🎮 Catch & Collapse

The Sardine Industry Business Simulation

🟩 Abstract

This article explores the historical collapse of the Pacific sardine industry as a systemic model of rise and fall. By creating a business simulation game, we invite business leaders, decision-makers, and students to understand how economic decisions—when disconnected from ecological feedback—can drive a profitable industry into collapse. The article links this real-world case to current business challenges, demonstrating how structural thinking enables sustainable strategies in resource-based industries.

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Keywords

Sustainability, Overfishing, Business Simulation, Systems Thinking, Tragedy of the Commons, Resource Management, Policy Design, Pacific Sardine Collapse

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Introduction

In the early 20th century, the Pacific coast sardine industry thrived. Within just two decades, it became one of the nation's top fisheries, processing over 800,000 tons annually at its peak in 1936–1937. Sardines were canned, turned into fertilizer, oil, bait, and pet food—fueling a booming economy.

But beneath this prosperity lay a systemic trap. The industry's growth was built on overexploitation. As catch per boat declined, more vessels were added to the fleet to maintain profits. Scientific warnings were ignored. Industry leaders rejected all forms of regulation. The result: ecological collapse. By 1951, the San Francisco fleet returned with only 80 tons, and the fishery shut down indefinitely.

This article and its accompanying business simulation seek to transform this historic collapse into a learning opportunity. Rather than simply analyze the past, we ask:
What decisions could have changed the outcome? What policies might allow today's companies to extract natural resources in a sustainable and profitable way?

🔧 MODEL REGISTRATION

This section captures the model's key metadata: title, short description, and tags. This information allows the model to be categorized, searched, and shared within the online simulator, supporting educational and collaborative use.

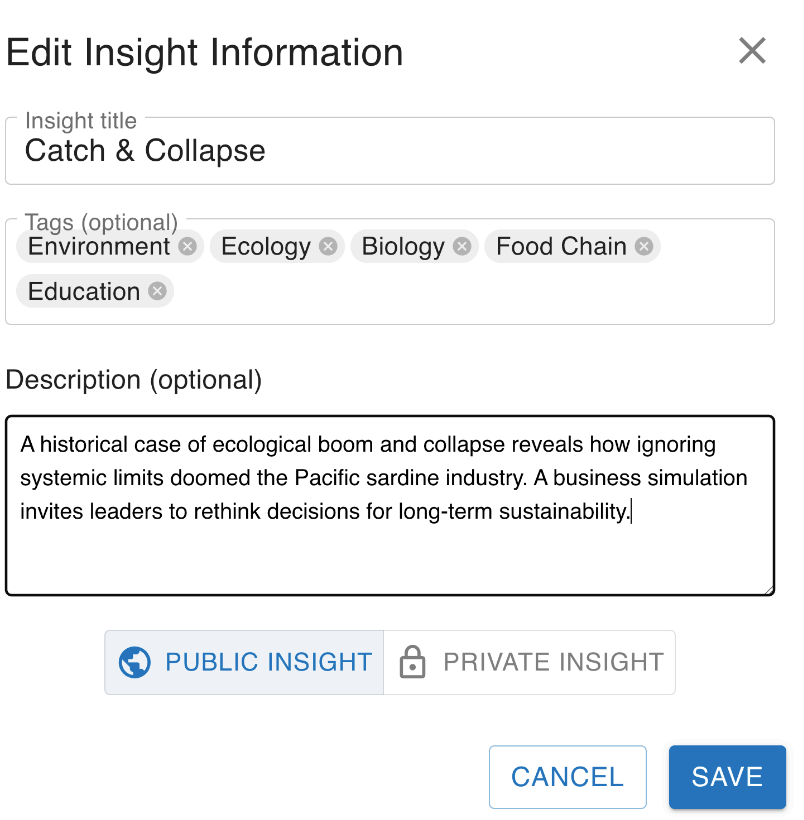

Figure 1: Model registration for "Catch & Collapse".

✅ Title

Catch & Collapse

✅ Tags sugeridos *(en ambos idiomas)*:

Sustainability, Overfishing, Business Simulation, Systems Thinking, Tragedy of the Commons, Resource Management, Policy Design, Pacific Sardine Collapse

📝 Model short description

A historical case of ecological boom and collapse reveals how ignoring systemic limits doomed the Pacific sardine industry. A business simulation invites leaders to rethink decisions for long-term sustainability.

