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FishPoll – a serious game about sharing moving fish stocks under climate change

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Climate change is driving shifts in fish stock distributions, creating challenges for transboundary fisheries governance and quota allocation. Traditional negotiation processes often fail to achieve consensus among stakeholders, leading to geopolitical tensions and unsustainable resource use. To address this, we introduce FishPoll, an innovative serious game designed to simulate the complexities of quota negotiations under changing ecological conditions in a fictional scenario. FishPoll provides a structured, yet flexible, role-playing environment where participants take on the roles of coastal state representatives, negotiating catch allocations based on shifting stock distributions. The game incorporates a dynamic “sliding scale” mechanism that transitions quota allocation from historical rights to zonal attachment, offering a realistic and interactive framework for decision-making. Through structured gameplay and facilitated discussions, FishPoll simulates quota negotiations to illustrate the consequences of participants failing to reach consensus. Thereby, the game fosters collaborative problem-solving, policy exploration, and stakeholder engagement in fisheries management. Furthermore, it encourages discussions about allocation agreements. Playtesting with scientists and policymakers demonstrated that FishPoll enhances understanding of allocation challenges, stimulates constructive dialogue, and serves as a practical tool for research, education, and stakeholder training. Hence, FishPoll may contribute to the discourse on the tragedy of the commons while offering a valuable addition to previous intervention games. FishPoll represents a novel application of serious gaming in fisheries governance, bridging the gap between scientific modelling and real-world negotiation dynamics.

KEYWORDS

participatory approach, TAC sharing, quota negotiation, resource management, global change, decision-making, experiential learning

1 Introduction

Climate change is driving significant shifts in the distribution of fish stocks, affecting their abundance and catch potential, particularly in high-latitude and temperate regions (IPCC, 2019, 2023). In the Northeast Atlantic, species distribution and fisheries patterns have shifted over the last two decades (Fernandes et al., 2020; Le Luherne et al., 2024). These changes pose governance challenges, as traditional fisheries management frameworks struggle to adapt to dynamic stock movements, since species distributions are no longer aligned with regulations and catch allocations (Fernandes et al., 2020; Pinsky et al., 2021; Reimer et al., 2025). The increasing complexity of quota allocation has escalated the political and economic stakes of fisheries negotiations, at times leading to geopolitical conflict over fishing rights (Stenseth et al., 2020).

To mitigate these challenges, affected states must develop new quota allocation agreements that account for shifting stock distributions while ensuring equitable and sustainable fisheries management (Gaines et al., 2019; Stenseth et al., 2020). Without adaptive governance frameworks, the risk of overfishing increases, exacerbating tensions between nations and threatening the long-term viability of shared fishery resources. However, establishing such agreements is inherently complex, particularly in multi-state, multi-stakeholder contexts where national interests often conflict. A prominent example can be found in the Northeast Atlantic, where changes in mackerel distribution have occurred since 2007 (ICES, 2013). Ever since, no long-term management plan has been agreed upon by the involved parties in the mackerel fishery (ICES, 2023). This is mainly due to their inability to agree on an allocation key (NEAFC, 2015, 2016; NAPA, 2024), which is an agreed-upon set of rules or criteria used to distribute fishing quotas among different countries or stakeholders. In such cases, many countries lack robust mechanisms for renegotiating access rights or historical agreements (Gaines et al., 2018; Pinsky et al., 2018). In these contexts, there is a growing need for international agreements and good regulatory practice recommendations to guide states in addressing emerging legal and institutional challenges (Andreassen et al., in prep; Gaines et al., 2018).

While legal frameworks and policy processes remain essential, one innovative approach to addressing these challenges is the use of serious games—interactive simulations designed for education, stakeholder engagement, and policy exploration rather than entertainment (Flood et al., 2018). Serious games can offer a complementary, creative approach to capacity building under conditions of global change. They provide supportive environments for experimentation and collaboration, while fostering a culture of mutual respect, openness, and shared understanding, which is a key aspect of capacity development to address global ocean challenges (Renaud et al., 2025).

In this study, we introduce FishPoll, a serious game developed to facilitate negotiations, enhance communication, and foster conflict resolution and decision-making in fisheries governance, particularly in contexts where fish stocks are shifting due to climate change. The game enables participants to role-play as coastal state

representatives, negotiating catch allocations based on dynamic stock distributions in a fictional scenario. A core innovation of FishPoll is its “sliding scale” mechanism, which transitions quota allocation from historical rights (relative stability) to stock-based access (zonal attachment)—a key issue in real-world fisheries negotiations (Fernandes and Fallon, 2020). Through structured gameplay, FishPoll fosters dialogue, builds capacity for cooperative decision-making, and deepens understanding of the challenges in managing transboundary fisheries under climate change. It offers a practical and participatory tool that can be used in policy discussions, academic research, and educational settings to explore and test adaptive governance strategies.

This paper presents the rationale and objectives behind FishPoll, details its game design and mechanics, and shares insights from playtesting sessions conducted with scientists and policymakers. For ease of use, a step-by-step guide is presented to allow others to download, print, and play FishPoll in various policy or classroom settings. We also discuss lessons learned from stakeholder engagement, explore potential areas for further development, and evaluate the game’s effectiveness and transferability in a context of global change.

2 The FishPoll game

2.1 Background and assumptions

Serious games have been used in policy exercises and economic experiments, and have been most commonly applied in the scientific disciplines of experimental and behavioral economics, social and cognitive psychology, and environmental and cultural psychology. As a participatory research method, serious games commonly serve the purpose of stakeholder engagement and co-production as well as policy and decision support and are well suited for addressing social learning, collective action and collaborative governance, amongst others (Barreteau et al., 2021).

