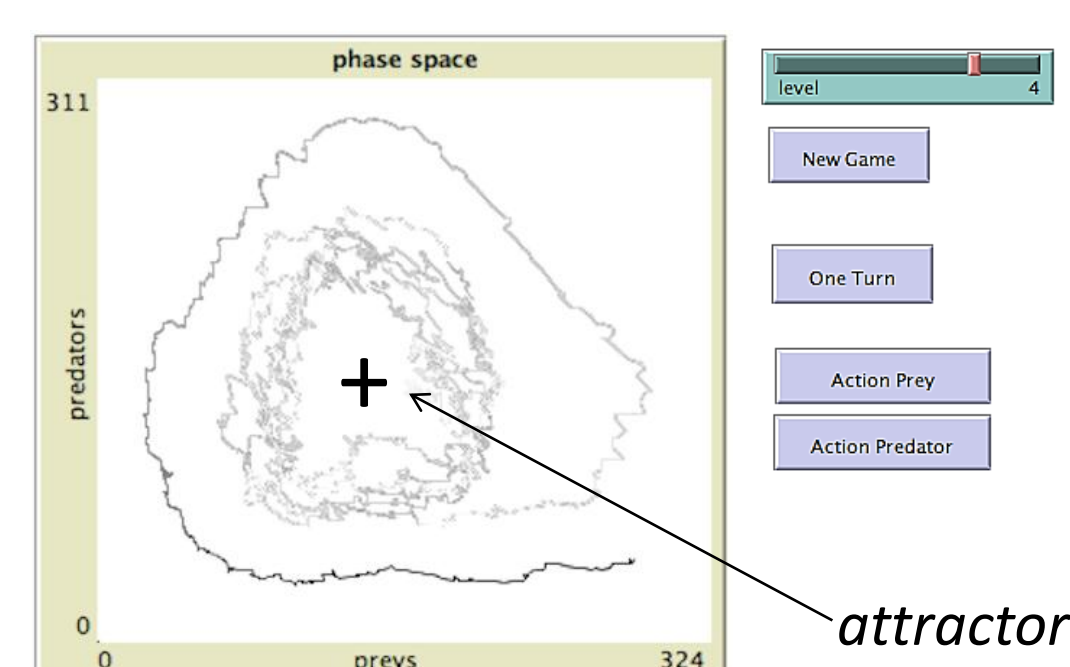
#### Model calibration:

- **Systematic exploration of parameter space** using OpenMole software<sup>3</sup>, to verify theoretical average trajectories in phase space, which allows analytical and numerical determination of initial position (**attractor**) and justify the use of this system for the game. The figures show **estimated average trajectories** for two points in parameter space.

