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Challenges of achieving Good Environmental Status in the Northeast Atlantic

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ABSTRACT. The sustainable exploitation of marine ecosystem services is dependent on achieving and maintaining an adequate ecosystem state to prevent undue deterioration. Within the European Union, the Marine Strategy Framework Directive (MSFD) requires member states to achieve Good Environmental Status (GEnS), specified in terms of 11 descriptors. We analyzed the complexity of social-ecological factors to identify common critical issues that are likely to influence the achievement of GEnS in the Northeast Atlantic (NEA) more broadly, using three case studies. A conceptual model developed using a soft systems approach highlights the complexity of social and ecological phenomena that influence, and are likely to continue to influence, the state of ecosystems in the NEA. The development of the conceptual model raised four issues that complicate the implementation of the MSFD, the majority of which arose in the Pressures and State sections of the model: variability in the system, cumulative effects, ecosystem resilience, and conflicting policy targets. The achievement of GEnS targets for the marine environment requires the recognition and negotiation of trade-offs across a broad policy landscape involving a wide variety of stakeholders in the public and private sectors. Furthermore, potential cumulative effects may introduce uncertainty, particularly in selecting appropriate management measures. There also are endogenous pressures that society cannot control. This uncertainty is even more obvious when variability within the system, e.g., climate change, is accounted for. Also, questions related to the resilience of the affected ecosystem to specific pressures must be raised, despite a lack of current knowledge. Achieving good management and reaching GEnS require multidisciplinary assessments. The soft systems approach provides one mechanism for bringing multidisciplinary information together to look at the problems in a different light.

Key Words: *ecosystem-based management; Good Environmental Status; Northeast Atlantic; soft systems methodology; trade-offs*

INTRODUCTION

Global seas are facing many threats, particularly those caused by human activity (Millenium Ecosystem Assessment 2005). Environmental change is ultimately driven by humans, and drivers may include, e.g., increasing demand for seafood or for energy. These driving forces lead to pressures such as increasing use of resources, which in turn may lead to ecosystem change (Cooper 2013). For this reason, the Marine Strategy Framework Directive (MSFD; European Parliament and the Council of the European Union 2008) is currently being implemented by European Union (EU) member states, requiring them to apply an ecosystem approach to the management of human activities with an aim to achieve Good Environmental Status (GEnS) of Europe's regional seas by 2020. GEnS is defined as "the environmental status of marine waters where these provide ecologically diverse and dynamic oceans and seas which are clean, healthy and productive" (European Parliament and the Council of the European Union 2008: Chapter 1, Article 3 [5]).

Growing human populations, increased per capita demand for marine ecosystem services, limited space on land, and the pursuit of offshore sources of energy have led to multiple competing drivers and in turn increased pressures across Exclusive Economic Zones in the North East Atlantic (NEA). The NEA has been exploited by society for many centuries, notably for transport, food, and other natural resources; and although this has affected the whole of the Greater North Sea, it is particularly true of the semienclosed shelf seas, i.e., the greater North and Celtic seas. Human pressures have increased considerably over the last century, but concerns about adverse environmental effects are not new. For example, warnings about overfishing in the North Sea were made in the late 19th century (Gulland 1958), with the decline of cod (*Gadus morhua*) seen in 20 stocks throughout the North Atlantic by the 1990s (Myers et al. 1996).

The increase in the number and extent of maritime activities and the demand for ecosystem services have changed the state of many environmental variables. Examples include the effects of contaminant emissions, e.g., hydrocarbons (e.g. Mendelssohn et al. 2012); changes in biological communities such as those caused by fishing (Thrush and Dayton 2002); introduction of nonindigenous species, e.g., the Rapana whelk (*Rapana venosa*), potentially through shipping (Kerckhof et al. 2006); and marine litter or microplastics (Cole et al. 2011), which can affect a range of species by causing decreased feeding ability or even death. These multiple competing drivers and pressures create a complexity that makes governance of the marine environment a difficult and complicated task.

The NEA region has well-established environmental governance structures (van Leeuwen et al. 2012). The 1992 OSPAR Convention (http://www.ospar.org), supported by 15 governments including non-EU countries such as Iceland, Norway, and Switzerland, covers dumping and land-based sources of waste and human activities that can affect the NEA. Regional Advisory Councils within Europe prepare and provide advice on fisheries management, with the North Sea Advisory Council (http://www.nsrac.org) being a key council in the NEA area. In addition, the International Council for Exploration of the Sea is an intergovernmental body established in 1902, primarily to

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encourage research on the living resources of the North Atlantic and act as a data repository. Despite the institutional framework and comprehensive knowledge base, it is apparent that defining and achieving GEnS as characterized by reference to the 11 descriptors prescribed by the MSFD in the NEA will be challenging (Ounanian et al. 2012, Bertram and Rehdanz 2013).