Research on serious games often centers on their role as educational tools that help individuals to make better informed decisions in complex or uncertain situations. They have been applied across a wide range of domains, such as global food security, disease control, biodiversity conservation, urban planning, and humanitarian support for refugees (Anderson et al., 2017; Briot et al., 2017; Perez Estrada et al., 2017). Serious games have also been applied in environmental decision-making, including climate change adaptation (Neset et al., 2020), fisheries governance (Meadows and Stermann, 2001; Parrondo et al., 2021), and resource management (Medema et al., 2016; Edwards et al., 2019; Dahdouh-Guebas et al., 2022). A common game design feature of serious games is role-playing, which facilitates learning through social interactions. Role play provides a fictional setting in which players take on particular roles in a defined situation. This not only encourages discussions among players but also allows them to explore decisions and interactions within a certain context or complex system (Barreteau, 2003; Barreteau et al., 2021).

An underlying characteristic of serious games includes that players are expected to adopt a role given to them with associated objectives, rather than following their own agenda. Another characteristic is that game capacity and complexity is limited. This means that games must be played within an acceptable and realistic duration to fit participants' available time, and hence actions need to be limited, while the game also has to be fun to play to ensure active participation. An additional characteristic is related to participants' willingness to play and the validity of the outcomes in the real world. And lastly, serious games must be able to lead players to accept the game's simulation as a reflection of real-world challenges, yet without a direct connection to these challenges, while limiting the space for players' collective exploratory behavior (Barreteau et al., 2021).

2.2 Game design

FishPoll was designed as a common-pool resource game with role-playing aspects, developed to simulate the complex challenges of quota allocation negotiations under climate-driven shifts in fish stock distribution. Given the limited real-world examples of successfully implemented allocation keys for moving stocks, there is a clear need to engage stakeholders with practical experience in fisheries governance. FishPoll was created as a participatory platform to support this process—enabling stakeholders to discuss, test, and refine allocation strategies in a realistic environment without real-world consequences.

FishPoll draws partial inspiration from PlayDecide, an open-access discussion game designed to support respectful, fact-based group decision-making (PlayDecide, 2020). Similarly, FishPoll emphasizes structured dialogue and cooperative problem-solving, enabling players to grapple with the biological, political, and legal aspects of transboundary fisheries governance. Central to the game is the concept of a “sliding scale”, which models a gradual transition between two widely used quota allocation principles: relative stability (fixed national quota shares) and zonal attachment (allocating quotas based on the location of the stock) (Fernandes and Fallon, 2020). The concept is implemented in the game through assigned player roles with opposing interests, where one player is strictly in favor of zonal attachment while one of the other players is a strong proponent of historical rights. The discussion around a sliding scale is “forced” further onto players through a moving fish stock that shifts its distribution further into other countries' waters. As the fish stock shifts across jurisdictions, the logic of zonal attachment becomes increasingly relevant. FishPoll allows participants to role-play negotiations, explore the implications of this transition, and co-construct decision-relevant knowledge through experiential learning, i.e. learning through *doing* something and then reflecting on it (Nicholson, 2012).

Designed to be completed in approximately 90 minutes, FishPoll progresses through three structured phases: the Game Master (GM) phase, the positioning and negotiation phase, and the generalization phase, followed by a debriefing. In the GM phase, players learn about the shared resource, review stock assessments, and are introduced to

their assigned country and roles. During the positioning and negotiation phase, players set their initial negotiation position and engage in negotiations with each other, respond to various stakeholder perspectives, and form strategic alliances and make decisions on quota allocations for each respective country, where consensus is encouraged but not enforced. Countries whose share of the stock is decreasing tend to advocate for relative stability, aiming to preserve historical access. In contrast, those gaining stock in their waters promote zonal attachment, calling for quota adjustments that reflect current biological realities. This dynamic interaction challenges players to balance national interests, scientific advice, and long-term resource sustainability. The players' decisions on quota allocation are then implemented in a responding scenario. After this positioning and negotiation phase, the FishPoll feedback loop is implemented: If players fail to agree on a quota distribution where the total sum remains within the Total Allowable Catch (TAC) limit, overfishing occurs, leading to stock depletion. This outcome introduces ecological consequences into the gameplay, emphasizing the importance of cooperation and sustainability. Thereby, players are not forced to reach consensus but rather have to experience the direct consequences of their actions. Finally, in the generalization phase, players attempt to formulate a general rule for a common quota allocation key. The game concludes with a facilitated debrief, where participants reflect on their decisions, group dynamics, and broader real-world parallels.

To guide players throughout the game, we developed several game components (see Table 1).

Game instructions and game information sheets (Figure 1) provide the necessary information to understand the objectives of the game, rules and mechanics, goals of the game, a code of conduct, and ethical principles for the players.

To visualize the issue of coastal states negotiating over moving fish stocks and make it more relatable for players, it was decided to create a player board for FishPoll. The board was designed for four players, with four coastal states and a Common Sea. Each coastal state differs in terms of population, dependency on the fisheries sector (% of GDP), and the size of its exclusive economic zone (EEZ). The board visualizes and reflects changes in stock distribution, showing the traditional and most recent distribution of the fictional *Fictus* fish stock (see Figure 2). The game should not be played with fewer than four players, as the negotiation dynamic will be limited. With more than four players (but less than eight, i.e. too few for an additional group) the additional player/s are allocated to the most populous coastal states in the game but given different roles e.g. one representing the fisheries authority and one representing the fishing industry.

A game master (GM) in FishPoll facilitates the progression of the game and implements the consequences of players' decisions on the affected fish stock. If players are unable to reach consensus, the GM also moderates the discussion and helps the continuation of the game. GM notes provide detailed instructions, along with tables that show how the stock distribution changes over time. The debrief and plenary discussion guide (including the General Principle Summary Table and Debrief Table), also included in the GM notes, support the GM after game end.

