Gaming the Future of the Ocean: The Marine Spatial Planning Challenge 2050

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Abstract. The authors present and discuss the conceptual and technical design of the game Marine Spatial Planning (MSP) Challenge 2050, developed with and for the Netherlands' ministry of Infrastructure and Environment. The main question in this paper is: What constitutes the socio-technical complexity of marine areas and how can it be translated into a simulation model for serious game-play with marine spatial planners? MSP Challenge 2050 was launched in March 2014 in a two day session with twenty marine planners from six countries. It aims to initiate and support MSP in the various Atlantic regions by bringing policy-makers, stakeholders, scientists together in a 'playful' but realistic and meaningful environment. In the North Sea edition of the game, six countries make and implement plans for this sea basin over a period of 35 years, with cumulative effects of their sectoral and national decisions emerging. The authors conclude that the combined and iterative use of complexity modelling and gaming is effective from the perspectives of design (development of a MSP model), research (insight acquired on MSP) and policy (policy-oriented learning and analysis for MSP). Further development and global dissemination of MSP Challenge 2050, as well as research and data collection, is foreseen.

Keywords: Complexity, Global System Science, Integrated Planning, Marine Spatial Planning, Policy game, Simulation-game, Serious game, Design.

1 Policy Making in the Wake of Complexity

For most of history, man has had to fight nature to survive; in this century he is beginning to realize that, in order to survive, he must protect it. Jacques-Yves Cousteau, (French Explorer, 1910-1997).

1.1 Socio-Technical Complexity

There are many examples that can back the proposition that socio-technical complexity is at the forefront of public policymaking, and that managing socio-technological

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complexity is the common denominator among the *grand challenges* of modern-day society [1]. Climate change, the banking crisis, the flooding of urban areas, migration are just a few consequences (or manifestations) of socio-technical complexity. In short, socio-technical complexity (STC) means that the complexity residing within the *natural-technical-physical* (NTP) realm spirals the complexity residing in the *socio-political* (SP) realm and vice versa (see Figure 1).

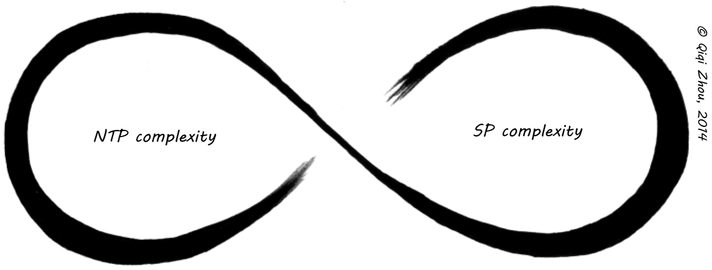

Fig. 1. Socio-technical complexity

Such spiralling complexity between NTP and SP complexity is prone to give the public policymakers involved persistent and recurrent headaches. That being the case, the diagnosis that grand challenges in society are both socially and technically complex, does not say very much about the 'patient's' condition or prospects, or about effective remedies (if there are any). So, the question should be asked what makes problems socio-technically complex and, even more important, how can we support public policymaking in the wake of socio-technical complexity?

1.2 Policy Response

Fortunately, there is growing awareness among scientists and politicians of the importance of understanding complexity and finding new ways to make policy in the wake of it. A connection with new media and computer technology is commonly made in these new forms of public policymaking, because things like big data analysis, visual analytics, citizen science, crowd sourcing, e-participation, and new forms of modelling, simulation and gaming (MSG) seem particularly suited to surround sophisticated analysis with extensive participation [2]. Many of such methodological innovations are – feel, look - *like game play* because they aim to let stakeholders play with (digital) models of complexity. The current EU initiative on *Global System Science* (DG Communications Networks, Content and Technology) calls for Global System Science ('FETPROACT-1-2014,' n.d.): 'Global challenges need fundamentally different policies, more *integrated* across sectors and stronger rooted in evidence and broad societal engagement. […] GSS will provide scientific evidence highly *integrated* across different policy sectors […]. Upfront stakeholder engagement in the process of gathering evidence is insufficient, e.g. in input to policies to reduce climate change impact. Collaborative ICT tools will facilitate *stakeholder engagement* in evidence gathering and thereby increase trust in *scientific evidence*.' ('Global Systems Science

- European Commission,' n.d.). This general perspective on Global System Science has significant consequences for the wider H2020 research agenda, among others in the work programme for *Blue Growth: Unlocking the potential of Seas and Ocean*s (H2020-BG-2014/2015).