MODEL SETTINGS

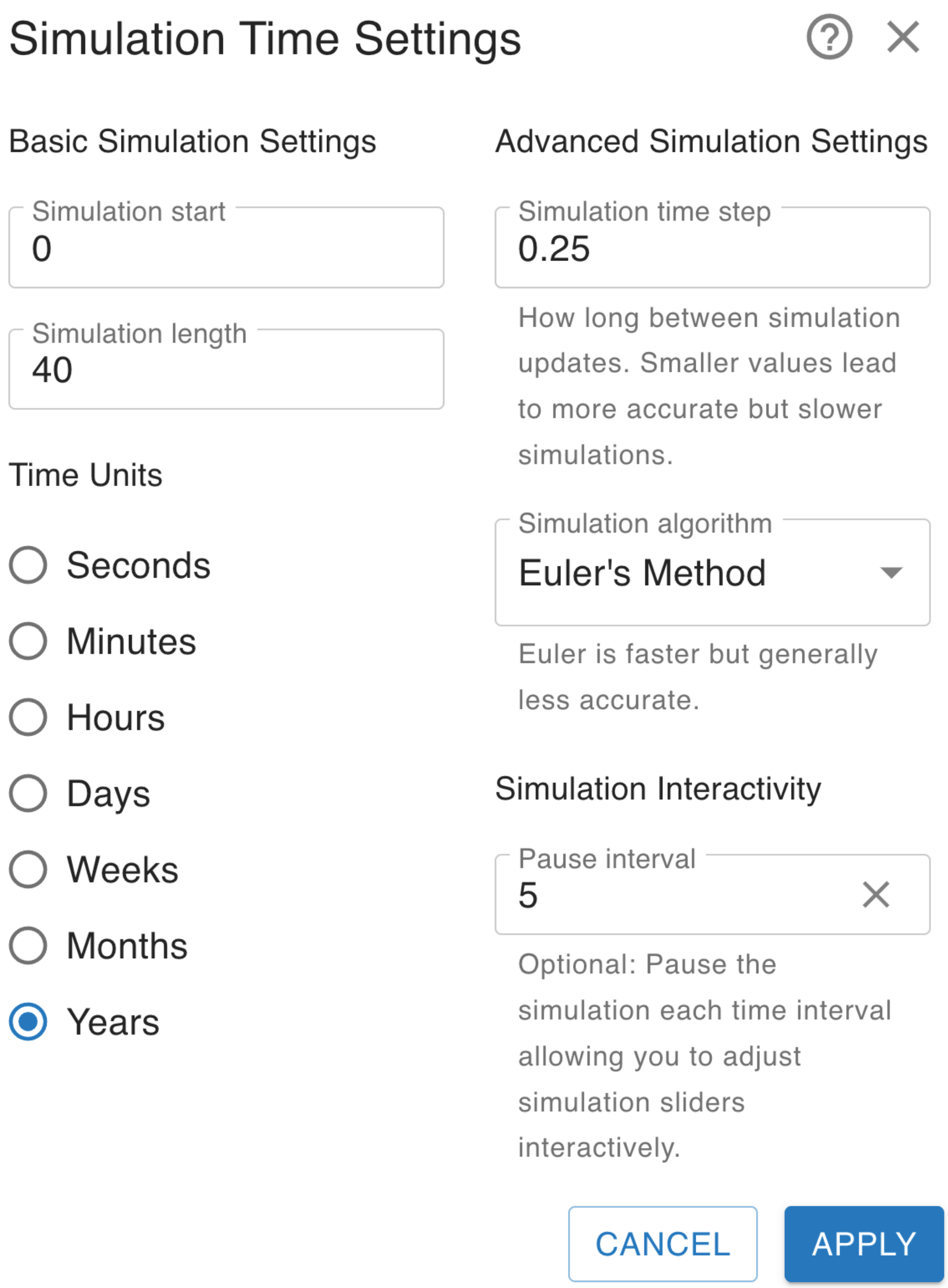

Figure 2: Simulation settings for the "Catch & Collapse".

Simulation settings for the "Mammoth Game" model.
This section defines the temporal and computational parameters that govern the simulation behavior. It includes the simulation start (e.g., 1), total length in time units (e.g., 40 years), time unit labels, time step, integration algorithm, and interactivity options. These settings control the model's accuracy and execution dynamics.

Catch & Collapse: The Rise and Fall of the Pacific Sardine Industry

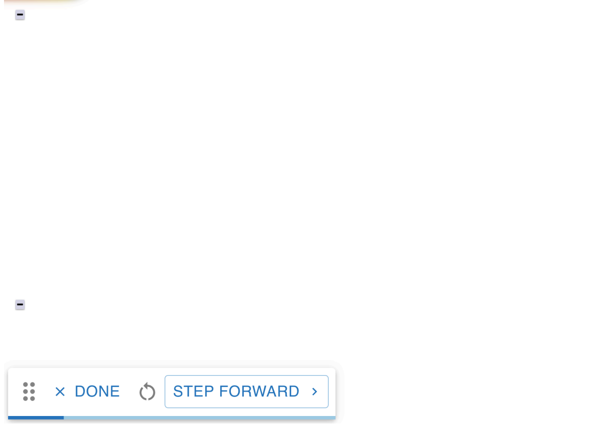

Figure 3: Step 1: Starting point — no boats, no fishing.

Figure 4: Step 2: Two sectors appear — sardines and boats.

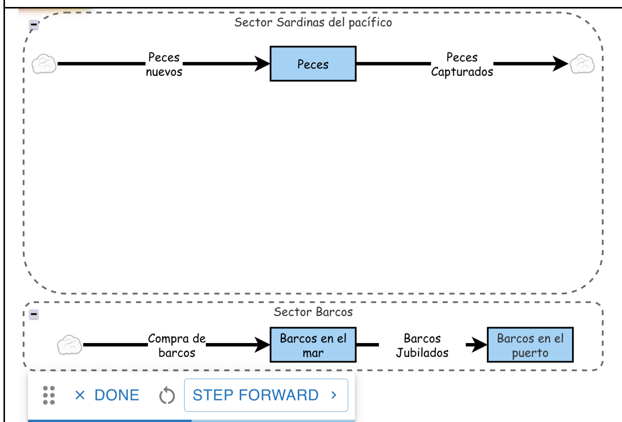

Figure 5: Step 3: Key stocks shown — fish, boats at sea, and in port.