TABLE 1 Overview of game components and their purpose.

| Game component | Purpose |
|-------------------------------|--|
| Game instructions | Introduce players to game instructions and what they should aim to do |
| Game information | Provide goals of the game, code of conduct and ethical principles |
| Player board | Shows countries' location, fishing zones, stock distribution and movement |
| GM Notes | Instructions for the game master on how to run the game through each playing phase |
| Character sheets | Define role and country-specific interests and attitudes |
| Individual catch quota sheets | Track countries' historical catch, percentage of stock currently in their respective waters, and countries' initial negotiation position regarding their allocated TAC for each game round (round 1: year 1-3; round 2: year 4-6; round 3: year 7-9) |
| Common negotiation table | Tracks allocation of each country's individual TAC before and after negotiations with the other countries |
| General principle sheet | Asks players to propose a general principle for stock allocation based on historical rights and on geographical allocation |
| Expert committee principle | An allocation key suggested by the GM, presenting verdict from a fictive expert committee in case a group does not reach a consensus agreement for the general principle |

Character sheets (see example in Figure 3) were designed to reflect diverse opinions and assign each player a specific role. With these roles, players must present a predefined perspective on the issue of moving fish stocks. The content of the character sheets was intentionally developed to introduce adversarial positions that may lead to conflict and tension between the players during gameplay.

During the game, players are tasked with negotiating quota allocations. To support this process, we introduced a mechanism to record individual quota proposals by different players. This includes catch-quota sheets (Figure 4) for each player (coastal states) and common negotiation tables (Figure 5) to record quota negotiations of the group. Additionally, a general principle sheet was created to record the group's suggested agreement for an allocation key. If the group fails to reach consensus, the GM presents an alternative allocation key based on the verdict of a fictional expert committee.

2.3 Game mechanics: a step-by-step guide

This section provides a step-by-step guide to walk readers through a game of FishPoll. For ease of use, an overview of the game structure and game flow is presented in Figure 6.

Initial game set-up: Before the game starts, the players and the GM are seated together around a table. The game begins and players receive game instructions, game information and the player board while the GM explains that FishPoll is set in a fictional world, which consists of four coastal states that share a Common Sea. The players

FishPoll - Game Information

Goals of the Game

- 1) Engage in negotiations about the shared fish stock in a meeting between all four nations.
- 2) Find an agreement on how to distribute the quota between all four nations.

Code of Conduct

- Play your role
- Speak your truth
- Allow everybody to speak
- Respect other opinions

Ethical Principles

- Equity
- Food Security
- Dependency
- Sustainability
- Good faith



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FIGURE 1

Game information sheet to be presented to players when first being introduced to the game.

receive their character sheets of the coastal state they are representing and their initial catch quota sheets.

Players are informed about the 'Fictus' fish stock in the Common Sea, which they share with the other coastal states and the changing distribution of the stock is highlighted. The traditional and the newest stock distribution within each of the coastal state's waters is indicated on the player board.

GM Phase: The GM instructs players to familiarize themselves with their role and their country's attitude. Players are told that they are preparing for a meeting to negotiate and decide the catch quotas for all countries over the next three years. Each player is informed of their country's historical catch and the current percentage of fish stock located within their waters (via their catch-quota sheets). Finally, the GM emphasizes that the TAC must not exceed 1000kTons.

Setting initial position and negotiation phase: This phase is structured into three interdependent negotiation rounds.

At the start, players are asked to establish an initial negotiation position for the TAC they consider reasonable for the next three years, divided between the four coastal states. Each player fills in their proposed catch for the next consecutive three years on their individual catch-quota sheet. Then the players introduce themselves in character, as representative of their assigned coastal state, to the other players. The GM reminds the group of the general ethical principles of equity, food security, dependency, sustainability, and good faith.

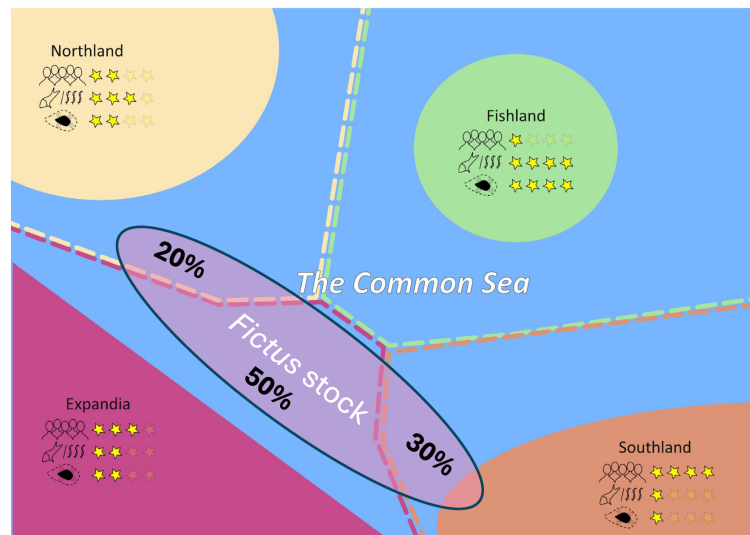
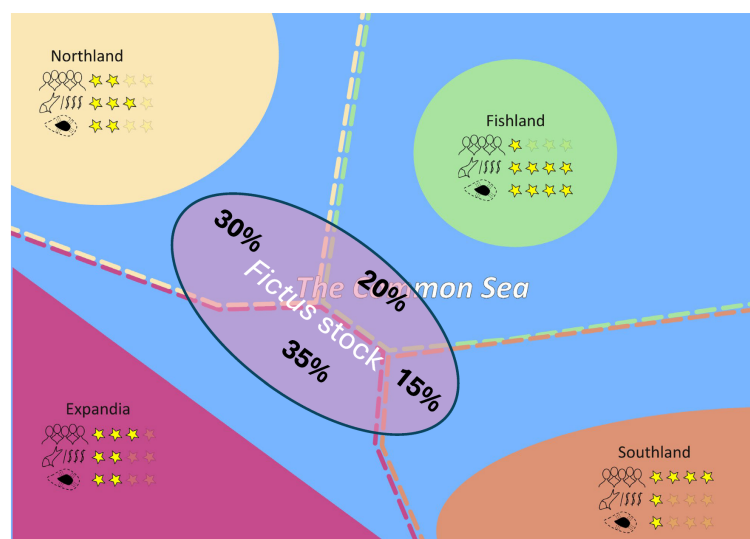
Traditional *Fictus* stock distribution in The Common SeaNewest *Fictus* stock distribution in The Common Sea