1.3 Earth Systems

Earth systems (forests, rivers and oceans, etc.) are an obvious target of global system science because they are under pressure from climate change and economic growth, and full of uncertainties and controversies about causes, consequences and coping strategies. Here, the dual nature of STC manifests itself clearly. In the realm of NTP complexity, earth systems are governed by the laws of nature, although we face severe limitations in how much we know about them (i.e. the hand of God). Scientists can be confused or err, but what we do know is stored and analysed in databases, GIS systems and simulation models that can simulate complexity through cause–effect and feedback relations. These may give us a glimpse of the future [5]. However, if we decide to negotiate out 'truth' for the sake of 'politics', reality will strike back sooner or later. At the other end of STC – the realm of socio-political complexity – there are enormous interests at stake in the way we, for instance, arrange our future energy provision. Because in the world of politics, truth is largely constructed, we can 'negotiate out' political problems by making compromises and deals. We can, for instance, decide to manipulate, ignore, buy off or compensate those who suffer the effects of shale gas drilling. Furthermore, data and knowledge systems are scattered among an almost infinite number of proprietary institutions. Large-scale trends associated with climate change, such as sea-level rise and weather extremes, affect numerous other issues at various geographical and spatial levels and in such sectorial domains as transport, health, housing and water. In *'big problems'*, everything is connected to everything [6].

1.4 Fragmentation

In order to reduce the complexity of 'big problems', system boundaries need to be drawn; but this gives rise to further fragmentation and compartmentalization into numerous 'silos' of governance and research. To some extent, this silo'ing is unavoidable – it is pragmatic, efficient and legitimate. But it is also a reductionist approach: when the problem becomes too big to handle, we simply break it up into manageable pieces [7]. Unfortunately, 'big problems' do not stay within the arbitrary boundaries of governance departments and research disciplines. So, the question is, how and when the various fragments of a 'big problem' can be put back together again. This in a nutshell explains the call for global system science, integrated (holistic) science and integrated policy analysis. Let us give an example from one of the most important earth systems: the ocean. What constitutes the socio-technical complexity of marine areas, and how can we understand and manage it in an integrated manner? And can we game the complexity of the ocean to achieve more integration in planning?

2 The Socio-technical Complexity of Marine Spatial Planning

2.1 The Rising Importance of Marine Spatial Planning

In 2008, the European commission published its ‘Roadmap for maritime spatial planning: Achieving Common Principles in the EU’ [8], followed by a 2010 Communication ‘Maritime Spatial Planning in the EU — Achievements and Future Development’ [9], which paved the way for a Framework Directive for Maritime Spatial Planning [10]. Under the EU marine strategy framework directive (MSFD), member states are required to make an initial ecological assessment of their waters in respect of each marine region or sub region and then define measures, including MSP, to achieve ‘good environmental status’ (GES). In March 2014, agreement on the directive was reached, and it now needs to be confirmed by the Council and the European Parliament. According to the responsible EU commissioners, ‘the directive will help Member States cooperate more closely over cross-border sea areas, enabling them to take full account of land-sea interactions when developing their Maritime Spatial Planning. (…) Maritime Spatial Planning is a cornerstone of the Commission's Blue Growth (BG) strategy and of Integrated Maritime Policy. (…) It should (…) help establish coherent networks of Marine Protected Areas, for which cooperation on planning across borders is essential, and ensure the participation of all stakeholders in planning processes.’ (‘Maritim Affairs and Fisheries Newsroom,’ n.d.).