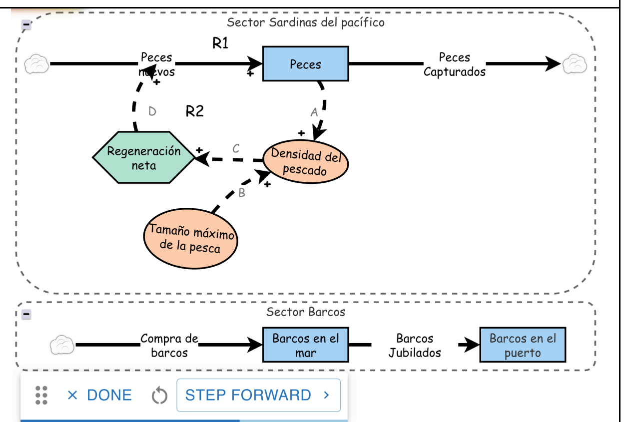

Figure 6: Step 4: Sardine regeneration loop (R2) appears.

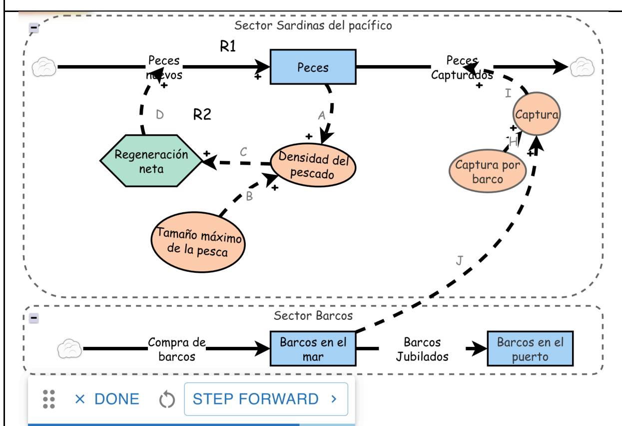

Figure 7: Step 5: Fishing without limits — still no density link.

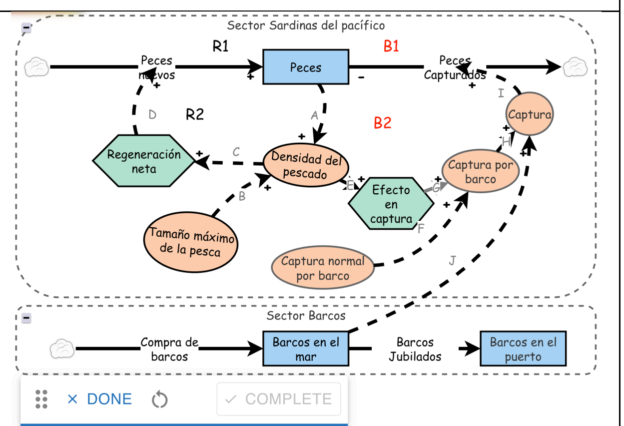

Figure 8: Step 6: Fishing is now tied to sardine density, Balanced feedback loop ,(B2).

This storytelling introduces participants to the true historical rise and collapse of the sardine fishing industry along the Pacific coast between 1915 and 1950. Through a guided narrative, it highlights the structural drivers behind the collapse: overfishing, resistance to regulation, and fleet expansion as a short-term fix. The story serves as a starting point for understanding how business decisions disconnected from sustainability can lead to failure—and how system modeling can help visualize policies that avoid the tragedy of the commons. It is an ideal educational tool to reflect on business systems, ecological limits, and sustainable management.

Full Model: Fishing, Regeneration & Balance

This model captures the full dynamics of the sardine fishing system. It includes the reinforcing feedback loop of natural fish regeneration (R1), the balancing feedback loop of fish capture (B2), and the critical role of fishing boats as pressure agents. The interplay of these loops shows how business decisions can lead to either sustainable growth or ecosystem collapse.

