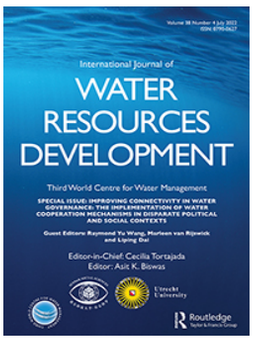

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On dynamic naturalness, static regulation and human influence in the Ems-Dollard estuary

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ABSTRACT

Many river systems in Europe have altered morphology and deteriorated ecosystems due to human interference. We demonstrate how conflicting interests of nature, society and economics in the Dutch–German Ems-Dollard system complicate achieving the nature restoration targeted by the EU Water Framework Directive. This article provides a multidisciplinary perspective on the natural characteristics of a water system and the practical implementation of regulation and policy in a transboundary setting. Important shortcomings of EU and national laws and directives are the static constraints for protection of demarcated habitats under EU directives, which do not do justice to natural hydro-morphodynamic processes.

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Introduction

Over the past few decades there has been a distinct increase in awareness regarding the ecological state of the natural environment, driven by many cases of pollution and strong ecological deterioration. For aquatic systems in the European Union, this culminated in the formation of the Water Framework Directive (WFD, 2000) and, extending towards terrestrial ecosystems, the Habitats and Birds Directives (HBD) (HD, 1992; BD, 2009). These are to provide the framework for improving and safeguarding the ecological state of river systems and other natural systems. In the Netherlands, for example, HBD areas often contain aquatic systems, and to these areas the WFD and HBD are simultaneously applicable. However, implementation of and compliance with these directives prove to be difficult and complex (SGD Eems, 2013). It is also not certain that the WFD, HD and BD are adequate in dealing with the full scope of problems in a river system, because they are centred around chemical and ecological aspects, and the physical hydro-morphological basis of river systems is only considered in minor detail as a necessary precondition. Furthermore, the conflicting short-term and long-term interests of society (particularly socio-economic interests) and nature are difficult to balance in decision making when it comes to managing the use of waterways. Implementation of these directives, laws and

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Supplemental data for this article can be accessed at here.

policy at an operational level brings to light the difficulties that are encountered in practice, in striving towards the goal of a healthier ecosystem.

An example of a riverine and estuarine system that is to be restored under the WFD is the Ems-Dollard, on the northern Dutch–German border. Like many water systems in Western Europe, it has altered morphology due to human intervention, and as a consequence the ecosystem is severely deteriorated (Bos et al., 2012). The interplay between water and sediment (hydro-morphodynamics) is out of balance due to the straightening and deepening of the channels for the benefit of navigation (De Jonge et al., 2014; Van Maren et al., 2015a). The consequences importantly include hyperturbidity, depriving flora and fauna at the basis of the food web of vital sunlight in the water column (Taal et al., 2015; Talke et al., 2009). Governance of the system is a transboundary affair between Germany and the Netherlands, which is complicated by disagreement on the course of the international border through the estuary (Disco & Van Heezik, 2015; IMP, 2016). The interests of economic stakeholders (several harbours and a large inland shipyard) influence efforts and policy for amelioration of the water system (IMP, 2016).

The WFD and HBD objectives include improving the state of water systems such as the Ems-Dollard towards more natural and balanced functioning. Various factors play a role in the current functioning of the system: natural processes, policy, law and economy, but also society's view of the natural system that humans are living in and around. The approach to amelioration should therefore encompass and bring together information and knowledge from a range of fields of expertise.

The potential of a rights-based approach in improving the 'health' of estuarine systems such as the Ems-Dollard has been discussed by Gilissen et al. (2019, 2020). The present article focusses on practical issues of current regulation, policy and governance regarding the WFD and HBD goals for the Ems-Dollard estuary. These issues are centred around the representation of what are thought to be the natural quality and functioning of water systems.