2.2 Modelling STC of Marine Areas

The ‘big’ problem of MSP is that marine ecosystems around the globe are increasingly being affected by human activities such as fisheries, shipping, offshore petroleum developments, wind farms, recreation, tourism and more. These can be visualized as the ‘pressures’ that human activities have upon marine eco- and geo systems (see Figure 2). The data and knowledge about how ecosystems are affected human activities by human activities are visualized as stressors (see Figure 2).

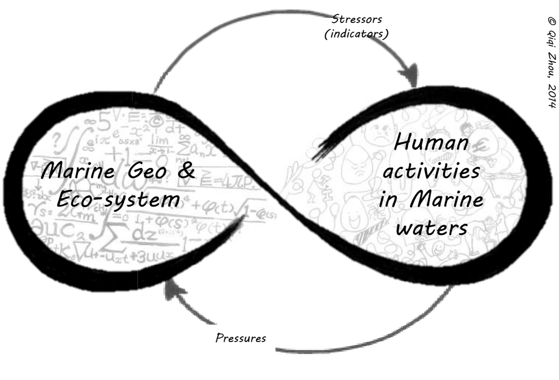

Fig. 2. Pressures and stressors

The simple scheme in Figure 2 gives us a first understanding of how NTP complexity and SP complexity spiral into STC complexity of marine areas and can be further elaborated as follows (see Figure 3):

1. *NTP-complexity:* This is represented by the feedback loop and delay symbols in the left part of Figure 3. Geo-system and eco-system of marine areas by themselves are of staggering complexity, full of non-linear behaviour, feedback relations, delays, and interaction rules. There is no saying how much we know about the complexity of marine ecosystems, but is fair to say that there is more that we do not know, than know. Scientists for instance model the build-up of pollutants in the ecosystem, and the effect it has on sea life [12]. Yet, it may take some time before the interaction effects within geo and ecosystems become apparent. In terms of scales and levels - from deep below sea floor to high above sea level - there is enormous heterogeneity of elements. Boundaries of subsystems are almost arbitrary: when it comes of seas and oceans, everything is connected to everything. Therefore we break up our knowledge into disciplines, theories and methods. Parts of what we know are captured in *geographical information systems* (GIS). Data about wind speed, currents, sea depth, sea levels, geological layers and minerals are stored in numerous data bases and models. Marine biologist, ecologist, and others have become quite advanced in modelling eco-systems, for instance with models and simulations like Eco Path (a food chain model) [13]. Some of this can be publically accessed but many data-systems and simulation-models are proprietary; and there is so much scattered information that searching and finding it, is almost impossible. The coupling of more data and more simulation-models is proposed to find more integrative knowledge about the complexity of the marine geo- and ecosystem.
2. *SP-complexity:* This is represented by the feedback loop and delay symbols in the right part of Figure 3. Human activities at sea are wide ranged and profound: from recreational sailing, diving and fishing, to mineral exploitation and wind farming. Many of the human activities at sea are linked to other complex systems, such the global energy or innovation system. One human activity at sea – for instance off shore wind farms or oil platforms - may cause or hinder other human activities, such as the redirection of shipping routes, the flying of helicopters, or the ban of fishing. A human activity today may prevent other human activities in the future. Furthermore, there are multiple interactions among all socio-political actors who have divergent beliefs, stakes, interests, actions, claims etc. with regard to the marine area.
3. *STC:* The interactions between the NTP and the SP complexity spiral into an even higher level of complexity, e.g., flaring stakeholder disputes on the cumulative impact of several human activities in a marine area. Despite the trend to more data, better models and more integrative simulations, there is an awful lot that scientists do not know about the marine geo- and ecosystem. There are cumulative effects of many human activities upon the marine ecosystem, but these are largely unknown and/or disputed. Indicators to monitor the stress of human activities put on the geo- and ecosystem are insufficient, inadequate or disputed. Trans-boundary issues spiral the complexity of MSP: e.g., human activities or policy measures in/by one country can be the problem of another country, and so on.