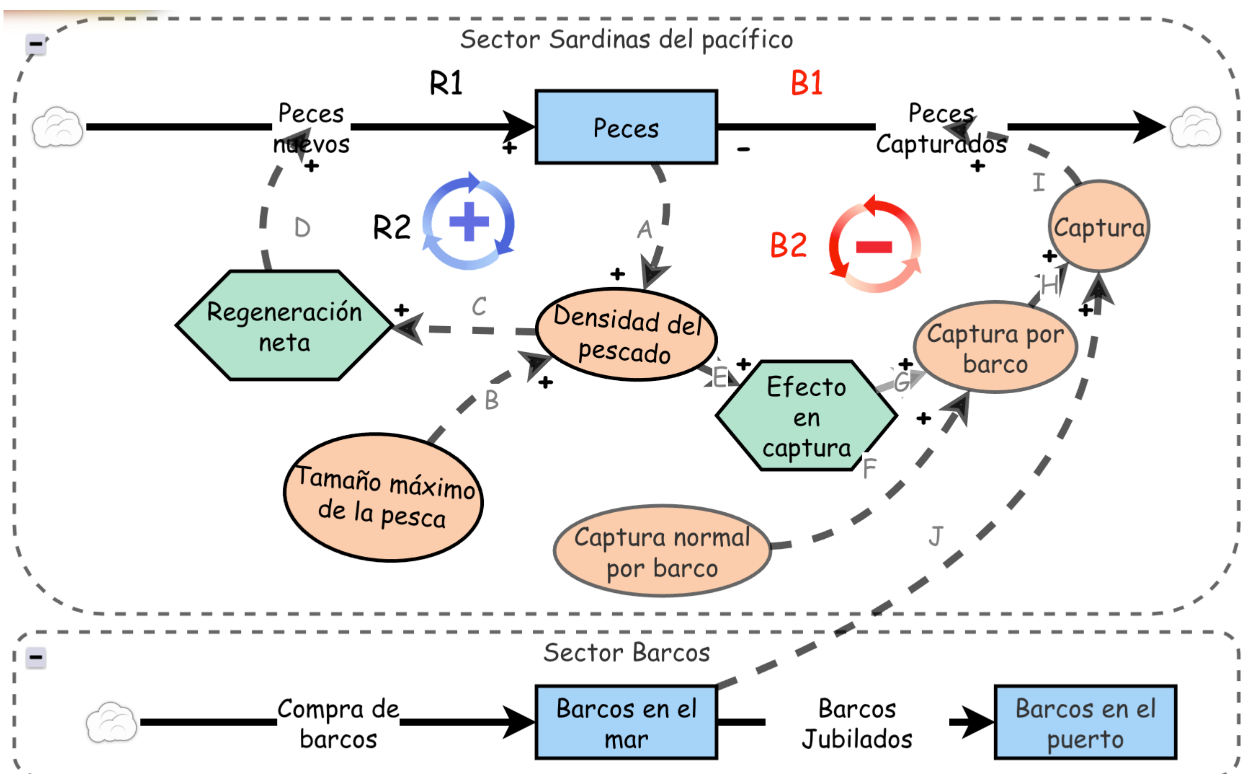

Figure 9: Full system dynamics: regeneration, catch, and fleet.

Structural Elements of the Model

This section documents all the fundamental components of the model: stocks, flows, auxiliary variables, and converters. These elements are essential for understanding the system's logic and help visualize how policies, resources, and behaviors interact over time.

Fishing Fleet Sector

This sector represents the dynamics of the fishing fleet, modeling both the boats operating at sea and those that have been retired and remain in port. It reflects the available fishing capacity and shows how aging vessels are "retired" as their useful life ends, transitioning to inactive status.

Name: Barcos en el mar (Boats at Sea)

Type: Stock
Initial Value: 0
Units: Barcos (Boats)
Description: Represents the number of active fishing boats currently operating at sea. This stock determines the real-time operational capacity of the fishing fleet.

Name: Barcos en el puerto (Boats in Port)

Type: Stock
Initial Value: 0
Units: Barcos (Boats)
Description: Represents the boats that have reached the end of their useful life and have been retired to port. This stock reflects the decommissioning or retirement of inactive vessels.

Name: Compra de barcos (Boat Purchases)

Type: Inflow
Units: Barcos/Year (Boats/Year)
Description: This inflow adds new boats to the active fleet fishing at sea. In the simulator, boat purchases can be adjusted every 5 years, allowing participants to make strategic decisions and visualize their intended and unintended consequences before they unfold in reality.

1️⃣Boat purchases every 5 years

- **Show value slider:** ✅ Enabled
- **Range:** Min = 0, Max = 10 **Step:** 1

- **Description:**
  This slider lets the user decide how many new boats are added to the active fishing fleet. A high number increases fishing pressure, which can lead to overfishing if fish regeneration is insufficient.

Type: Barcos jubilados (Outflow)

Units: Barcos/Year (Boats/Year)
Description: This is the outflow of boats that have reached the end of their useful life and are moved from sea to port. In the simulator, this variable can be adjusted every 5 years based on the chosen retirement policy, enabling participants to assess its impact on the system's sustainability.

Boat retirements every 5 years

- **Show value slider:** ✅ Enabled
- **Range:** Min = 0, Max = 10 **Step:** 1
- **Description:**
  This setting determines how many boats are retired from fishing activity every 5 years. It can be used as a control mechanism to regulate fleet size and help prevent ecosystem collapse.

Fish Sector – Regeneration Cycle (R1)

Introduction:
This sector models the natural regenerative dynamics of the sardine population in the marine ecosystem. Through the reinforcing feedback loop (R1), it shows how a healthy fish population can grow over time, provided that extraction rates remain within sustainable limits. Understanding this cycle is essential for visualizing the ecosystem's recovery potential when fishing levels are properly managed.

Name: Peces (Fish)

Type: Stock (Accumulator)
Initial value: 500
Unit: Peces (Fish)
Description: Represents the number of fish (sardines) in the marine ecosystem at the start of the simulation. This stock is affected by natural reproduction and by fishing activities that remove part of the population.

Name: Tamaño máximo de la pesca (Maximum Catch Size)

Type: Variable
Value: 4,000
Unit: Peces (Fish)
Description: Sets the maximum number of fish that could be caught annually under ideal conditions. It reflects the theoretical fishing capacity of the fleet in the absence of ecological constraints or population density limits.

Name: Densidad del pescado (Fish Density)

Type: Variable
Formula: Fish / Maximum Catch Size
Unit: Dimensionless, Unitless
Description: This variable represents the current proportion of fish relative to the ecosystem's maximum catch size. It serves as a key indicator of the marine system's health by reflecting how full or depleted the fish population is compared to its regenerative capacity.

Name: Regeneración neta (Net Regeneration)

Type: Converter
Definition: A nonlinear function that calculates the number of regenerated fish based on **fish density**.
Unit: Fish/Year
Description: Net regeneration is represented by a lookup table defining a nonlinear curve. Using **linear interpolation**, the model estimates intermediate values between defined data points. This function reflects typical biological population behavior: regeneration is low at very low or high densities and peaks at moderate density levels.

Figure 10: 📈 Net regeneration curve: shows how fish density influences reproductive capacity.