The following sections introduce the Ems-Dollard example from the viewpoint of two different disciplines, dynamic nature and static regulation and policy. The characteristics of the natural system and its dynamic functioning are discussed first, as they form the basis on which restoration measures are to be founded. Next, the governance of the Ems-Dollard is outlined to illustrate the current static approach of legislation and policy that is implemented in practice, and the complex web of different interests that are in play. Finally, the two are brought together in a multidisciplinary discussion that provides both a practical view on the shortcomings of the current management approach as well as how to meet the requirements of the natural system, which are not yet being cared for, and the alternative vision of the necessary naturalness of a system in combination with sustainable human activities. With that, an integrated view is presented that is not only applicable to the Ems-Dollard but could be useful for any natural water system dealing with human influence and static regulatory frameworks.

Ems-Dollard: the natural system

Nature conservation and restoration under the WFD and HBD require definition of a 'good state' of the natural system. The Ems-Dollard is an artificially modified natural water system (WFD, 2000); human interference in the system goes back centuries (Vos & Knol, 2015). It can be argued that the estuary as it is would not exist without some sort of

anthropogenic influence. It is therefore difficult to objectively define what a good or 'healthy' state of the Ems-Dollard would be on the basis of its historical state.

A good or healthy state is principally based on the functioning of natural processes. If this natural functioning is allowed to take place, the hydromorphology of the system and its dynamics move in the direction of equilibrium with the boundary conditions of the river and the sea, and if water quality is good, the appropriate development of the ecosystem will follow. It is important to stress that the different aspects of a natural system are intricately woven together and that one cannot be changed without influencing the others. System understanding therefore incorporates all small-scale and large-scale processes, feedback mechanisms (both within and between abiotic and biotic factors), and upstream–downstream connectivity, including backwater effects (long-distance, upstream influence on water level). Next, aspects of the natural system are discussed that are relevant for, but not properly implemented in, policy making: the history and naturalness of the water system and the consequences of human interference for the natural functioning.

History of the Ems-Dollard and human interference

The Ems-Dollard comprises the estuary and lower reaches of the river Ems up to Herbrum, or Tideems, where water levels oscillate due to the semi-diurnal tide. The Dollard embayment within the estuary was formed around 1400 CE by several of many sea ingressions, which could occur as a consequence of land reclamation, embankments and land subsidence behind the dikes (RWS, 1966; Stratingh & Venema, 1855). Sluices and weirs, primitive or sophisticated, have controlled inflow from the hinterland for centuries (RWS, 1966; Vos & Knol, 2015). These early interventions should not be overlooked, even though major construction works for direct shaping of the river and channel system only commenced in the nineteenth century. Major works include the expansion of three harbours, an inland shipyard for manufacturing of large cruise ships along the Ems River, the Geise dam, the Herbrum weir and the Ems storm surge barrier. Importantly, the channels of the estuary and river were deepened and straightened in various stages, to accommodate passage of ever-larger ships (Bos et al., 2012). Since the 1950s the desired channel depth has doubled, and frequent dredging maintains channel depth and keeps the harbours accessible (De Jonge et al., 2014; Krebs & Weilbeer, 2008).

The water system has been adjusting to find a dynamic equilibrium since the maximum extent of the Dollard was reached in the sixteenth and seventeenth centuries. Infilling with sediment has gradually reduced the size of the tidal basin by 40% since 1650 (Van Maren et al., 2015a). The major construction works have redirected the system further away from equilibrium, and a tipping point for the strong deterioration of the sediment dynamics and its consequences for the ecological state was reached in the 1990s, when the system became hyperturbid (De Jonge et al., 2014; Van Maren et al., 2015b; Winterwerp et al., 2013).

The current state and functioning of the water system

The hydromorphology of the estuary has been shaped by engineering practices, such as delimitation by dikes and modification of the channels, and with that, the functioning of the system. Hydro-morphodynamics has adjusted accordingly (Bos et al., 2012; Van Maren et al., 2015a). The functioning of a water system depends on the hydro-morphodynamics,

which is the interaction of sediment supply, discharge and tides that drive the distribution of sediment and flow in the formation of channels, bars and tidal flats (De Haas et al., 2018; Pritchard, 1967). Consequences of artificial modifications include higher flow velocities in the channels; a changed salinity gradient and with that, the characteristic estuarine circulation (Van Maren et al., 2015a); a strongly increased suspended sediment concentration in the water (Van Maren et al., 2015b); and a more-than-doubled tidal amplitude (Herrling & Niemeyer, 2015; Schuttelaars et al., 2013). Inland, the higher high-water levels are a concern for flood protection (Bos et al., 2012), and lower low-water levels cause problems for navigation. To mitigate these problems, the water levels are controlled by the storm surge barrier, but this itself has side effects for the flora and fauna in the area, especially during the breeding season of birds (Bos et al., 2012). Additionally, layers of fluid mud have developed on the bed since 1995 (Van Maren et al., 2015b), probably mainly due to the changed dredging strategy in Emden harbour (De Jonge et al., 2014; see also the online supplement for Gilissen et al., 2019).