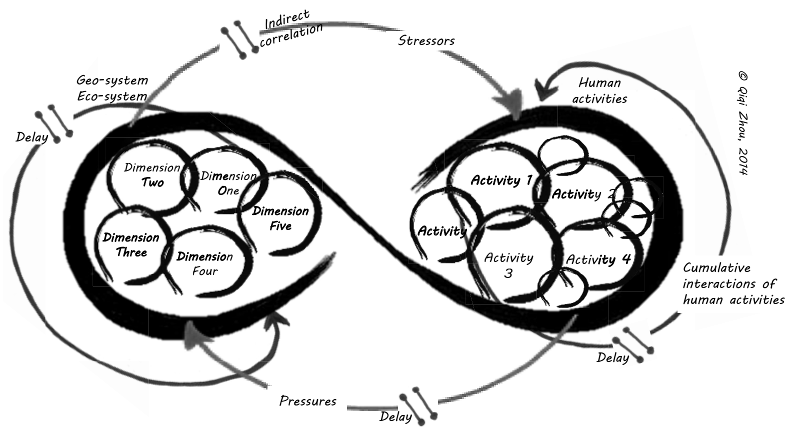

Fig. 3. A STC model of MSP

2.3 The Science-Policy Interface

The 'big problem' of managing the human pressures upon the marine ecosystem, needs to be resolved in the nexus or interface of science and policy. This explains the culmination of proposals and methods for an integrated, eco-system based approach to MSP. Calls from scientists for integrated science and modelling usually entail the incorporation of more data about the impact of more economic sectors upon more dimensions of the eco- and geo system. Politicians and stakeholders on the other hand will commonly urge for more stakeholder consultation in the consideration of interests (see Figure 4). In this fashion, the demand for integrated analysis ánd stakeholder participation, is driving marine spatial planning. The fusion of the two in integrated, participatory analysis, makes it 'like game-play'.

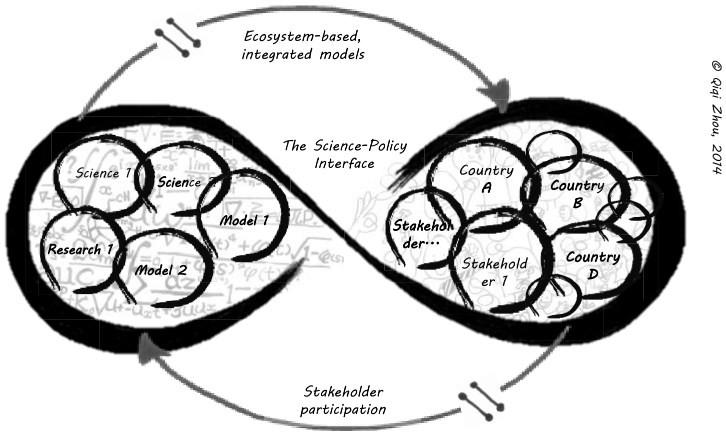

Fig. 4. Worlds of Science and Politics in marine spatial planning

2.4 Marine Spatial Planning

In most simple terms, MSP is ‘spatial planning at sea’, thereby dealing with human use of sea space. In many cases (especially in Europe) two or more countries share the same sea basin or marine space, as in The Sound, the Kattegat and the Skagerrak, the Gulf of Finland, the Baltic Sea and the North Sea. The cumulative effect of all human maritime activities and all sectoral planning decisions in one or more countries in a marine basin can impact the entire basin as an ecological and economic system. In other words, marine ecosystems are not bounded by administrative borders (see Figure 4 at right side). Consequently, there is a need for transnational co-operation in MSP to ensure that these pressures and effects are adequately managed and planned, and also that opportunities are identified and realized. Given the fact that MSP is about competing spatial claims, assessing the potential impact of human activities is bound to lead to controversy [14]. Societal or stakeholder discussions are likely to flare up about the potentially negative impact of, say, constructing wind farms [15], [16] or offshore drilling for gas on sea birds and mammals. Or, as during the Brent Spar controversy, scientific claims may be used to win a strategic game [17], [18]. In cases of uncertainty and controversy, planning professionals and stakeholders commonly turn to science for answers – that is, for facts and proof – and arbitration. Although we know a lot about marine ecosystems, there is even more that we do not know, especially when marine ecosystems are influenced by the cumulative activities from socio-political systems. One major uncertainty, for instance, concerns the amount of stress that specific human activities put on the marine ecosystems and how then marine ecosystems respond in the short, medium or long term. This becomes even more problematic when we consider the cumulative effects of so-called stressors, i.e. the negative impact of the marine eco-system such as reef degradation and habitat destruction. Actually, dealing with cumulative impacts is one of the big challenges for MSP. GIS technology allows us to overlay various activity, pressure and impact maps and at the first glance to determine the sum of those impacts, but the effects may actually be much more complicated and subtle than simply adding together impacts.