FIGURE 2

Player board with the four coastal states and the changing distribution of the *Fictus* stock – traditional distribution (top) and newest distribution (bottom).

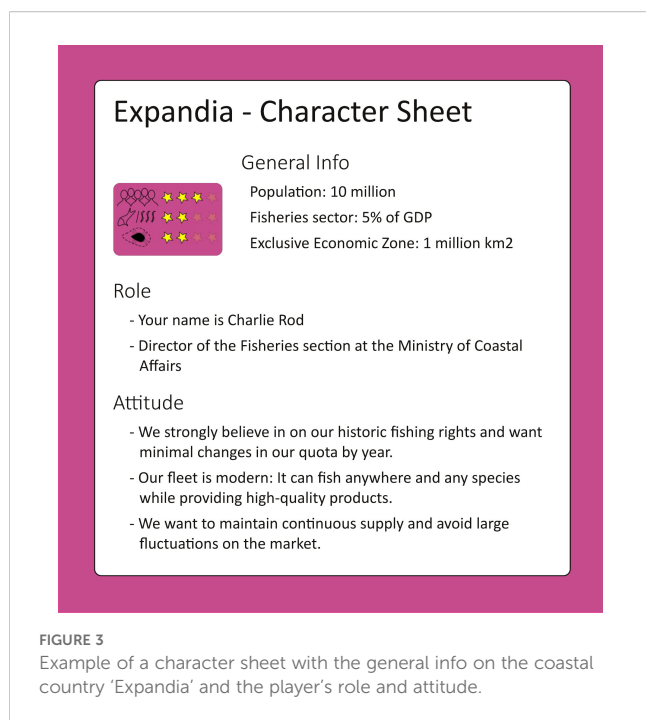
Round 1: After individually deciding on initial positions for quota allocation, players engage in a group negotiation to try to reach a common agreement on the quota allocation among the countries for the next three years (Years 1–3). After the negotiation, players are encouraged to find a consensus but are not obliged to, and to fill in the common negotiation table, indicating the agreed quota division between countries and the total catch. If there is no consensus, each country decides on how much they will catch. Players hand the filled-out common negotiation table to the GM.

Between round 1 and round 2: The GM sets a new TAC for the second round based on the players' decisions in round 1:

1. If the players successfully agree on TACs for Years 1–3 that total 1000kTons, then the GM sets the TAC for round two

(Years 4–6) to 1000kTons again. The GM explains to the players that there was no reduction in TAC because they managed to agree on individual TACs that supported sustainable fishing.

2. If the players fail to agree on TACs for Years 1–3 that total 1000kTons, but fish beyond this limit, the GM calculates the amount of 'overfishing' in Year 3 (i.e., the amount fished above 1000kTons). The GM introduces a consequence of overfishing by adding a 'penalty' in the form of a reduction of TAC. The penalty is calculated by doubling the amount of tons overfished and rounding up to the nearest 50,000 tons. The penalty is deducted from the 1000kTons and is used as the new TAC for round 2. The GM explains to the players that the TAC has been lowered due to overfishing.



Round 2: Players are informed that they all went home after the previous negotiations, and that they meet again after three years to resume their negotiations. The GM gives the new catch-quota sheets for the next negotiation round to the players (Years 4-6).

The GM gives players their new TAC, possibly modified by overfishing. Players decide on their initial positions of the shifting fish stock individually and set their respective TAC for the upcoming three years (Years 4-6) by filling in their individual catch-quota sheets. They then repeat the process from round 1, where players negotiate, and hopefully reach a common agreement on the quota allocation among the countries for the next three years

(Years 4-6). When a decision is made, players fill in the common negotiation table and hand it to the GM.

Between round 2 and round 3: As between round 1 and round 2, the GM sets a new TAC based on the players decision in round 2. The GM deducts 20% from the calculated TAC and rounds to the nearest 50,000 tons. Players are informed about the new TAC which they can allocate if they want to avoid overfishing. The GM explains that the general stock reduction was because of a combination of factors: the stock was previously overestimated, some of the stock moved out of the Common Sea, and there has been significant Illegal, Unreported, and Unregulated fishing of this stock recently.

Round 3: Players are informed that they all went home after the previous negotiations, and that they meet again after three years to resume their negotiations. The GM distributes updated catch-quota sheets to each player, covering the next three-year negotiation period (Years 7-9).

Players repeat the negotiation process as above, fill in catch-quota sheets individually, and find a consensus agreement (if possible) on the TAC and TAC distribution and hand the filled in common negotiation table to the GM.