The biotic ecosystem

The natural hydromorphology of the system and its dynamic processes provide the canvas on and within which the biotic ecosystem has its necessary natural habitats. Estuarine flora and fauna are tuned to, and improve, the specific conditions of intertidal flats, supratidal areas, varying salinity and water depths, and are thus highly specialized, which makes estuaries much-valued ecosystems (Bos et al., 2012; ED2050, 2016; Jones et al., 1994). In addition to suitable habitats, water quality must be sufficient, and the food web needs to be functioning, for the flora and fauna to thrive. In the Ems-Dollard, all three requirements are under pressure.

Upstream pollution causes high nutrient levels in the Ems-Dollard (SGD Eems, 2005, 2015), and oxygen conditions are of particular concern. Organic matter attached to the suspended sediment and, importantly, to fluid mud, uses up oxygen in the water, causing oxygen depletion, especially in the hyperturbid zone (Talke et al., 2009). Primary producers such as algae in the water column and microphytobenthos on the flats depend on nutrient supply (mainly by river inflow), oxygen and light conditions. High turbidity prevents the growth of these micro-organisms, and primary production has decreased dramatically since the 1970s (Taal et al., 2015), disrupting the basis of the food web (Bos et al., 2012). The oxygen-depleted zones cannot support other species, such as fish, either. Fish also have trouble migrating up and down the Ems system because of the physical barriers of weirs and sluices (SGD Eems, 2005), the abrupt changes of salt to fresh water instead of a gradual brackish zone, and the turbidity, which impairs orientation (Bos et al., 2012). The Ems-Dollard is an important foraging and resting site for migratory birds and other bird species, which suffer not only from the disruption of the food web but also from loss of habitat and nesting grounds (IMP, 2016).

Anthropogenic changes in the abiotic part of the system have caused the turbidity and loss of habitat that are among the biggest problems for the biotic ecosystem. If the ecosystem is to be restored in a resilient and durable manner (which can be regarded a 'healthy state'), the functioning of the system as a whole needs to be addressed, especially hydro-morphodynamics at the basis of naturalness. The next part discusses to what degree this requirement has been recognized and met in river system governance so far.

Governance of the river and estuary

Governance of the Ems-Dollard natural system is arranged at river basin scale under EU legislation and encompasses nature legislation and policy at different administrative levels in the two countries. Cooperation at river basin scale is necessary because of upstream–downstream connections. These extend over the entire system in a downstream direction through the flux of water, and in an upstream direction through backwater effects on water levels. The influence of actions in one part of the natural system extends to other parts of the system that may lie in a different region or country (and thus a different jurisdiction). In the Ems basin, the river Ems not only flows from one country into another, as is common in European river systems, but importantly, the disputed international border runs through the length of the Ems estuary. Therefore, management of the estuary is truly transboundary and a shared responsibility between Germany and the Netherlands, under the umbrella of European and international law (see also the online supplement for Gilissen et al., 2019). In the lower Ems basin, where the estuary is located, stakeholders and NGOs are involved in regional policy making. Cooperation (and the intention to do so) is a prominent component in the current governance structure and policy making, but the question is whether it is succeeding substantively in its fundamental aim of improving the state of the natural system. The current arrangement of governance and policy is outlined next, and then shortcomings and possible improvements of regulation are discussed.Figure 1 provides an overview of the relevant authorities and policy documents.