Densidad de pescado (Unitless)	Regeneracion neta (Peces/Year)
0	0
0.1	50
0.2	100
0.3	200
0.4	320
0.5	500
0.6	550
0.7	480
0.8	300
0.9	180
1	0

📥 Flow: Peces nuevos (New Fish)

Type: Flow
Name: New Fish
Formula: [Net Regeneration]
Units: Peces/Year (Fish/Year)
Description:
This flow represents the number of fish regenerated each year based on the current density of the fish population. It is part of the reinforcing feedback loop (R1), supporting the ecosystem's natural ability to recover.

Balancing Loop B2: Sustainable Fish Catch

This balancing loop captures the dynamics of **fish catch regulation** based on the **stock density**. As fish numbers decline in the ecosystem, the effective catch per boat decreases, which lowers total harvest and helps stabilize the system. This negative feedback is essential to prevent ecological collapse and promote sustainable exploitation.

Converter: Effect on Catch

Type: Converter
Value: Defined by a **data table** with **linear interpolation**.
Unit of Measure: 1/Year
Description: This is a **nonlinear function** that links the **fish catch per boat** to the **fish density** in the ecosystem. It helps prevent overfishing by reducing the effective catch rate when fish density is low, simulating a more sustainable, self-regulating system.

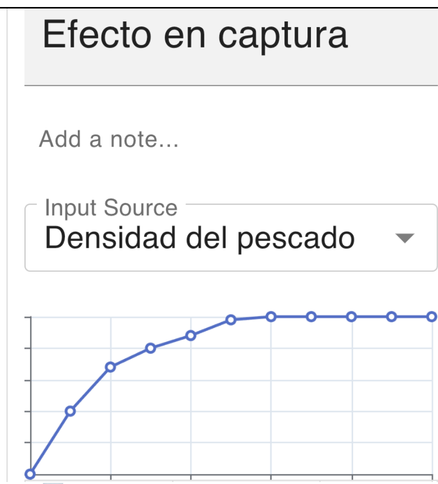

Figure 11: Curva de ajuste de captura: reduce la pesca cuando la densidad de peces baja.

Densidad del pescado (Unitless)	Efecto Captura (Unitless)
0	0
0.1	0.4
0.2	0.68
0.3	0.8
0.4	0.88
0.5	0.98
0.6	1
0.7	1
0.8	1
0.9	1
1	1

Variable: Captura normal por barco (Normal Catch per Boat)

Type: Variable
Value: 20
Unit: Peces/Barcos (Fish/Boat)
Description:
Represents the average number of fish each boat catches under normal conditions, not yet considering the impact of fish stock density. It is a fixed value that reflects the baseline fishing efficiency of each active vessel.

⚙️ Variable: Captura por barco (Catch per Boat)

Type: Variable
Formula: [Normal Catch per Boat] * [Catch Effect]
Unit: Peces / (Barco * Año), Fish / (Boat * Year)
Description:
Calculates the adjusted number of fish caught per boat per year, based on the normal catch rate modified by the effect of fish density. This variable captures how resource scarcity affects fishing efficiency.

⚙️ Variable: Captura (Catch)

Type: Variable
Formula: [Catch per boat] * [Boats at sea]
Unit: Peces/Year (Fish / Year)
Description:
Represents the total number of fish caught annually by all active fishing boats at sea. This variable reflects the direct pressure exerted on the fish population by the fishing fleet, allowing users to observe how changes in fleet size and fishing efficiency impact the ecosystem.

🐟 Flow: Peces capturados (Captured Fish)

Type: Flow
Formula: [Catch]
Units: Fish / Year
Description:
Represents the outflow of fish from the ecosystem due to fishing activity. This flow reflects the direct impact of the fleet on the fish population and is essential for tracking resource depletion or sustainability over time.

🎮 Play to Understand: Business Lessons from the Ecosystem

This section invites users to engage with the model as a serious game. It's not just about catching sardines—it's about understanding how decisions shape the behavior of complex systems over time. Just like in business, actions that seem profitable in the short term can trigger collapse when system limits and regeneration cycles are ignored. The game provides a powerful metaphor for developing systems thinking, anticipating unintended consequences, and dning sustainable strategies.

Visual Guide for Chart Setup

This section outlines the key parameters (axes, ranges, and variables) needed to build and visually analyze the model's charts in simulation tools.