Generalization phase: The players are asked to translate and generalize their intuitive decision-making processes of the previous rounds into a general rule. Each player has to use their understanding and experience of the prior positioning and negotiation phase, to formulate a rule or guideline by which quota should be allocated in the form of a general principle, where some form of sliding scale is implied as they have to move from historical rights to zonal attachment. For this purpose, the GM asks the players to try to formulate a general principle that all players can agree on with respect to how the TAC should change from one year to the next when the stock moves, or when the estimated size of the stock changes. Players are asked to consider the following questions when discussing and deciding on a general principle:

Initial negotiating position for Expandia – Year 4-6

| | kTons TAC / Actual catch Year 3 | Percentage of stock currently in respective waters (newest estimates) | Proposed kTons TAC Year 4 | Proposed kTons TAC Year 5 | Proposed kTons TAC Year 6 |
|----------------------------------|---------------------------------|---|---------------------------|---------------------------|---------------------------|
| Northland | | 25% | | | |
| Fishland | | 40% | | | |
| Expandia | | 25% | | | |
| Southland | | 10% | | | |
| Sum | | 100% | | | |
| Recommended sum TAC for Year 4-6 | | | | | |

FIGURE 4
Catch quota sheet for Expandia for year 4-6.

Common negotiation – Year 7-9

| | kTons TAC / Actual catch Year 6 | Percentage of stock currently in respective waters (newest estimates) | Proposed kTons TAC Year 7 | Proposed kTons TAC Year 8 | Proposed kTons TAC Year 9 | Negotiation outcome Year 9 |
|---|---------------------------------------|---|---------------------------------|---------------------------------|---------------------------------|----------------------------------|
| Northland | | 35% | | | | |
| Fishland | | 30% | | | | |
| Expandia | | 35% | | | | |
| Southland | | 0% | | | | |
| Sum | | 100% | | | | |
| Recommended sum TAC for Year 7-9 | | | | | | |

FIGURE 5
Common negotiation table for year 7-9.

- In the fairly unrealistic case that the stock remains stable, how long should it take until there is a match between the respective country's TAC and the proportion of stock in their waters?
- Should there be a limit to the amount of change in the TAC for a country from one year to the next? If so, should this be an absolute number, as in "No country will gain or lose more than 10.000 tons from one year to the next", or should it be a percentage, as in "No country will gain or lose more than 10% of the TAC that they had last year from one year to the next"?
- Should this limit apply to TAC increases, TAC decreases, or both?
- Should countries that no longer have any part of the stock in their waters still be invited to negotiate about the upcoming TACs? If so, for how many years after the stock has disappeared from their waters?
- Should there be a negative cut-off point for stock presence, as in "If less than 5% of the stock is in your waters, you are not invited to participate in these negotiations"?
- Should there be a positive cut-off point for allocated TACs, as in "Anyone who receives a TAC as a result of the negotiations will receive at least 10% of the TAC, otherwise the fishery is not viable in that country (e.g. not enough vessels to keep a single processing plant in business)"?

The players discuss and make suggestions for a general principle and allocation agreement. The players fill in their proposed general principle in the general principle sheet as a group.

Debrief: Within each group the GM runs a debrief after the final round. First, the GM summarizes the main outcome of the game, i.e. the general principle and allocation agreement in the General Principle Summary Table (available in the GM notes), to capture results in a coherent manner and to facilitate comparison between

groups. The table is based on the questions that guide players when deciding on a general principle and allocation agreement. Second, the GM collects feedback on the game experience and the game itself. The following questions are presented to the players: How did you experience the game? How did you reason during the negotiations? Was it easy to agree on a general principle? Did the negotiation feel realistic? Would the general principle you agreed upon be relevant for a real-world situation? Responses are captured by the GM(s) in the Debrief Table (available in the GM notes).

Afterwards, if playing with more than one group, all groups join for a plenary discussion with the GM(s). In this plenary discussion, each group presents their results. The General Principle Summary Table and the Debrief Table are displayed to the plenary. The groups are asked to identify commonalities between the solutions presented. Can the plenary agree on a sharing principle? Groups are asked to discuss if the general principle could be applied in a real-world situation in their area. What consequences would this have for the quota allocation in the future? Would the fishery stay sustainable despite moving stocks? See also the Debrief Guide for GM(s) in the GM notes in the [Supplementary Material](#).

2.4 Game testing

Three testing and playing events were conducted: 1) with 14 international PhD-students in three groups at UiT – The Arctic University of Norway in March 2019, 2) with 20 international scientists in five groups participating in the EU-funded ClimeFish project in April 2019, and 3) with 16 European scientists and stakeholders interested in the Northeast Atlantic pelagic fisheries in four groups during a ClimeFish meeting in April 2019. Playing the game with stakeholders involved in Northeast Atlantic fisheries seemed particularly relevant as fish stocks within the Northeast Atlantic are showing distributional shifts ([Baudron et al., 2020](#); [Fernandes and Fallon, 2020](#)) and states are not able