The aim of this study was to analyze the complexity of social-ecological factors to identify common critical issues that are likely to influence the achievement of GEnS for the MSFD descriptors in the NEA more broadly. In this paper, we "zoom out" to examine the wider social-ecological system and present a conceptual model developed using a soft systems approach to highlight the complexity of social and ecological phenomena that influence, and are likely to continue to influence, the state of ecosystems in the NEA.

METHODS
We undertook this research as part of the EU-FP7 funded project KnowSeas (see Mee et al. 2015 in this Special Feature for further information). As part of the aforementioned project, three case studies were undertaken in the NEA region (Fig. 1): an examination of the interaction between trawl fisheries, climate change, and the cold-water coral *Lophelia pertusa* (*Lophelia* reefs); an investigation of ecosystem services related to offshore renewable energy development (offshore wind farms); and research into the effects of transboundary nutrients in the coastal North Sea (transboundary nutrients). The three case studies provided the building blocks on which to develop a conceptual model to identify issues that are likely to influence the achievement of GEnS for the MSFD descriptors in the area. The Driver–Pressure–State–Welfare–Response (DPSWR) framework (Cooper 2013), which was derived from the original Driver–Pressure–State–Impact–Response (DPSIR) framework but with Impact replaced by (change in human) Welfare, was used as a methodology to structure the case studies investigated (Table 1), with 9 of the 11 MSFD GEnS descriptors believed to be affected by the activities described (D1-D7, D10, D11; Fig. 2).
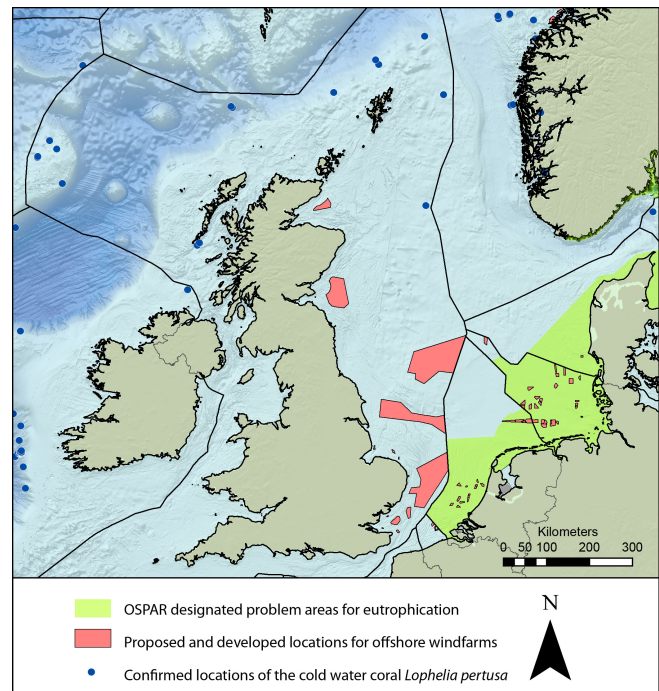
A number of "hard" models and statistical methods were applied during each of the case studies. However, because our aim was to examine the wider social-ecological system, which can at best be described as messy and highly complex, a method was required that would allow us to take the case study expertise, use it in a new way, and gain a new perspective. For these reasons, the soft systems approach was chosen.

Soft systems approach
Soft systems methodology is a systematic approach for tackling real-world problematic situations (Checkland and Poulter 2006). It does this by treating the notion of "system" as a construct rather than a concrete entity. It is particularly useful in those situations in which there is a lack of agreement regarding what constitutes the problem, or indeed, hundreds of inter-related problems. In such situations, there may be a number of different perspectives, values, and beliefs regarding which aspects of the situation are most important and how to address them. In addition, changing just one aspect of the situation may have a knock-on effect on other aspects. The purpose of the soft systems approach is to develop a comprehensive understanding of the various aspects of the problematic situation and to enable the drawing of different boundaries around what the system is perceived to be. The models

developed as part of this process are not supposed to represent the real world but rather to allow us to structure thinking about the real world.

Fig. 1. Map detailing the spatial location(s), within the Northeast Atlantic (NEA), of the three case studies used as the basis for this study.