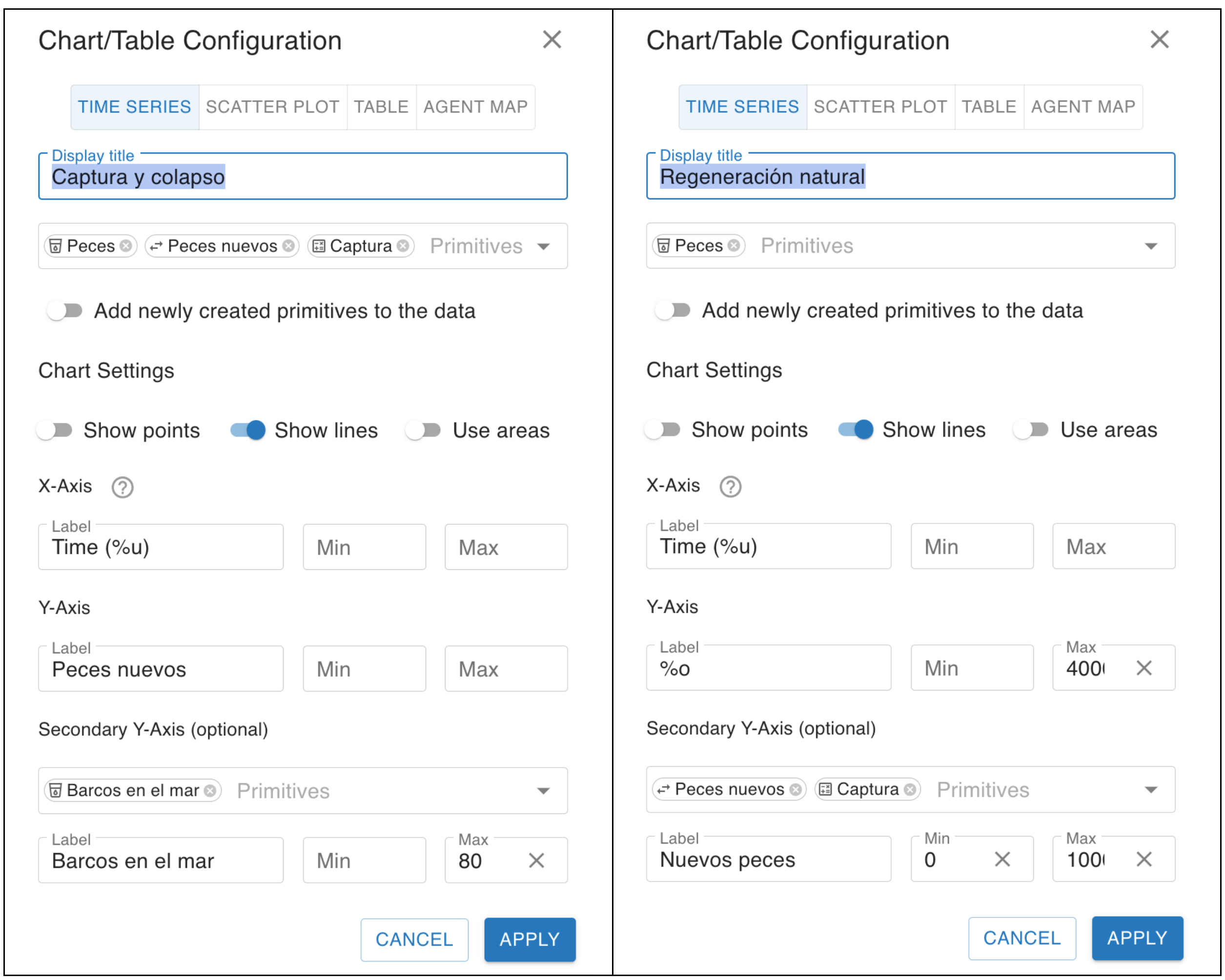

Figure 12: Technical details to replicate the model's charts.

🌿 Scenario 1: Natural Regeneration, No Fishing Boats

This first scenario explores how the ecosystem behaves when there is no fishing activity at all. With no harvesting pressure, we observe the natural regeneration process of the fish population. The key question is: how many years does it take for the system to fully recover and reach its natural balance?

🟩 **The answer becomes the first rule that all fishing stakeholders must respect:** giving the ecosystem the time it needs to regenerate undisturbed. This recovery policy is the baseline and must be fulfilled before envisioning any other strategy for resource exploitation or fleet expansion.

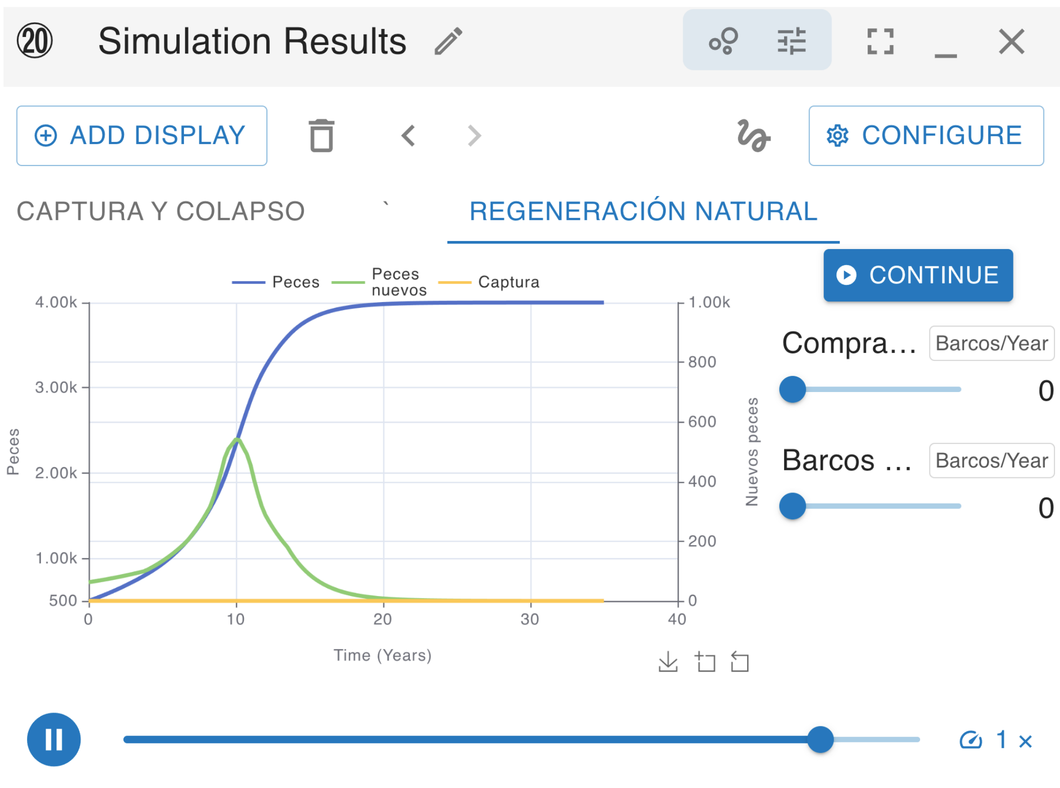

Figure 13: Full ecosystem recovery takes 10 years with no fishing activity.