3 Gaming the Complexity of Marine Spatial Planning

3.1 Gaming

STC complexity needs to come to some kind of synthesis at the Science-Policy Interface. Precisely this argument was put forward, in slightly different words, by Dick Duke in Gaming: the Future’s Language [19], where he argued for gaming as a holistic language of complexity. ‘The interweaving of problems in this era has forced attention to wider and more complex fields by each decision maker and by staff or research efforts set to aid him. The mode of understanding is one of gestalt appreciation rather than explicit knowledge of bits of data.’ [19, p. 43] [...] The citizen, policy researcher or other decision-maker must first comprehend the whole – the entirety, the system, the gestalt – before the particulars can be dealt with.’ [19, p. 10] Let’s see how the STC of MSP can be turned into a complexity model that can be played.

3.2 First Experiences with MSP Challenge 2011

MSP Challenge 2050 is a follow up on an earlier version of a similar game that we refer to as MSP Challenge 2011. To understand the 2050 edition, it is necessary to

Table 1. Comparison between 2011 and 2050 editions

MSP Challenge 2011	*MSP Challenge 2050*
Development in 2011	Development between 2012-2014
Played in Lisbon 2011 & Reykjavik 2013	Launched in Delft, February 2014
Four countries	Flexible number of countries: 4 - 8
Sea of Colours	Sea of Colours
Based upon Kattegat but changed	Based on accurate data of North Sea
60-80 players in one session	18-40 players in one session
Minimum of 8 hours play	Four to forty (discontinuous) hours of play
Planner roles with eight stakeholder groups per country	All players in a country are planners
Simplified data	Realistic data and maps
Digital drawing tool	Simulation, foodweb calculations
60 layers of map information	Flexible number of layers of map information
2D	2D to 3D zoom in
Individual lap tops, not networked	3 lap tops per country, networked
Learning, training, collaboration	citizen and stakeholder participation, learning, training, policy exploration, design and scenario development, etc.
Limited performance indicators	Performance indicators, dashboard, analytics
Limitations:	*Limitations*
Great event effort; large facilitation effort	No stakeholder interaction
No simulation;	*Future:*
Not networked;	Interconnection with GIS;
No underlying performance model;	Customization and changing maps
Case not changeable	Train the trainer; dissemination (website, licensing, trailer).

know a little about the first edition. In 2011, the Netherlands Ministry of Infrastructure and the Environment (I&E) commissioned and financed the design and facilitation of the simulation game on behalf of an international planning group led by the International Council for the Exploration of the Sea (ICES). Actual design of this edition of the game took place between August and November 2011, and it was played at two occasions, in 2011 (Lisbon) and 2013 (Reykjavik) with around sixty international marine planners in each session. Results of the Lisbon session have been published in [20]. In November 2013, policy makers from the Nordic countries played the MSP Challenge game in Reykjavik, Iceland. The one-day game-play was part of a two day workshop commissioned by 'Havgruppen' (transl., marine group) under The Nordic Council of Ministers (Nordic Council of Ministers, n.d.). The aim was to establish a common understanding of the ecosystem approach and the application and administration of the Nordic seas. Both sessions were considered a success and the Netherland's ministry saw potential for a new edition of the game, with advanced features but easier to disseminate and organize. The end vision is a digital aquarium where multiple users in different countries can playfully make marine spatial plans on the basis of real and accurate data. Table 1 compares the 2011 and 2050 editions.