OSPAR designated problem areas for eutrophication

Proposed and developed locations for offshore windfarms

Confirmed locations of the cold water coral *Lophelia pertusa*

An expert workshop was held in November 2012 during an annual project meeting for the KnowSeas Project in Bruges, Belgium, in which the soft systems methodology was used to explore the complexities involved in achieving GEnS in the NEA. Seventeen participants were drawn from those who had worked on the NEA case studies during the KnowSeas project. In accordance with the method described by Checkland and Poulter (2006), and in the context of MSFD implementation in the NEA, participants worked collaboratively to undertake the following steps:

1. Describe the perceived real-world problematical situation based on experience gained during the case study research.

2. Create a purposeful conceptual model based on a combined worldview.

3. Use the model to question the real situation.

4. Define the actions required to improve the situation.

This allowed for a comprehensive examination of the widely varying spatial and temporal scales of Pressures, State changes, Welfare effects, and regulatory Response that need to be considered when trying to establish whether and how GEnS can be achieved.

RESULTS
The real-world problematic situation was discussed by workshop participants. They defined it as the difficulties in achieving GEnS in the NEA because of the complex arrangements of

Table 1. Driver–Pressure–State–Welfare–Response (DPSWR) framework components of each of the three case studies used as the basis for this study.

	Drivers	Pressures	State	Welfare	Response	References
Offshore wind farms						
	Demand for energy; security of supply; commitments to reduce carbon emissions; focus on renewable energy; regional development	Habitat disturbance; smothering; electromagnetic change; noise; collision potential; vectors for invasive species; increased food supply after construction	Noise as example: Marine mammals and fish with swim bladders change behavior, are injured, or die, affecting distribution and abundance of species	Contributes to societal goals such as reduction of CO_2 emissions and can impact local and regional development of coasts; may reduce area available to fish	Measures can be imposed or encouraged to reduce impact on State by technical solutions, spatial planning, or timing of operations	Gill 2005 Breton and Moe 2009 Tougaard et al. 2009 Lange et al. 2010 Lindeboom et al. 2011 Alexander et al. 2013 O'Higgins and Gilbert 2014
Lophelia reefs						
	Main reef-forming species in Northeast Atlantic; however potential conflict with deep-water fisheries	Reefs and slow growing and susceptible to destruction by bottom trawls; ocean acidification also a risk	In present state, provide habitat for many organisms as well as feeding and breeding grounds for commercially important fish species	Existence and educational values for society	Creation of no-fishing zones; banning of certain gear types; achieving stabilization of increasing ocean acidification by reaching targets for GHG reductions	Hall-Spencer et al. 2002 Costello et al. 2005 Hall-Spencer et al. 2009 Foley et al. 2010 Howell et al. 2011 Söffker et al. 2011 Purser et al. 2013 Jackson et al. 2014
Transboundary nutrients						
	Application of fertilizers, dependent on market forces and Common Agricultural Policy; societal demand for food, cleaning products, and sewage collection; increased urbanization and population growth	Increased nutrient loading in rivers and subsequently coastal waters; treatments do not entirely get rid of excess nutrients	Additional nutrients may lead to increased primary production, affecting fish stocks and seabirds; can also lead to eutrophication adversely affecting fish and shellfish populations; poor water quality; toxic phytoplankton species	As State	Derived from land-based human activities; regulatory measures must be targeted appropriately	Vermaat et al. 2008 Van Beusekom et al. 2009 Lenhart et al. 2010 Ferreira et al. 2011 Los et al. 2014 Troost et al. 2014

socioeconomic demands and controls, benefit allocation mechanisms, policy fragmentation and differing spatial scales of management.

Conceptual model

To link the political, social, economic, and ecological elements of the NEA system, we developed a conceptual model based on the DPSWR framework (Cooper 2013). This model identified the complexity of social, economic, and ecological factors that influence a desired outcome in the context of the specific NEA case studies (Fig. 3).

The model in Figure 3 aims to show causal relationships among selected features of the social system within an EU member or associated state and the marine ecosystem that the state is responsible for. At the heart of the model are the relationships between ecosystem State and human Welfare. The ecosystem provides services that, distributed by markets or public provision, benefit welfare by satisfying human well-being needs. At the same time, the use of these services leads to Pressures on the marine ecosystem that may change its State, with consequent impact on services and Welfare. According to the DPSWR framework, this leads to a societal Response acting either on the societal Drivers of these Pressures or on the coupling between Drivers and Pressures. Following Elliott (2011), the relevant Pressures, i.e., those that are vulnerable to management by the member state,

are called endogenous, in contrast to exogenous Pressures such as those caused by climate change, which can only be managed, if at all, by collective global action.