Legal framework

European Water Framework Directive

The WFD provides an integrated policy and legal basis for water management in the European Union. Its primary concern is water quality, and it aims to prevent long-term deterioration of water bodies, and where possible, foster amelioration. The WFD (2000, preamble) prominently states that 'water is not a commercial product like any other, but rather, a heritage which must be protected, defended and treated as such'. Water bodies are considered on river basin scale in river basin districts, each having a river basin management plan (RBMP) specifying the state of the surface and groundwater in the river basin district and measures for improvement, such that all waters should have attained 'good status' by 2015. Exceptions such as postponing or even lowering goals are allowed for water bodies that have been severely affected by human activity and for which amelioration is too expensive or not deemed feasible, but further deterioration has to be prevented. In the Ems-Dollard, an extra management cycle was appealed for under the WFD (SGD Eems, 2013), because timely realization of 'good ecological and chemical status' was deemed highly unlikely or unclear (SGD Eems, 2009).

According to the WFD, 'good status' consists of good ecological and chemical status, where the chemical status also supports the ecological elements. Hydromorphological conditions in surface waters are only expressed as 'elements supporting the biological elements' (annex V.1), in the sense that the hydrological regime and morphology need to be in such shape that the biota that would naturally occur in a water body have a suitable habitat. Salinity is considered only as a chemical element, not as a driver of estuarine circulation. For each river basin district a reference state needs to be determined that

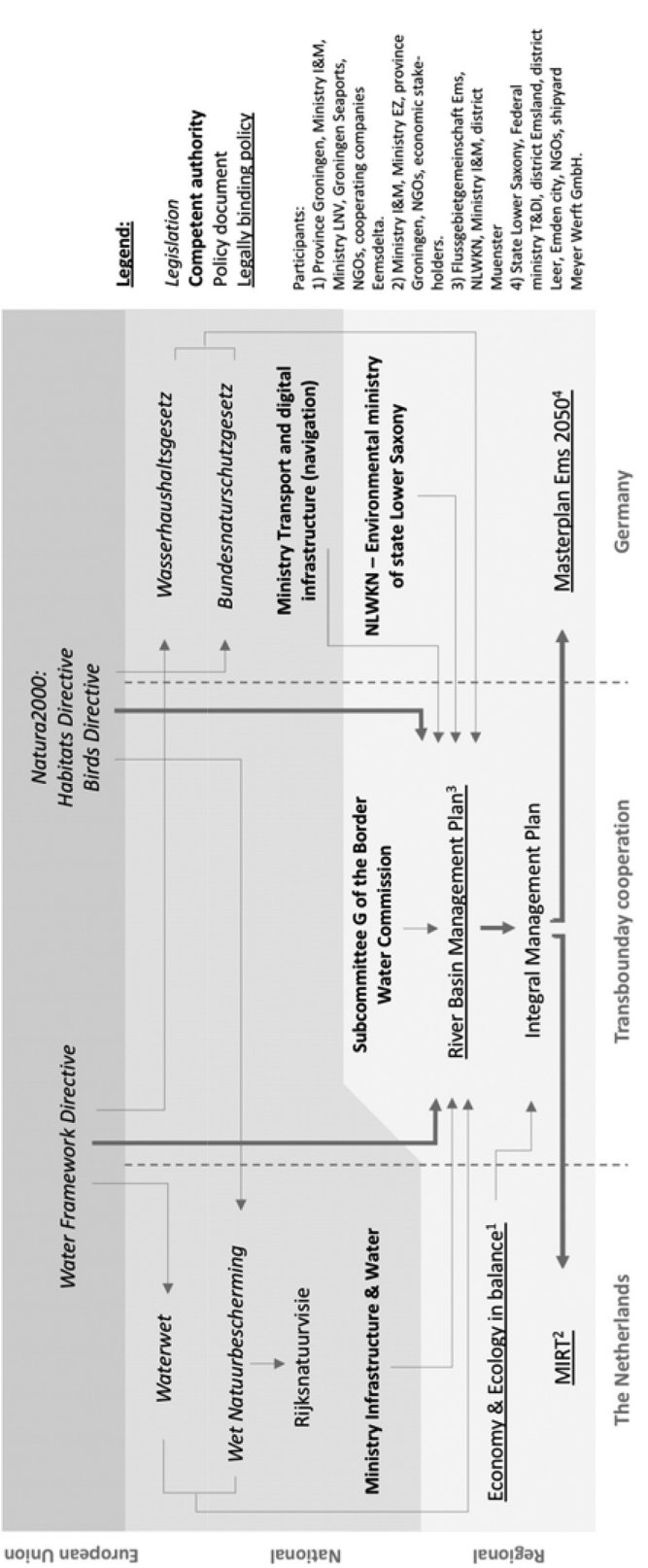

Figure 1. Generalized overview of the governance structure in the Ems-Dollard estuarine system and the multilevel mismatch between competent authorities. Arrows indicate relations between laws, policy and authorities. Bold arrows indicate main path from European directives to regional policy (colour image available in online supplement).