MSP Challenge 2050 initiates and supports integrated MSP planning processes in the various Atlantic regions by bringing policy-makers, stakeholders, scientists and citizens together in a 'playful' but realistic and meaningful environments. The game has three potential uses that can be combined:

1. Enlightenment (e.g. awareness, general education)
2. Planning support (exploration, consultation, design)
3. Research and analysis (data collection, meta-analysis of results, evidence based recommendations).

The game is designed to make maximum use of participants' general and expert knowledge about the region. The game is not well-suited for, or interesting to players who lack affinity for its content and context. The format of game-play is flexible, it can be played in a national or international workshop or meeting, be part of a conference, it can be integrated into a curriculum, or demonstrated in a science museum. It can even be distributed (online). The exploration with MSP Challenge can be quick and shallow (e.g., for demonstration purposes), or be longer and profound (e.g. in a planning process). The game-play can be paused periodically for facilitated discussions among participants and /or lectures that go in-depth on certain issues, like cumulative effects or safety zones in shipping routes. It is also possible to spread out the game-play over a longer period of time, like three days of a conference, a week of training or several weeks of a curriculum. The objective of MSP Challenge 2050 is to contribute to international learning processes with regard to ecosystem-based, integrated and participatory MSP (as described above), with a particular focus on the following aspects:

1. The underlying socio-technical complexities of MSP
2. The underlying regulatory principles and institutional frameworks of MSP, and how they might vary from country to country

3. The joint development of best practices for MSP amongst stakeholders and countries
4. The use of science, knowledge, data, methods and tools in MSP

3.3 The 2050 Edition

MSP Challenge 2050 is a multi-player, computer-supported game involving considerable social interaction between planners. A trailer of the game can be viewed at www.mspchallenge2050.com. The game is built around a flexible number of countries (e.g. four to eight) represented by a flexible number of players per country (e.g., three to six) that share a sea basin (e.g. the North Sea, the Baltic, the North Atlantic). For reasons of simplicity and abstraction the real sea basin, is renamed into 'Sea of Colours'. At present we have a North Sea edition of the game, and the real countries are indicated as colours: Orange (the Netherlands), Blue (Belgium), Green (Norway), Yellow (Germany), Red (Denmark), Purple, (the UK), Indigo (Scotland).