Societal Responses typically entail political and economic costs. In the absence of transnational agreements, Responses would differ between countries because each national governance system would be motivated by specific national considerations. A consequence might be the relocation to other member states or to states outside of the EU of externalities associated with use of marine ecosystem services. The MSFD is shown externally to the main elements of the modeled social-ecological system, providing guidance through the treaty obligations of the member state to the other states of the EU. These obligations include those of monitoring, reporting, and managing in relation to targets agreed with other states. However, according to the principle of subsidiarity, i.e., that social problems should be dealt with at the most immediate (or local) level consistent with their solution, each state implements the directive in its own way.

Issues arising from model

The development of the conceptual model and the associated discussion raised four issues that may complicate the implementation of the MSFD in the NEA region. The majority arose in the Pressures and State sections of the model. They are as follows:

Fig. 2. Major maritime and land-based drivers, associated human activities that result in pressures on the marine environment, and the potential direct (uppercase) and indirect (lowercase) effects on the 11 Marine Strategy Framework Directive (MSFD) Good Environmental Status (GEnS) Descriptors related to 3 case studies from the Northeast Atlantic. D1 indicates Biodiversity; D2, Nonindigenous species; D3, Commercial fish and shellfish; D4, Food webs; D5, Eutrophication; D6, Seafloor integrity; D7, Hydrographical conditions; D8, Contaminants; D9, Contaminants in fish and shellfish; D10, Marine litter; D11, Underwater noise.
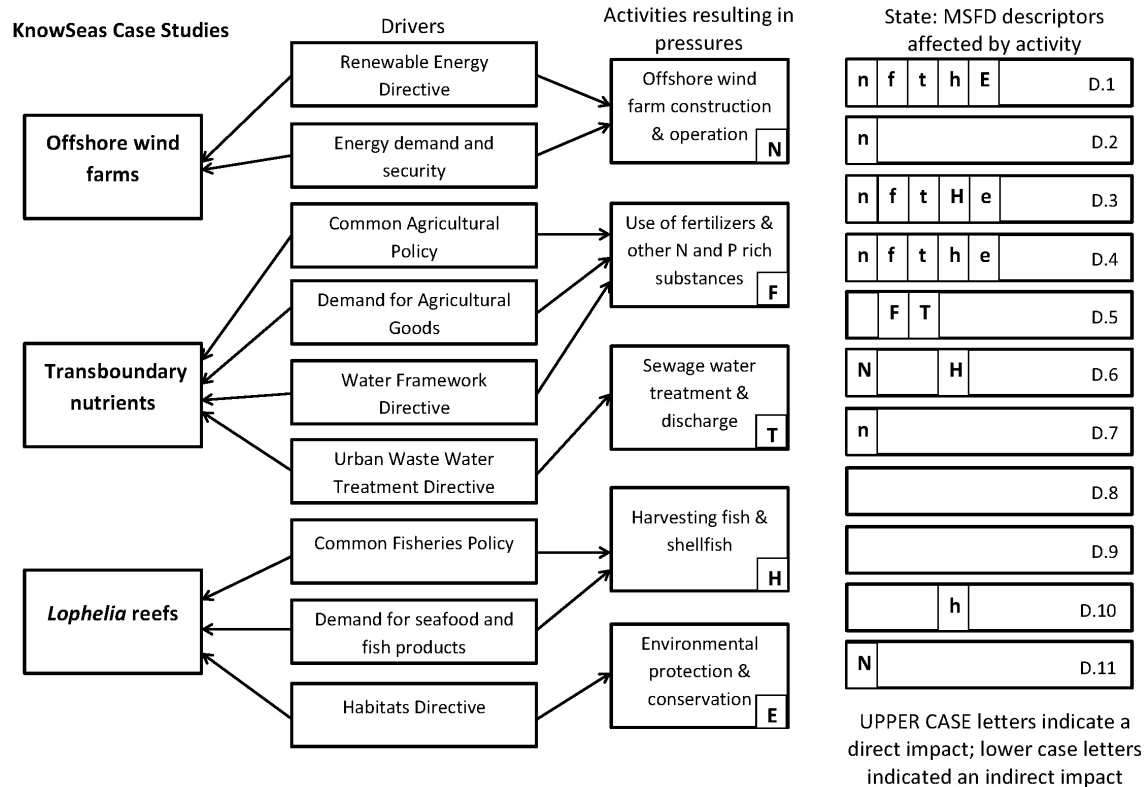

1. **Variability in the ecosystem.** Although the DPSWR framework is primarily concerned with anthropogenic State change, in practice this may be difficult to disentangle from changes that would have occurred even in the absence of related Pressures. In this light, what is labeled as State is perhaps better seen as an attractor in ecosystem state space (Holling 1973). In any event, ecosystem indicators may change over time for reasons other than anthropogenic Pressures, and such variability has implications for setting targets. Within the model, natural system variability is represented within the Pressures box by "nonmanageable Drivers" and "exogenous (unmanageable) Pressures."