serves as an end goal, representing (relatively) undisturbed conditions without anthropogenic influence. From that reference state, a quantitative 'good status' is derived (Stowa, 2012). For the Ems-Dollard, this reference state is the 1950s to 1960s, as a fully natural state was deemed unfeasible (Wielakker et al., 2011). European law warrants that noncompliance with EU directives leads to a sentence that may include financial penalties (WFD, 2000).

European Habitats and Birds Directives

For protection of valuable species and habitats in the European Union, the Natura2000 network was established in 1992 and has been expanding since. The importance of the HBD for the governance of natural systems is that protection of species is mainly carried out through the protection of habitats in which endangered, vulnerable, rare or endemic species reside during some phase of their lives (BD, 2009; HD, 1992). The abiotic conditions in those habitats therefore need to be in sufficient or good ecological condition. Deterioration of habitats is to be prevented. This means that the area of certain habitats, such as intertidal flats, is not allowed to decrease, while it is also mentioned that the flats are part of a dynamic system that is prone to erosion and sedimentation processes and thus vary in extent (Ministry LNV, 2008). In case of reasons of overriding public interest, projects that cause significant harm to the protected nature may still proceed, and compensation measures are required to warrant the overall coherence of the N2000 network (HD, art. 6).

National legislation of Germany and the Netherlands

With reference to the constitutions of the Netherlands and Germany, recognition of the interests of nature only occurs in the Netherlands. The Dutch constitution states that the government has a duty of care towards the 'habitability of the land and the protection and improvement of the environment' (Nederlandse Grondwet, n.d., art. 21). This is to be explained in a broad sense as the government being obliged to safeguard the natural environment.

The Wet Natuurbescherming (2015) (Nature Conservation Act, Dutch national law) gives effect to this duty of care, but the 'view on nature' itself is not anchored in law; Dutch nature conservation law refers to the policy document National Nature Vision (Ministry EZ, 2014) for the view on governance of nature, which means that it can be adjusted in case of a change in opinion, policy or change in political views (elected government), provided it stays in line with European Union obligations.

In Germany, nature conservation policy is anchored in the Bundesnaturschutzgesetz (2009) (Nature Conservation Act, a federal law). German states have their own laws stating the particulars for their states in addition to the federal law. The importance of nature is acknowledged as 'Nature and landscape need to be protected for their intrinsic value and for the basis of life and health' (Bundesnaturschutzgesetz, art. 1.1).

Both countries have an economic component in their nature conservation laws, stating that damage should be avoided (D) or mitigated (NL). In Germany, all measures for nature conservation and landscape development need to be weighed against the effort required. Exemptions can be granted for activities that infringe nature conservation or N2000 areas in case of imperative national interest and if there are no alternatives (Bundesnaturschutzgesetz,

art. 34.3; Wet Natuurbescherming, art. 2.8), or if the implementation of policy is disproportionate with the interests of nature (Bundesnaturschutzgesetz, art. 67).

International cooperation

International cooperation between Germany and the Netherlands in the Ems-Dollard region has a long and complicated history because of the disputed border area stretching as a wedge from the Dollard to the North Sea. In the Ems-Dollard Treaty, the two countries agree to respect each other's positions on the course of the international border and to cooperate within this area as 'good neighbours' (Ems-Dollard Treaty, 1960, art. 1). The treaty arranges for the settlement of matters of navigation and maintenance, but it was not until the WFD (2000) that environmental issues or protection of nature became more prominent in the governance of the Ems-Dollard (Disco & Van Heezik, 2015; Van Rijswick & Havekes, 2012).