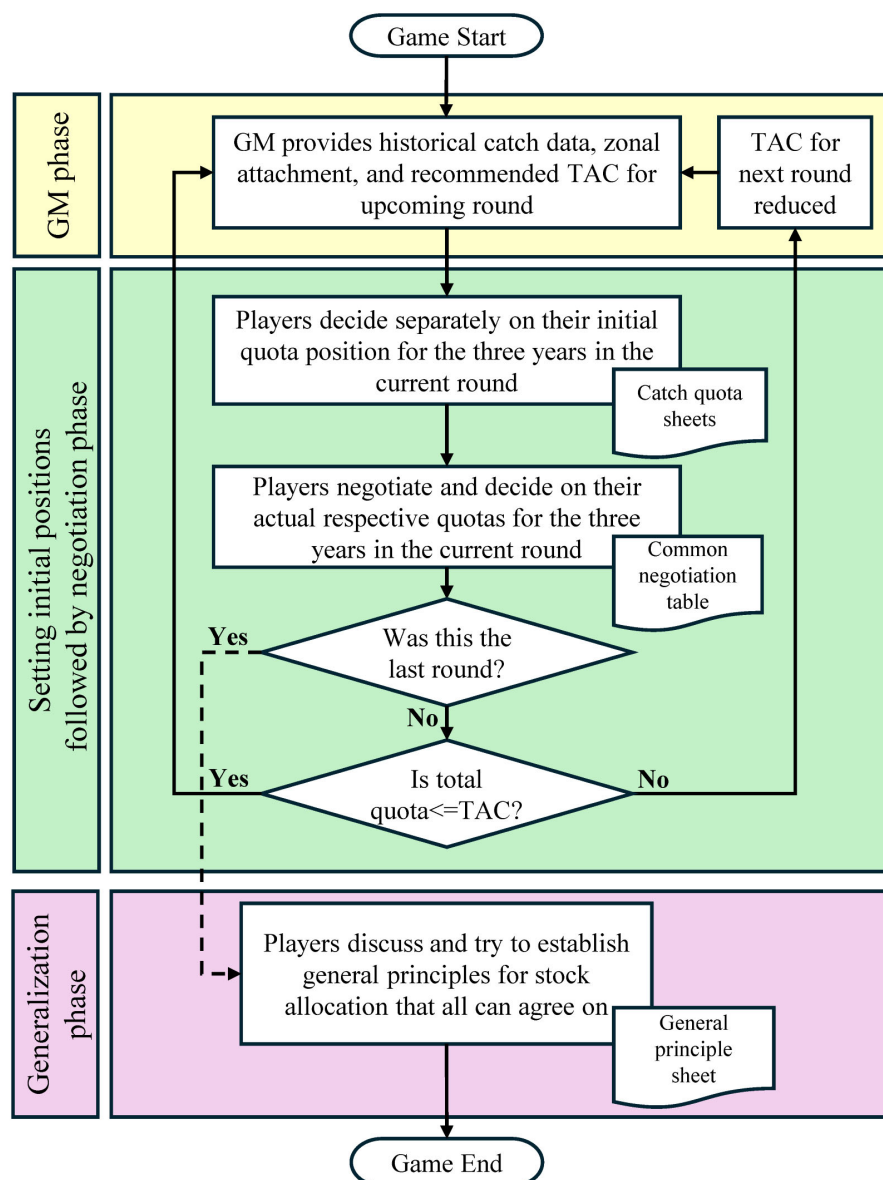


FIGURE 6

Overview of FishPoll game structure and flow, showing the game components used during each step.

to agree on how to share quotas (Spijkers and Boonstra, 2017; Stenseth et al., 2020).

The first two events were used to test the game mechanics, practice the GM role and enhance the instructions. At the third event four groups of fisheries stakeholders and experts with both social and natural science backgrounds reviewed the FishPoll game content. Each of the four groups play-tested the game for validity and usability and minor changes were made to the information materials, the materials for players and the instruction sheets for the GM.

Testing FishPoll with scientists and stakeholders:

The players were assigned into groups to create well-balanced player groups in terms of gender, age, professional expertise and seniority. Also, while the country names in FishPoll are fictitious,

these countries are clearly inspired by actual countries involved in these types of negotiations in the Northeast Atlantic (Iceland, Norway, UK and the EU), and care was taken to allocate each stakeholder to a fictional country different from the one they actually represented, thus forcing everyone to argue a different point of view from the one they would normally represent.

The stakeholders and scientists were curious and interested in playing the game and players in all four groups remained engaged throughout the gaming time. All players managed to understand and follow the game mechanics. There were lively discussions in the groups and strong arguments were presented from different players, while other players insisted on their quota and were not willing to move from their position. In the end, all four groups managed to reach a consensus agreement on an allocation key and a general

principle. Debrief within the groups focused on each player's game experience. During the debrief in plenary, each group presented their suggested allocation agreement to the other groups. Then the players discussed the presented general principles, their gaming experiences and their impressions and usefulness of the game. None of the 12 player groups fished far above the declining TAC in three rounds that would have resulted in depletion of the stock.

2.5 Game material and instructions

All game materials and detailed game instructions are available in the [Supplementary Material](#) as ready-to-play print files.

3 Discussion

3.1 Game characteristics

FishPoll is a negotiation-driven serious game designed to simulate the challenges of quota allocation for transboundary fish stocks under climate change. Unlike other fisheries-related serious games, such as Fishbanks (Meadows and Sterman, 2001) which primarily focus on overexploitation and resource depletion, FishPoll places emphasis on policy negotiations and multi-stakeholder conflicts. By assigning predefined roles to participants, the game replicates the complexities of real-world fisheries governance, requiring players to balance ecological constraints, economic priorities, and geopolitical pressures in decision-making. FishPoll can bridge between hypothetical developments and knowledge from experience by encouraging players to consider possible scenarios.

The three-round structure of FishPoll contributes to a narrative that deepens player immersion and engagement in the game (Naul and Liu, 2020). As the consequences of earlier decisions unfold over time, players begin to experience the cumulative impact of their strategies. This encourages reflections on long-term thinking and adaptive governance.

A defining feature of FishPoll is its sliding scale mechanism, which gradually shifts quota allocation from historical rights (relative stability) to stock distribution-based allocation (zonal attachment). This creates a dynamic decision-making process, forcing players to reconsider their negotiation strategies over multiple rounds. The tension between maintaining established quota shares and adapting to changing stock distributions mirrors real-world fisheries disputes, making the game a useful tool for exploring adaptive governance solutions. It also embraces Elinor Ostrom's idea that in certain conditions, groups could avoid the tragedy of the commons without the dependency on top-down regulation (Ostrom, 1990).