2. **Cumulative effects.** Changes in human society take time to implement, and in the meantime Pressures may increase despite regulation of Drivers because of legacy and future effects. Past behaviors may have generated a reservoir of Pressure either within or upstream of the marine ecosystem (O'Higgins et al. 2014), exemplified by phosphorus-rich terrestrial catchments or phosphorus-rich marine sediments (Puttonen et al. 2014). Quantifying cumulative effects and subsequent impacts presents a difficult management challenge (Van der Wal et al. 2006, Stelzenmüller et al. 2010, Crowe et al. 2012, O'Mahony et al. 2014) and is acknowledged as being a Europe-wide issue in relation to environmental management and assessment. Cumulative effects are represented in the model at the stage of Pressure-State coupling, through some combination of "endogenous (manageable) Pressures" with the potential for additional exogenous Pressures.

3. **Ecosystem resilience.** Resilience is the emergent ecosystem property that resists Pressures, adapts systems to pressure, or brings about recovery when pressure is relaxed (Folke et al. 2004). Tett et al. (2013) argued that GEnS could be equated with high resilience. Current ecological theory holds that damage to ecosystem organization (Mageau et al. 1995) reduces resilience, leading to regime shift, which is often conceptualized as a move to a new basin of attraction. A resilient ecosystem may show little response to increasing pressure; hence, conventional indicators may be of little help in detecting State change until too late. Scheffer et al. (2009) suggested that increasing variability might provide advance warning of regime shift. Resilience is represented in the State box and can affect Pressure-State coupling.

Fig. 3. Conceptual model showing those elements of the DPSWR framework that have to be taken into account to achieve GEnS. The individual elements of the model are described in the text.
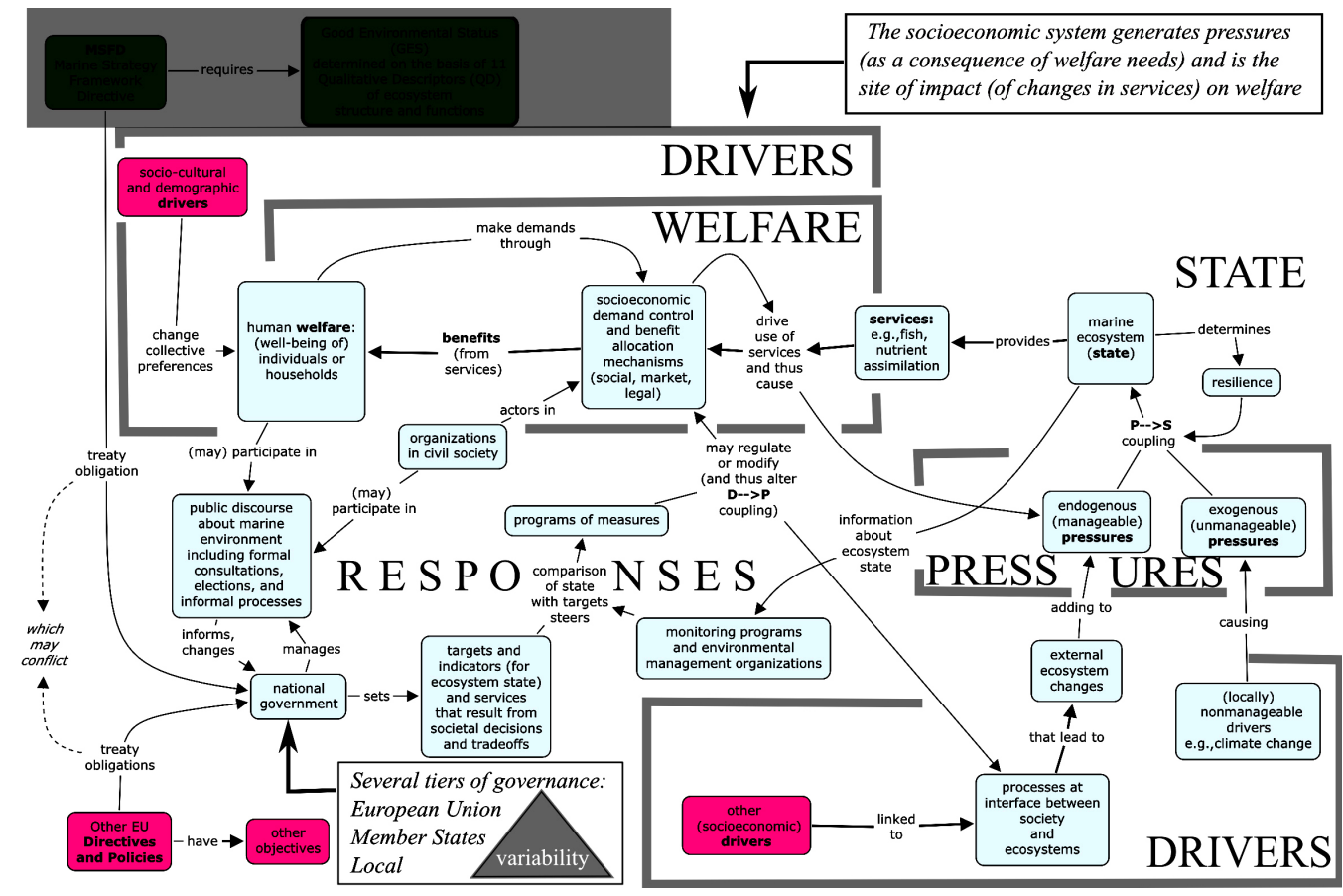
4. Conflicting policy targets. Many policies affect marine areas (Kannen 2014). Even specifically marine legal instruments such as the MSFD and the recently EU-adopted Directive on Maritime Spatial Planning are in their argumentation taking different perspectives. Similarly, the EU Blue Growth strategy, which aims to support sustainable growth in Europe's marine and maritime sectors, has potential to clash with the objective of the MSFD, which has the overall aim of promoting sustainable use. This indicates a clash of goals in society concerning human use of marine areas and explains why in many cases decisions include compromises between use and protection of ecosystem goods and services. The clash occurs at several levels of governance. Within member states it is described in the model by the boxes Public Discourse, Human Welfare, Socio-economic Demand, and Targets and Indicators for Ecosystem States and Services. At the EU level, it is described in terms of conflicts between member states' treaty obligations under the MSFD and under other EU directives.