Scenario 2: Designing a Collective Strategy

Description:

All participants are invited to the table to envision a set of policies aimed at sustainable operations. The first collective agreement is to respect the first 10 years of natural regeneration. No fishing activity or policy should be introduced before year 11. This foundational step allows the ecosystem to recover its balance.

Policy agreements for simulation:

1. Natural regeneration (years 0–10)
2. Fleet expansion (years 10–30) – Buy 2 boats
3. Fleet reduction (years 30–40) – Buy 0 boats

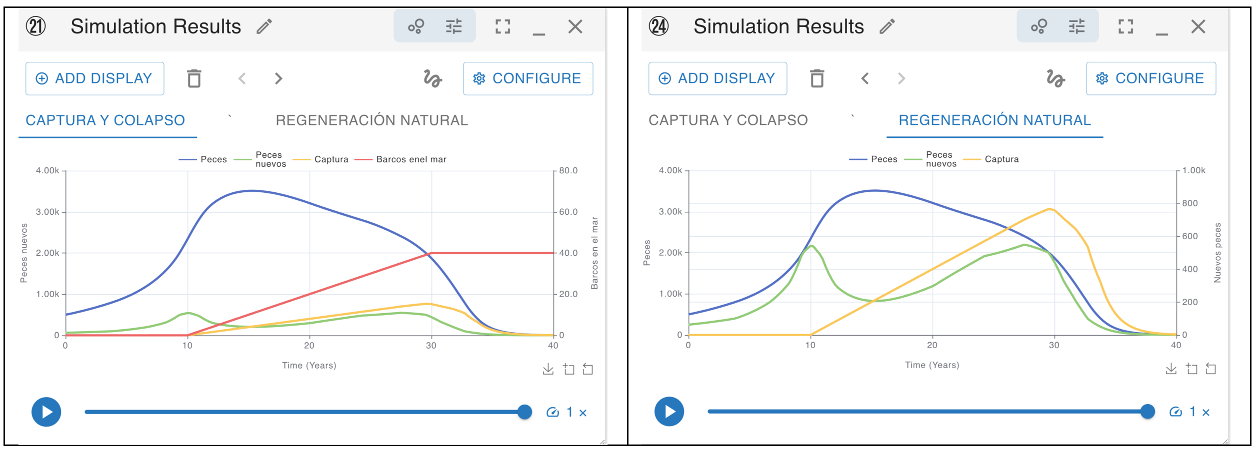

Figure 14: The ecosystem collapses after an aggressive fleet expansion. The late reduction policy fails to reverse the damage. This scenario highlights the limits of natural regeneration under early overexploitation.v

Scenario 2 Outcome: Ecosystem Collapse

Although participants agreed to allow **natural regeneration for the first 10 years**, the subsequent strategy of **fleet expansion from years 10 to 30** led to overexploitation of the fish population. The ecosystem was unable to sustain the increased capture rate, and fish stocks began to decline rapidly.

By the time the **fleet reduction policy** was applied in years 30 to 40, the damage was already done. The fish population had collapsed, rendering fishing activities unviable. This scenario clearly illustrates that **timing and magnitude of decisions are crucial**. Even with good intentions, sustainability can't be achieved if decisions are delayed or too aggressive.

🇬🇧 Scenario 3: Initial regeneration, early expansion and late fleet withdrawal

🧭 **Agreed policies:**

1. **Natural regeneration** of the ecosystem during **years 0–10** (no fishing vessels at sea).
2. **Fleet expansion** from **years 10–30**, with **2 boats purchased per year**.
3. **Progressive fleet reduction** during **years 30–40**, with **no new purchases and 4 boats removed per year until reaching zero**.

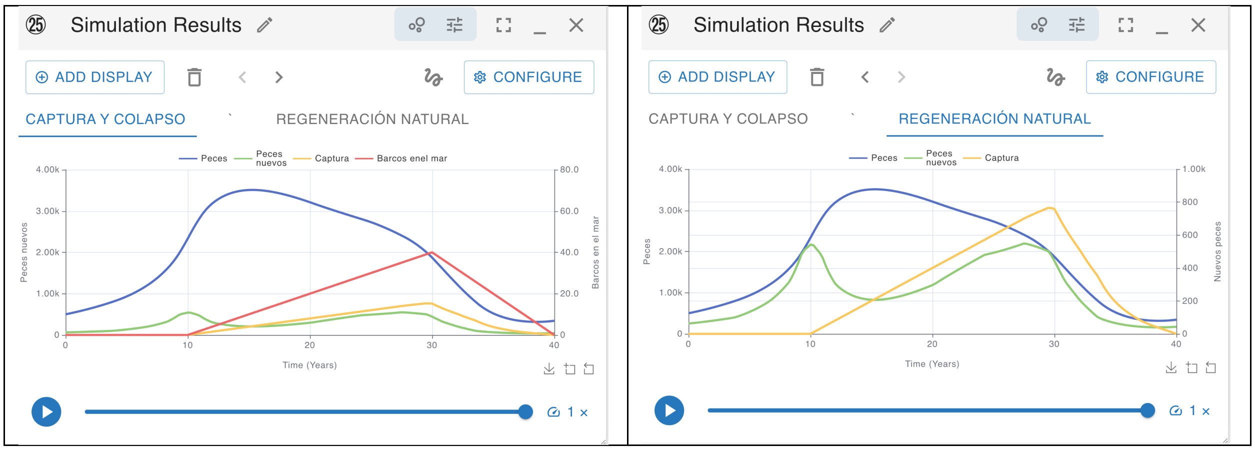

Figure 15: The withdrawal came too late: the ecosystem collapsed after uncontrolled expansion.