Managing the water system is arranged first and foremost at river basin scale under the WFD. The current state of the water system, goals and proposed measures are formulated in the Ems RBMP, which subdivides the basin into coordination areas, of which Ems South (German responsibility) and Ems NL (Dutch responsibility) include the Tideems and estuary districts. Subcommittee G of the German–Dutch Border Water Commission is in charge of decisions regarding the district of the disputed area. The competent authorities in the German areas are the environmental ministries and offices of the states (for Ems South this is Lower Saxony and its environmental office, Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz, NLWKN), as the German principle of subsidiarity requires the transfer of decisions to a lower authority whenever possible, while matters of navigation remain under federal responsibility. German competent authorities do not always act as executive authorities. In the Netherlands, a national ministry is the competent authority. The General Directorate on Planning and Water (Rijkswaterstaat) coordinates WFD measures in cooperation with provincial, district and municipal authorities and water boards. The RBMP itself is implemented by a range of commissions, steering groups, coordination groups and districts in transboundary cooperation. However, the different administrative structures in the two countries do not always pair well in terms of competences (SGD Eems, 2015),

Regional implementation

More specific than the basin-scale RBMP, the implementation of the WFD and HBD for the Ems-Dollard is outlined in the Integral Management Plan (IMP, 2016). Formulated in the IMP are restoration and improvement of hydro-morphological integrity, estuarine connections and the basis of the food web. The IMP itself is not legally binding but a policy document involving deliberation with other parties, in particular NGOs and economic stakeholders. It serves as a specialist grounding for management that is effectuated in each country in documents that do provide a legal basis, the MIRT-report (multiannual investment programme for infrastructure, spatial planning and transport, customary in Dutch policy) (NL) and the Masterplan Ems 2050 (D) (IMP, 2016). Importantly, both documents include cooperation with regional authorities, NGOs and economic stakeholders.

The Dutch MIRT-report is the culmination of a series of studies commissioned by the Dutch government, in cooperation with the E&E (Ecology and Economy in Balance) platform, to map out problems and opportunities in the Ems-Dollard under the umbrella of the Programme Eems-Dollard 2050 (Ministry I&M, province Groningen, 2015). The aim for 2050 is that the estuary has 'appropriate dimensions, with healthy habitats, with natural transition zones and sufficient food at the basis', with unfragmented and connective functioning in the geographical and ecological senses (p. 1). The German Masterplan Ems 2050 focuses more on economics, 'to align the ecological and economic interests, that are recognised as equivalent' (Masterplan Ems 2050, 2015, preamble); its aim is 'sustainable development and optimisation of the Ems estuary in view of naturalness, safety and accessibility' (art. 4.4). Aims for improving and the importance of hydro-morphological integrity as formulated in the IMP and MIRT were not adopted in the Masterplan.

The web of say and interests

The many different parties involved in the Ems-Dollard discussed in the previous sections form a complicated web of say and interests, and the question is whether it is succeeding in moving the Ems-Dollard towards a naturally balanced riverine and estuarine system. After the management period of the first RBMP, it was found that the fact that the RBMP does not have legal consequences for third parties is hampering implementation of the measures (SGD Eems, 2015). At EU level, the WFD obligates member states to determine penalties for breaching the regulations that each country develops to implement the WFD. The difficulties with shared responsibilities within transboundary river basins as to a lack of legal accountability for the river basin as a whole is a known problem in EU water law. Therefore, water management continues to depend on the cooperation of the states in the river basin (Van Rijswick et al., 2010). Nevertheless, EU directives did provide the necessary incentive for Germany and the Netherlands to seriously start to take action and cooperate internationally on water quality and nature in the Ems-Dollard region (Disco & Van Heezik, 2015).

Although policy documents frequently state the need for cooperation, the difference in focus and priorities between the two countries becomes apparent when comparing the German Masterplan and the Dutch MIRT. Emphasis in the MIRT lies more on developing ways to reach the 'ecological target state', while the Masterplan is a formal document with more room for economic interests and does not mention any hydro-morphological renaturalization measures. The Dutch E&E platform, the German Masterplan and the international IMP all involve public and private parties and stakeholders already from an early stage. This should improve the support for restoration projects, which is especially desirable if measures touch on socio-economic or other anthropogenic activities. The IMP allows all parties involved to comment on the proposed measures. It was stated that the parties in the Dutch deliberation rounds searched for synergies and mutual interests, while German deliberation rounds with similar stakeholders were characterized by a focus on business and conflicts, mainly between economic interests and nature conservation (IMP, 2016).