Conceptual model testing

The four critical issues were then tested against the real-world case studies. The results indicated that the issue of policy conflict was prevalent throughout the case studies; however, not every issue identified by the conceptual model was present in every case study (Table 2).

Three of the critical issues were identified within the offshore wind farm case study. Cumulative effects may occur through Pressures; for example, some fish species may be subject to the combined effects of electromagnetic change and collision risk. Ecosystem resilience related to offshore wind farm installations is still an unknown. For that reason, the participants believed that it should be included as a critical issue in this case study. In terms of policy conflict, the Drivers of offshore renewable energy, e.g., demand for energy and security of supply, occur in tandem with a desire to reduce the environmental impact of human activities.

Two of the critical issues were identified within the *Lophelia* reefs case study. In the case of cumulative effects, *Lophelia* reefs may be subject to combined Pressures such as bottom trawling and ocean acidification. Conflicting policy was also recognized as a critical issue affecting *Lophelia*. Some countries have policies to ensure the continued existence of the fishing industry; however the MSFD aims to preserve biodiversity, the very thing that the fishing industry may prevent.

All four of the critical issues could be identified within the transboundary nutrients case study. Eutrophication-related

Table 2. Critical issues found within each case study.

	Variability in ecosystem	Cumulative effects	Ecosystem resilience	Conflicting policy targets
Offshore wind farms		•	•	•
Lophelia reefs		•		•
Transboundary nutrients	•	•	•	•

variability occurs on a range of spatial and temporal scales, and includes an underlying trend of increasing temperature that may also affect resilience. An obvious cumulative effect with respect to eutrophication is that multiple river loads and other nutrient inputs like atmospheric deposition will all contribute to the nutrient concentrations in the North Sea. Finally, although the MSFD aims to mitigate eutrophication by reducing nutrient concentrations, other legislation such as Natura 2000 (http://ec.europa.eu/environment/nature/natura2000/) aims to sustain or increase certain bird or fish populations. However, nutrient concentrations may lead to reduced productivity and hence to a decrease in the fish or bird populations that directly or indirectly depend on this productivity.