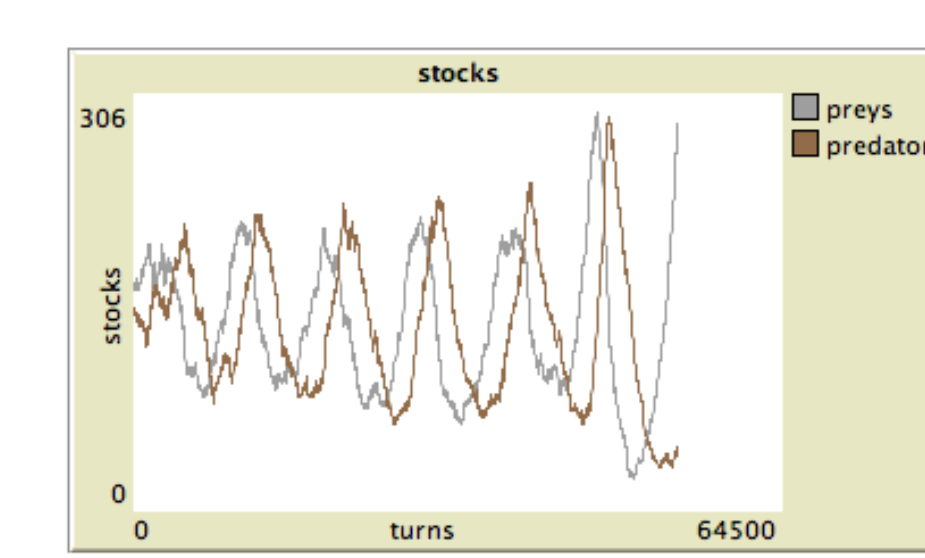


### HOW TO PLAY THE GAME

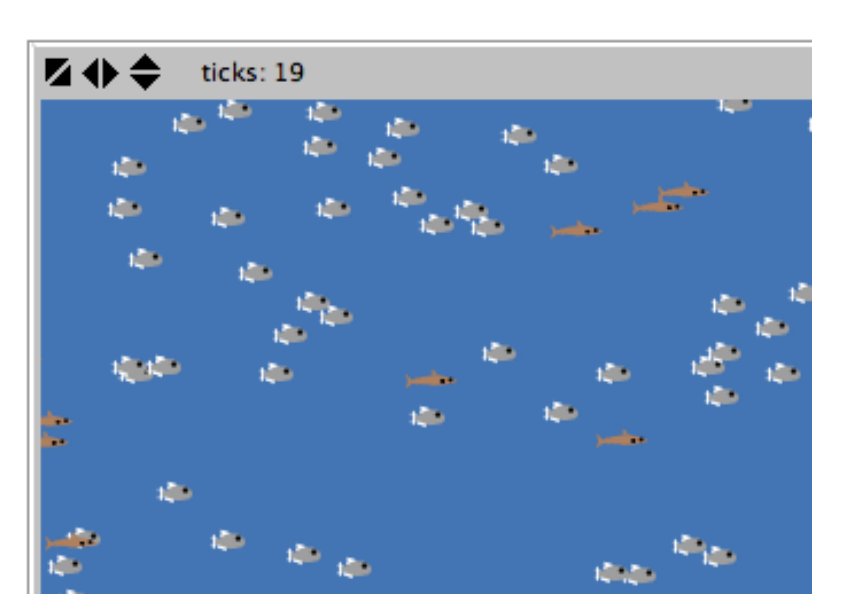
- The player starts the game with a **stable ecosystem**: the **initial position** is the **attractor**
- The button « **one turn** » makes the ecosystem evolve during **50 time steps**
- The player **sees the changes** in the fish populations **simultaneously on the screen**
- The **trajectory can be corrected** towards the attractor in the **phase space** by **changing the parameters** of the model (predator survival, prey reproduction and hunting behavior)
- **External events randomly perturbate the ecosystem**
- The game includes **5 levels of difficulty** based on **event strength**



Phase space figuring in Y axis the predators and in X axis the preys (Netlogo interface)



The stock: representation of the oscillations in fish populations (Netlogo interface)



The ecosystem: representation of the fish populations (Netlogo interface)

- Open source: code available at <https://github.com/JusteRaimbault/MediationEcotox>

## DISCUSSION

- ✓ Demonstration of the **proof-of-concept**: the **prototypes are available for testing**
- ✓ Both game are **complementary** as they integrate different time scales and illustrate diverse basic concepts of aquatic ecology
- ✓ **No knowledge in aquatic ecology is needed to play both games**: wide possibilities in targeted audiences
- ✓ The methodology is **flexible and adaptable**:
  - **On-going development** of the games
  - **Refinements** and changes are **easy to integrate** in new versions of the games

## PERSPECTIVES

#### Short term perspectives:

- **Next step** of the project: **test the games and gather player feedbacks** → do players like the games?
- **Identification of potential players** (children, school/university, family, adults...) and **adaptation of the games** accordingly (simplification/complexification)

#### Long term perspectives:

- **Potential uses** of the games as **educational tools** (with educative support) or **sensibilisation tools** (e.g. adapting the species and perturbations)
- **Funding and diffusion** of the **board game** through **crowdfunding platforms** and **game festivals**
- **Diffusion of the computer-based game**: open online access through **Netlogoweb** and development of **mobile applications**