For the duration of one game, a player takes on a distinct role, and by doing so, they gain new perspectives (Vaajakallio and Mattelmäki, 2014). Through taking on roles, players are allocated societal priorities and can take on adversarial positions without being compromised. As such, role play in gaming can facilitate a shift in

views and help to perceive and understand other players' positions (Ahamer, 2013). The assigned player roles in FishPoll create an argumentative landscape, while the code of conduct and game rules promote ethics of negotiation. During the gameplaying phases as well as during debriefing, the game design and facilitation allow for players to reflect, participate, and share information, which are processes known to foster social learning (Medema et al., 2016). Several scholars highlight the debriefing phase as a crucial point where gameplay experiences are transformed into more meaningful and reflective learning (Lederman, 1992; Crookall, 2010). The gaming aspects of facilitation and communication are typically found in climate adaptation games, and have been found to foster effective serious game engagement and increase the learning aspect (Flood et al., 2018). These aspects are reflected in FishPoll via the clear framing of the moving stock and changing quota, facilitated through the GM and the players' catch-quota sheets.

3.2 Stakeholder perspectives on the sliding scale approach

The FishPoll game served as a platform for engaging stakeholders with an interest in the Northeast Atlantic fisheries in discussions about quota allocation under climate change. Through gameplay and structured debriefing sessions, participants explored the feasibility of a general principle for a sliding scale approach. While stakeholders expressed diverse opinions on implementation, certain areas of consensus emerged. For example, most agreed that transitioning from historical quota shares to zonal attachment should occur gradually over three to five years to balance economic stability with ecological sustainability. However, some participants emphasized the need for more flexible timelines based on species-specific stock mobility and national economic dependence on fisheries. They also agreed that there should be a limit to change in TAC for a country, both for increase and decrease, from one year to the other. This is in line with the common practice on gradual quota change in a fishery to avoid abrupt change in the industry (Kvamsdal et al., 2016).

However, regarding the principle of zonal attachment, stakeholders had mixed opinions. Generally, stakeholders agreed that zonal attachment should be taken into consideration in the allocation of fisheries resources. Yet, the opinion was that zonal attachment should not be the only principle considered. Instead, negotiations over stocks should consider a variety of criteria and principles, e.g. historical catch, and historical relationship to the stock in question, raising questions like:

- Do the people in the country eat the fish in question?
- Do processing facilities exist?
- What is the cost of buying new or updated gear to access the new fishery?
- To what degree is the country in question dependent on the fishery (GDP, number of fishers, etc.)?
- What has the research effort been, and who has contributed to knowledge creation and sustainable management?

3.3 Negotiation dynamics

A key observation from gameplay was the diverse negotiation behaviors among participants. While player roles were predefined with specific objectives, actual behavior varied significantly. Some participants treated the game competitively, aiming to maximize their country's quota at all costs, while others actively sought collaborative solutions that would benefit all players in the long term. This divergence suggests that, even in a simulated setting, negotiation behavior is influenced by personal traits and perspectives, risk tolerance, and strategic inclinations. This finding closely mirrors real-world quota negotiations, where geopolitical and economic pressures often override formal policy frameworks. In some cases, players deviated from their assigned roles, instead advocating for personal views on fair resource allocation. This could be improved by refining role descriptions or introducing stronger incentive mechanisms to encourage more authentic negotiation behavior. For example, modifying scoring criteria to reward compromise and long-term sustainability rather than just immediate gains could help align player actions more closely with real-world fisheries governance.

While most groups eventually reached an agreement, some negotiations were prolonged and challenging, as players hesitated to adjust their positions. In some cases, participants were reluctant to compromise, even when overfishing penalties were introduced, reflecting the real-world complexities of international quota negotiations. This is also in line with the objectives of the game, namely, to simulate negotiations and their outcome, rather than reach consensus.

3.4 Take-aways from playtesting

FishPoll proved to be an effective tool for stakeholder engagement, interactive learning, and policy discussions around quota allocation for shifting fish stocks. Across all playtesting sessions, stakeholders actively participated in negotiations, engaged in discussions, and reflected on the challenges of fisheries governance under climate change. The game encouraged interaction between participants from different backgrounds, fostering interdisciplinary dialogue among scientists, policymakers, and industry representatives.

Most players found the game engaging, describing it as an interesting and unconventional way to explore complex issues. However, some participants felt constrained by their assigned roles, as they had limited flexibility in their decision-making processes. At the same time, this role-based structure forced players to adopt different perspectives, encouraging them to step outside their own biases and consider alternative viewpoints—a key objective of the game. Some stakeholders also suggested that the game could be made more realistic by incorporating multiple fish stocks rather than focusing on a single species. In real-world fisheries negotiations, states with shared stocks often negotiate across multiple stocks simultaneously, using trade-offs to reach agreements (Stokke et al., 2022; EC, 2024).

The importance of the debriefing process was particularly evident in this study. As noted in previous research (Barreteau et al., 2001; Nicholson, 2012), debriefing sessions are a crucial component of serious gaming, allowing players to reflect on their experiences, provide feedback, and link gameplay insights to real-world contexts. In FishPoll, the debriefing led to highly dynamic discussion, where participants reflected on their negotiation strategies, the realism of the game's mechanics, and how the sliding scale approach could be applied in real-world fisheries governance. Several stakeholders commented that the complexity of discussions increased during the debrief, as they placed game-based insights into a broader fisheries management context.

Beyond the structured debrief, the game had a lasting impact on stakeholder interests. Several participants later requested copies of FishPoll to use in their own organizations and stakeholder meetings, recognizing its value as a tool for training, policy discussions, and participatory research. This underscores the game's potential as a flexible and scalable tool for different fisheries governance contexts, from educational workshops to international policy negotiations.