The IMP explicitly does not weigh the interests of nature versus economy, but the Masterplan and MIRT do. The Masterplan holds assurances for those using the Ems for navigation, and especially for the inland shipyard. The importance of the shipyard is acknowledged, and the location in Papenburg is warranted. Furthermore, NGOs have

committed to not making any appeals against the extension of the winter operational period of the Ems storm surge barrier, and it is stated that 'proposed measures may not adversely affect the functioning of the Ems national waterway, nor hinder ship conveyances of Meyer shipyard' (Masterplan Ems 2050, 2015, attachment E to art. 13). In the Dutch E&E agreement, the previously decided further deepening of the channel towards Eemshaven is warranted because the harbour has already expanded in anticipation of the deepening. NGOs agree to be reserved in taking legal action against deepening activities, provided that MIRT measures offer enough prospects for the recovery of the system (E&E, 2014). Along with signing this agreement, the Dutch NGOs also demanded that serious efforts finally be undertaken for nature restoration, and that has been agreed to by the authorities and other parties.

Despite the cooperative approach to governance and nature restoration, and the extended management cycle, the ecological problems proved difficult to mitigate, and WFD standards difficult to meet (SGD Eems, 2013). It is deemed unlikely that the good status or good ecological potential required by the WFD will be achieved even by 2027 (P. Dankers, W. Iedema, pers. comm.). How to improve the potential to achieve the WFD and HBD goals is discussed next.

How to integrate dynamic naturalness in law and policy?

The Ems-Dollard system is a clear example of an estuarine system in which human intervention has created a cascade of problems that severely disrupt the natural functioning of the system, its hydro-morphodynamics (including turbidity), and flora and fauna. The 'Natural System' section explained that the Ems-Dollard system is *dynamic* (as are all riverine and estuarine systems) and that the basis of its proper functioning is importantly defined by hydro-morphodynamics. Conversely, the 'Governance' section mentioned that legislation and measures to address the problems in the natural system (e.g. WFD) are aimed at the ecological and chemical state, and protection and restoration law and policy mainly consist of *static* definitions of the natural system (e.g. habitat types of the HD). Additionally, conflicting interests between nature and economics complicate decision making in restoration projects, and warranties in legally binding law and policy still provide opportunities for economic activities at the cost of nature restoration. Combining the findings from the natural and governance components of the Ems-Dollard brings forward two dimensions for the present discussion. Both dimensions follow from the way the natural quality of natural systems is currently considered and represented in regulation and policy.

Firstly, the practical dimension. Practical examples from the Ems-Dollard demonstrate why it is essential to incorporate the dynamic character of natural systems in nature conservation and water legislation and policy that takes an ecosystem approach, how these issues can be resolved, and how the current weighing of interests hampers achieving the WFD and HBD goals.

The conceptual dimension ventures into the wider scope of *what* a natural water system would actually be in the presence of human activity, in light of the 'good' or 'healthy' state that nature legislation and policy aim for. In the Ems-Dollard (and many other natural systems), humans live and operate within a natural world and are therefore also part of this natural system. Contemplating the implementation of restoration measures therefore also entails a

discussion on the value and importance of naturalness in the environment. It is customary for science and engineering to study the functioning of a natural system, to understand the processes behind it, and, if a process is hampered, to find a solution to try and fix it. Such a solution may be to interfere in the natural system and guide it around the problem and tinker with the system, or to intervene in such a way that the system returns to a balance defined by science and engineering. The choice between tinkering interference and intervention for balance is the difference between controlling the environment and working with the environment. It is the former that has contributed to the problems in the Ems-Dollard.

Contemplating this choice in, for example, nature restoration, requires consideration of the role of nature and that of humans. This would appear to entail a choice of allegiance to the interests of either nature or society. However, it does not take away from the unbiased view with which science is undertaken. It is actually the choice to weigh the interests of nature that already guides each decision whenever remediation measures invented by science or engineering are proposed, as initial or boundary conditions are often already shaped by humans. For example, the reference state of the surface area of intertidal flats for the WFD was chosen as 1950–1960 (Wielakker et al., 2011) – see the 'Legal Framework' section. This automatically assumes some human interference, as some artificial alterations to the natural system had already taken place. Therefore, scientists should be aware of the choices they may make (directly or indirectly) in assuming the boundary conditions of their object of study, which afterwards are incorporated into the legal system with its strict binding obligations.