DISCUSSION
The key finding of this study was the four common critical issues found to complicate the implementation of the MSFD: variability in the ecosystem, cumulative effects, ecosystem resilience, and conflicting policy, although these were not found to occur across all case studies. However, understanding these issues more clearly may lead to progress in addressing continued ecosystem deterioration. It should be remembered that this study was based on a conceptual model, and models present necessarily strong abstractions of reality. Soft systems methodology and the creation of conceptual models through this process are only a "process of inquiry" into problematical situations (Checkland and Poulter 2006). Also, the key method of this study was an expert workshop, and limitations to expert knowledge always exist.

Variability in the ecosystem
All natural systems exhibit some degree of variability in space and time, which can impose challenges in setting realistic GEnS targets (Kenny et al. 2009, Blenckner et al. 2015). If the overall aim is to achieve sustainable exploitation of ecosystem goods and services, natural variations in the ecosystem must be taken into account. Variability occurs on a range of spatial and temporal scales. These include an underlying trend of increasing temperature caused by global warming, which has had a dominant influence on biological systems in the NEA since the mid-19th century (Edwards et al. 2013). This is overlain by basin-wide alternate warming and cooling periods, with a frequency of about 60 years, described as the Atlantic Multidecadal Oscillation. Even small changes in temperature can have significant effects on the onset of the spring phytoplankton bloom, the relative abundance of zooplankton, and the abundance and distribution of commercial fish species (Edwards et al. 2013, Nye et al. 2014). Hence, these changes influence descriptors for biodiversity (D1), nonindigenous species (D2), commercial fish and shellfish (D3), food webs (D4), eutrophication (D5), and seafloor integrity (D6). In addition, warmer waters can allow the spread of harmful bacteria and

viruses (e.g., *Vibrio* sp., Reilly et al. 2013) and lead to increased outbreaks of toxic algal blooms (D9 contaminants in fish and shellfish). Fluctuations in precipitation can lead to significant variability in nutrient loadings and hence influence eutrophication status (de Vries et al. 1998).

Natural ecosystem variability is not something that can be readily dealt with through changes to decision making, management systems, or governance. However, it is an issue that should certainly be borne in mind during these processes.

Cumulative effects
Repeated Pressures from one or more maritime or land-based activity may produce a cumulative effect on ecosystem State. Although cumulative effects may be conceptualized readily, establishing causal relationships and estimating the magnitude of the effects are much more problematic (ICES 2013), and there is limited guidance for decision makers on how to minimize them (Cooper 2004).

Cumulative effects may occur in a number of ways. Spatial overlap may mean that the "footprint" of one Pressure overlaps with that of adjacent similar Pressures, e.g., construction of multiple wind turbines, to which there may be a nonlinear response or tipping point on the distribution or breeding success of seabirds at increasing spatial extents (Busch et al. 2013). Multiple sources may lead to cumulative effects, such as a Pressure from multiple Drivers that acts on one or more features, e.g., multiple river inputs of nutrients to the coastal zone that results in eutrophication. Finally, additive/synergistic effects may be found when two or more Pressures affect a feature: e.g., ocean acidification and fishing pressures on *Lophelia* reefs (Tittensor et al. 2010).

Currently, sector-based legislation allows the introduction of controls to modify the effects of particular activities. Unfortunately, it may require apportioning the effect of each sector/activity on an environmental State descriptor, as well as recognizing that some of these will be land based, e.g., agricultural production as a source of nutrients under the influence of the EU Common Agriculture Policy and effects on D5. Some GEnS descriptors may have multiple and poorly defined Drivers and Pressures, such as the effects of land-based waste management, coastal tourism, and shipping on marine litter (D10).

Ecosystem resilience
In many cases, major problems exist concerning the assessment of the effects of human activities on the resilience of marine systems. A particular example is offshore wind farms, which are a recently developed, and still developing, sector in which long-term time series of monitoring data do not exist and for which there is a high level of uncertainty in assessing impacts on ecosystem structures and processes. In some cases, e.g., eutrophication, the different components of the North Sea

ecosystem show different responses in terms of resilience. Timing of phytoplankton blooms in the eutrophic coastal areas is resilient (Wiltshire et al. 2008), but climate factors like winter temperature play a dominant role (e.g., van Beusekom et al. 2009). Also, the decrease in summer phytoplankton biomass in response to decreasing nitrogen loads supports the resilience of the phytoplankton community to nutrient disturbances. In any case, it should be noted that modern coastal ecosystems, including those of the North Sea, are strongly degraded compared with earlier system States deduced from palaeontological, archaeological, historical, and ecological records (Lotze et al. 2005, 2006).