Key learning outcomes from playtesting include:

- **Experiential learning:** FishPoll provided a hands-on way for participants to experience the challenges of quota allocation, balancing national interests with sustainability goals.
- **Perspective shifts:** Role-playing helped players understand the economic, ecological, and political constraints faced by different stakeholders in fisheries governance.
- **Structured dialogue:** The game fostered meaningful discussions between players from different disciplines, encouraging cooperation and shared problem-solving.
- **Value of debriefing:** The post-game discussions were crucial in deepening engagement, allowing players to connect their game experiences to real-world fisheries challenges.

3.5 Areas for further development of the game

Several areas for game improvement and future research were identified based on stakeholder feedback. We do not recommend that all the improvements are introduced to the game as each additional tweak will complicate the game:

- **Introducing multiple fish stocks**
Including at least two species in FishPoll could encourage greater strategic depth by allowing players to exchange quotas across stocks, fostering win-win scenarios rather than zero-sum competition. However, this would also introduce greater complexity, increase play time, and require careful balancing to ensure accessibility and engagement.
- **Enhancing role representation and authenticity**
Future iterations of FishPoll could refine role descriptions by developing additional player description for three fishers'

representatives. One may also wish to adjust the roles to simulate the real-world governance structure.

- Expanding incentives and penalties

To encourage more realistic negotiation behavior or test stakeholder response one may introduce more incentives. For example, a system that rewards long-term cooperation (e.g. stability bonuses for countries that engage in fair negotiations) or penalizes aggressive overfishing strategies (e.g. loss of international credibility) could help reinforce the real-world trade-offs policymakers face.

- Introducing uncertainty in the game

To increase realism in the game one may introduce uncertainty by determining positioning and size of stock based on if a heat wave occurred recently (where heat wave = dice showing even), and then e.g. reduce uncertainty if players pay a part of their quota for research and increased precision in stock size and distribution estimates next year.

- Comparing the game results with previous game results and real-world solutions

In the panel discussion with player groups one could towards the end bring in the results from previous games, and/or discuss real-world examples to stimulate the discussion and identify new approaches. Such an example is the quota sharing scheme for shared groundfish stocks between Canada and the USA in the Georges Bank region (TMGC, 2001, 2023).

- Exploring digital implementation

While FishPoll was designed as a physical tabletop game, it could also be developed as a digital version that could be played online. A digital platform could allow for broader participation, integrate data-driven simulations, complexity, and enable real-time adjustments based on player decisions. This could be particularly useful for policy workshops, international training programs, and educational institutions. In a digital version of the game a GM would not be necessary.

3.6 Global environmental change and the transferability of FishPoll

The challenges addressed through FishPoll, namely, transboundary resource governance, negotiation under uncertainty, and equity in quota allocation, are not unique to the Northeast Atlantic. They are emblematic of broader governance dilemmas emerging from global environmental change, where ecosystems, resource distributions, and geopolitical relationships are being reshaped by shifting baselines. Climate-induced changes in species distributions are already affecting fisheries worldwide, and projections estimate that by 2030, 23% of transboundary stocks will have shifted while 78% of the world's Exclusive Economic Zones will have encountered at least one shifting stock (Palacios-Abrantes et al., 2022).

Against this backdrop, FishPoll provides a transferable tool for engaging with these complex challenges. Its core mechanics, negotiating quotas under shifting stock distributions, balancing

historical claims with ecological realities, and managing stakeholder asymmetries, are relevant to any transboundary or contested marine resource system. The sliding scale mechanism, for instance, could be adapted to simulate alternative transition frameworks that incorporate climate vulnerability, economic dependence, or evolving legal norms.

Moreover, FishPoll's emphasis on role-playing and structured negotiation provides a flexible platform that can be adapted to various regional, institutional, or thematic contexts. Fish Poll is also well suited for simulating negotiations about marine and freshwater resources in a country e.g. among states, provinces, and municipalities, or within a country or state to discuss quota allocation between gears (which often have spatial or depth restrictions) or sectors such as small boats vs. large/processing vessels. With relatively modest adjustments, the game could be used to simulate other shared resource challenges, such as transboundary water governance or migratory species management, supporting dialogue, trust-building, and policy innovation. Its experiential format allows participants to explore legal, ecological, and political tensions in a risk-free setting, thereby building capacity for real-world negotiation and decision-making.

FishPoll thus contributes to a growing family of serious games that serve not only as tools for learning and engagement, but also as boundary objects, bridging the divide between scientific knowledge and policy action in the face of rapid global change.

Author contributions

CW: Visualization, Methodology, Formal Analysis, Writing – review & editing, Writing – original draft, Investigation, Conceptualization. MA: Project administration, Formal Analysis, Methodology, Visualization, Funding acquisition, Conceptualization, Investigation, Writing – review & editing. TS: Investigation, Visualization, Methodology, Writing – review & editing. PO: Conceptualization, Investigation, Visualization, Funding acquisition, Writing – review & editing, Formal Analysis, Methodology.

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Conflict of interest

Author CW was employed by Akvaplan-niva. Author PO was employed by Nofima.

The remaining authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Generative AI statement

The author(s) declare that Generative AI was used in the creation of this manuscript. The large language model ChatGPT, Model 4o from Open AI has been used to edit text of this publication.

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Supplementary material

The supplementary materials provide the FishPoll game as ready-to-play print materials. We recommend printing the player board in A3, while the other sheets can be printed in A4.

The Supplementary Material for this article can be found online at: <https://www.frontiersin.org/articles/10.3389/fmars.2025.1625861/full#supplementary-material>

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