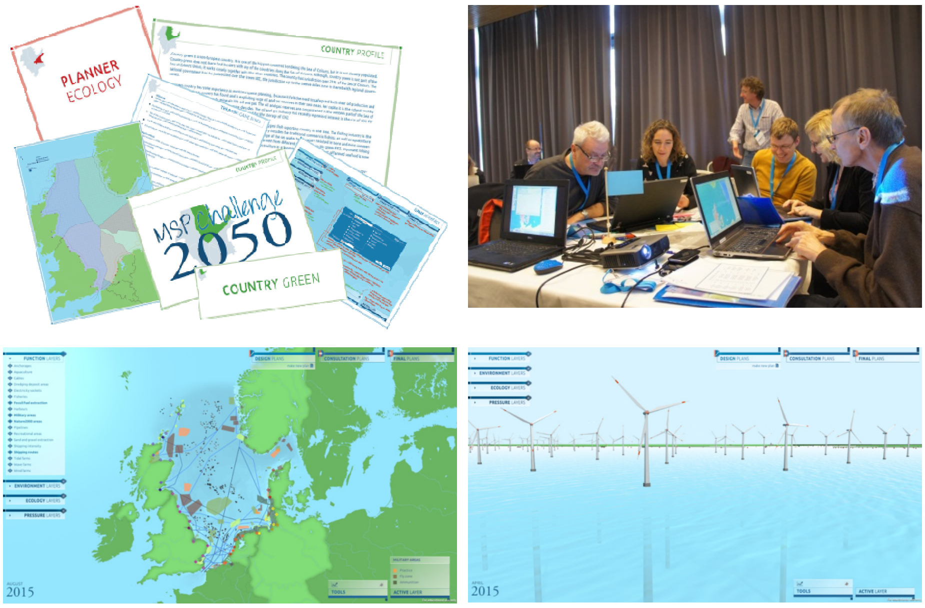

Fig. 5. Impression of the game

Three to six players form a group of country planners with different sectoral authorities, thus requiring a total of 18 to 36 players with knowledge and expertise in the field. The players are briefed and receive general information on paper about the geographical, ecological, political and other characteristics of the countries concerned. Each country and player is provided with a specific profile containing goals and objectives to achieve during the game. The players' goal is to plan and manage the development in their EEZ from 2015 until 2050 as well as they can. The planners' task is difficult, as they handle the content and substance of the planning, as well as the consultation and coordination process with other countries. There are several additions to the game that make it interactive and engaging, such as a news blog called the Puffington post. Players can send Puffins (a kind of local twitter) from their mobile or tablets. A Game Overall Director (G.O.D) has the authority to intervene by taking up a role at the boundary of the game, such as European Commission (EC) or minister of a country.

3.4 Simulating Complexity in the Game

An interactive digital planning tool, partly designed in the Unity game engine, plays a crucial role in the game. The tool is designed to be highly interactive, robust and stable, in addition to being attractive for gameplay. It allows 2D to 3D zooming to view the marine world. The complexity model that drives the simulation consists of the following components:

1. Human Activities (A)
2. Factors in the Geo system (G)
3. Factors in the Ecosystem (E)
4. Pressures (P)
5. Indicators (I)

The interaction effects among the components (positive/negative, strong/weak, or quantified when possible etc.) are identified in a number of matrices:

1. A/A matrix to show the cumulative impact of Activities upon other Activities
2. G/A Matrix to show what Activities can be performed under what conditions in the Geosystem
3. A/P matrix to show what Pressures come out of Activities
4. P/G matrix to show how Pressures influence the Geo system
5. P/E matrix to show how Pressures influence the Ecosystem
6. G/A matrix to show how Geosystem changes affect Activities
7. E/A matrix to show how Ecosystem changes affect Activities.

The pressures and indicators are then attributed to countries in the game and/or stakeholder interests (e.g., fishery, conservationists, green energy sector):

1. Country model to assign weight of Pressures and Indicators to specific countries
2. Stakeholder model to assign weight of Pressures and Indicators to specific stakeholders

Fifty-five layers with geo and eco information present sufficient detail and richness without becoming overwhelming. Examples of map layers include oil and gas infrastructure (platforms); commercial fishing; energy; sea cables and pipelines, and marine protected areas. A layer can contain one or a few similar objects (wind farms, birds, wind speed) in the form of points (power grid connector), lines (e.g., shipping routes) or shapes (e.g., marine protected area). Some layers like sea depth, and wind speed are static and cannot be changed. Proposition layers such as for wind farming can be changed by the players to propose or make a plan. It basically works like a standard digital drawing tool. The simulator continuously runs in the background of the game. It manages the cause-effect matrices and works on three levels. First, when planning human activities, the simulator checks potential conflicts with other activities or the environment in the Activity/Activity and Environment/Activity matrices. When confirming a plan, the activity starts up and the simulator uses the Activity/Pressure matrix to apply the pressures caused by the activity, and potential effects of the activity on other activities in the Activity/Activity matrix. Second, the internal ecosystem (modelled with an Ecopath food chain model) continuously adapts itself to pressures and changes through a feedback loop based on Pressure/Ecology and Ecology/Ecology rules. When players approve a plan, the simulator will start updating a layer. The impact of the simulation is fed back to the players in a visual way by changes in the 2D and 3D world. Furthermore, the effects are summarized in a dashboard with dynamic indicators.

4 Conclusion

In this paper, we have presented a model to understand the socio-technical complexity of marine areas and demonstrated how it can be translated into a simulation model for serious game-play with marine spatial planners. The combined and iterative use of complexity modelling and gaming proved effective from the perspectives of design (development of a MSP model), research (insight acquired on MSP) and policy (policy-oriented learning and analysis for MSP). At the time of writing, the MSP Challenge 2050 has only just been launched. One of the key results was the confirmation that over a period of decades, there is insufficient space on the North Sea to meet all sectorial spatial claims and that the cumulative pressure on the eco-system will rise to an unsustainable level. No data have been collected yet. Further development and large scale global dissemination of MSP Challenge 2050, as well as systematic research and data collection, is foreseen.

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