Adaptive management recognizes that the natural resources being relied on by society will always change; therefore, humans must be flexible in responding to these new situations. This is likely to be a key way to deal with continuously changing environments resulting from changes to ecological resilience caused by human activity. The precautionary principle, i.e., if an action or policy has a suspected risk of causing harm to the public or the environment in the absence of scientific consensus that the action or policy is not harmful, means that the burden of proof that it is not harmful falls on those taking an action. Precaution and adaptive management have been advanced in response to the recognition that scientific uncertainty and limited understanding are often significant features of decision making, particularly in relation to environmental management. However, these principles are intimately connected with values that may vary from one decision maker to another, meaning that it is important that there be increased specificity in exercising these principles. For example, what kind of follow-up measures will be used to monitor what kinds of remaining uncertainties (Benedickson et al. 2005)?

Conflicting policy
The three case studies, all of which relate to human activities within or nearby the marine environment, provide clear examples of policy conflict. Countries within the NEA area subscribe to the European agenda of Blue Growth, the long-term strategy to support sustainable growth in the marine and maritime sectors, including those such as aquaculture, marine tourism, fishing, marine biotechnology, seabed mining, and ocean energy. However, in the case of the MSFD, there are requirements that biological diversity is maintained (D1) and that the quality and occurrence of habitats, of which cold-water corals are an example, and the distribution of species are in line with prevailing physiographic, geographic, and climatic conditions. It is also required that populations of commercially exploited fish and shellfish are healthy (D3), and cold-water corals contribute toward achieving this criterion by providing, e.g., nursery areas. Attempts to conserve species by closing areas to fishing or hydrocarbon exploration or development may mean that other maritime industries are unable to operate in some ocean areas. Alternatively, enabling maritime growth without conservation of these species may be to their detriment. In many cases, the response is to minimize detrimental effects as development proceeds. This may be adequate to comply with the MSFD at this relatively early stage of implementation but might present challenges in the future, particularly when cumulative effects become more apparent and issues relating to ecosystem resilience are better understood.

Policy conflicts between economic and policy sectors must be solved by setting and agreeing on political priorities. Although institutions and governance processes develop at the national level, a major challenge is the need for transnational cooperation mechanisms, not only in specific sectors such as energy or fishing, but also in terms of marine spatial planning and marine environmental management as a whole. This needs to go beyond directives at the EU level and reflect the specific needs in the different European marine regions, involve Regional Sea conventions, and could provide key mechanisms of collaboration and information exchange as well as a vision of how to deal with transnational components (Kannen 2014). A first example of how such a vision could look is the BaltSeaPlan Vision for Marine Spatial Planning in the Baltic 2030 (Gee 2013).

CONCLUSIONS
The achievement of GEnS targets for the marine environment requires the recognition and negotiation of trade-offs across a broad policy landscape involving a wide variety of stakeholders in the public and private sectors. These include policies specifically aimed at managing maritime activities, those targeted at land-based activities, and overarching policies relating, for example, to energy security, conservation, food security, and meeting international targets for a reduction in CO_2 emissions. Policy conflicts are inevitable, so it is essential that mechanisms are provided to facilitate dialogue to discuss priorities, explore management and policy, and encourage informed decision making.

Targets for GEnS need to be viewed within the context of the sustainable utilization of ecosystem services and the ecosystem approach to management. The potential cumulative effects of several Pressures may introduce significant uncertainty, particularly in selecting appropriate management measures. In addition, there are endogenous Pressures that society cannot control and variability within the system, e.g., climate change, that cannot be controlled on a timescale of decades. Such Pressures may affect several of the MSFD descriptors and need to be recognized to ensure that GEnS targets are achievable. Also, questions relating to the resilience of the affected ecosystem to specific Pressures must be raised, despite a lack of current knowledge.

Management of the North Sea has been the subject of scientific enquiry for decades, as have other regional sea areas. The four critical issues identified during this study are likely to also be applicable to the implementation of MSFD in other regional seas, and indeed should be considered in marine environmental management beyond Europe. Achieving good management and reaching GEnS require multidisciplinary assessments. The soft systems approach provides one mechanism for bringing multidisciplinary information together to look at the problems in a different light. We have tested the application of the soft systems approach in the context of implementing MSFD and achieving GEnS, primarily using members of the scientific community. Future work should iterate the process while including the policy community and other actors in the process, using their input to enrich the model exercise and arrive at workable pathways to support implementation.

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