📉 Scenario 3 Results

Despite allowing an initial recovery period and later enforcing a total fleet withdrawal, **the ecosystem collapsed**.

The fleet expansion during years 10–30 led to overfishing that **exceeded the system's natural regenerative capacity**.

By the time corrective actions were taken, **fish stocks had already fallen below critical levels**. This scenario proves that **late reaction is not enough**: even with strong withdrawal policies, **there wasn't enough time for recovery**.

🇬🇧 Scenario 4: Moderate expansion and natural fleet renewal

🧭 **Agreed strategy:**

1. **Natural regeneration** of the ecosystem during **years 0–10** (no fishing activity).
2. **Fleet expansion** during **years 10–20**, with **2 boats purchased per year** and **no removals**.
3. After **year 20**, a **fleet renewal policy** is applied, replacing **only the boats that have reached the end of their useful life**.

Figure 16: A sustainable strategy: everyone wins and the ecosystem thrives.

📈 Scenario 4 Results

By limiting fleet growth to only 10 years and avoiding rushed fleet reductions, the system achieved greater balance.

The natural renewal strategy —replacing only boats that age out— helped maintain **stable fishing pressure**.

The ecosystem **regenerated sustainably**, boats kept fishing, and **everyone benefits**: sustainable profits, a healthy ecosystem, and fish forever.

📊 Comparison of Fishing Strategy Scenarios

Scenario	Applied Policies	Ecosystem Outcome	Business Outcome	Final Evaluation
1	🔹 Natural regeneration (years 0–∞)	✅ Fully regenerated ecosystem	❌ No fishing, no income	🌱 Complete recovery, but no business
2	🔹 Natural regeneration (0–10) 🔹 Fleet expansion (10–30, +2 boats/year) 🔹 No retirement	❌ Ecosystem collapse after year 30	⚠️ Too many boats, no fish	❌ Poor planning, unsustainable strategy
3	🔹 Natural regeneration (0–10) 🔹 Fleet expansion (10–30, +2 boats/year) 🔹 Rapid retirement (30–40, -4 boats/year)	❌ Ecosystem collapses before recovery	⚠️ Fishing declines rapidly at the end	❌ Late reaction, no time for regeneration
4	🔹 Natural regeneration (0–10) 🔹 Fleet expansion (10–20, +2 boats/year) 🔹 Natural renewal (after year 20)	✅ Stable and healthy ecosystem	✅ Sustainable and consistent fishing	✅ Win-win, balanced and viable strategy

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📝 Key Takeaways:

- **Scenario 1** proves the system can regenerate naturally, but there's no viable business.
- **Scenarios 2 and 3** reveal how **uncontrolled expansion** or **delayed action** leads to collapse.
- **Scenario 4** achieves the **ideal balance**: moderate expansion, regeneration time, and sustainable renewal.

🧭 Part 2 – Playing Beyond

What's Next?

After analyzing the four core scenarios, a powerful question arises:
What else can we do to build a truly sustainable fishing future?
This model invites us to experiment and co-create better strategies before implementing them in the real world. Now is the perfect time to integrate smarter policies that promote conservation, fairness, and shared prosperity.

🌱 New Regulatory Policies to Explore

These policies provide a systemic framework to strengthen sustainability in the fishing industry:

- **Tax on acquiring new boats**: To discourage unplanned overexpansion.
- **Regulations for sustainable boat construction**: Encouraging cleaner technologies and eco-friendly designs.
- **Maximum operational lifespan for boats**: Prevent indefinite use of outdated fleets.
- **Variable selling price system**: Based on fish availability and market demand, encouraging balance and smart harvesting.
- **Ecological tax**: To charge higher-impact activities and reward best practices.
- **Managing human variability**: Including working hour limits and training programs in sustainable practices.

These new layers allow us to **simulate more realistic scenarios** and collaboratively design **resilient strategies for a thriving marine ecosystem**.

🧩 Conclusion

Final Reflection — Regenerating the Future: When Business Wisdom Aligns with Nature's Rhythm

The four scenarios explored illustrate how individual and collective decisions, made without a systemic perspective, can lead to the collapse of an ecosystem that once seemed limitless. However, they also demonstrate that **it is possible to design policies where everyone wins**, as long as the ecosystem's timing is respected, clear rules are applied, and human and natural complexities are fully integrated.

This is not just a lesson in fisheries — **it's a metaphor for the business world**. Many businesses fail because they overexploit their key resources (customers, staff, suppliers, or technology), without acknowledging the **system's regenerative capacity**. Reactive or poorly timed policies, even if well-intentioned, often arrive too late.

Likewise, in education, this model becomes a powerful tool for active learning. It helps students, teachers, and decision-makers develop **critical thinking, long-term vision, and strategy design skills**.

Learning to see systems, play with policies, and simulate consequences **broadens perspective and nurtures both strategic and ecological intelligence**.

Play becomes serious when it's about understanding the future.
And only those who see the whole can protect the parts so that everyone wins.

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Fish and Ships
A Simple Model for Introducing System Dynamics and Communicating its Appeal

A Breakout Session at the isee User Conference
Burlington, Vermont, October 2008
John Morecroft
London Business School

London Business School