With all this in mind, we turn to the practical and conceptual paths.

Practical representation of the natural system in law and policy

Static regulation in a dynamic natural system

Restoration of the state of the Ems-Dollard is currently arranged under the European WFD, HD and BD, as transposed and implemented in national legislation and policy. As described in the 'Legal Framework' section, the WFD focusses on ecological status (or potential) and chemical status. Hydromorphology is only an additional aspect that arises in creating habitats for flora and fauna. The current subdivision in the WFD between hydro-morphological elements supporting biological elements (variation in depth, substrate, structure of the riverbank or tidal zone, flow quantity and dynamics, and river continuity) and chemical elements (salinity, dissolved substances including turbidity) ignores some of the most crucial systemic characteristics of riverine and estuarine systems, namely the interplay between the different aspects of hydromorphodynamics. Although it would thus result in an incomplete approach to restoring a natural water system, this subdivision is nevertheless employed in other places where focus lies on an ecological perspective, such as Wuijts et al. (2019).

Salinity in particular is currently considered a characteristic of the chemical state, or indicative of the types of flora and fauna that can reside in such waters. However, it is also a vital driving force for estuarine flow and circulation (Savenije, 2015; Van Maren et al., 2015a). Turbidity (suspended sediment concentration) is an aspect of sediment transport processes and thus of morphology and intricately linked to the estuarine circulation. Furthermore, the interaction between abiotic and biotic components is overlooked in EU environmental law, even when it aims to protect ecosystems. Eco-engineering species

have important influence on the development of morphology (De Haas et al., 2018). Hydro-morphodynamics should therefore be recognized in its own right as a characteristic of a natural system, one that indeed provides the canvas for biotic elements, but nevertheless an assemblage of processes that principally guides the functioning of the natural water system.

Additionally, hydromorphology appears to mainly be portrayed in the EU directives as a requisite for the biotic ecosystem. The risk here is that restoration projects may focus on (re)establishing habitats for the sake of having certain habitats (such as riparian forests, intertidal flats and supratidal zones) of a certain acreage because they desire a complete and static picture of the ideal estuary or river. In reality, natural systems are dynamic and constantly reshape themselves. It may therefore very well be that certain habitats are destroyed by natural processes in one place and develop again in another, and not all characteristic habitats may be present in the system continuously. EU nature conservation legislation does not recognize these dynamics. The boundaries of HD habitats are delimited, and conservation goals state that these habitats are not allowed to decrease in extent or to move.

Suppose that the water flowing through a channel is eroding part of the mudflats (N2000 habitat type H1140), which is not allowed because the areal extent of this habitat type has to be preserved (HD, 1992; Ministry LNV, 2008). According to current law and policy, the system would then be in violation of itself, even though it is performing nothing but its natural processes. For the particular case of H1140, the explanation of this conservation goal does state that the exact location and surface area may fluctuate yearly, because the environment is highly dynamic (Ministry LNV, 2008), but this directly contradicts its own conservation goal of preservation of area. And other habitat types (e.g. salt marshes, sand flats, young dunes) do not have such an explanation, even though they are also prone to natural fluctuations in area. H1130 (estuaries) incorporates several intertidal and subtidal habitat types and allows some internal fluctuation, but again is demarcated at the transition to e.g. supratidal habitats.

The 'for the benefit of' condition allows the extent of one habitat type to decrease for the benefit of another, if the other is declining in quality or area (Ministry LNV, 2008, attachment C). If this condition were extended to incorporate the intrinsic hydro-morphodynamic processes of a system, it might provide a temporary solution to the problem of preserved areal extent. A different practical implication of hydro-morphodynamic processes concerns locating an international border. According to international law (and the position of the Netherlands on the disputed area – Disco & Van Heezik, 2015; SGD Eems, 2009) it is customary to define the *thalweg* (the deepest path in the channel network) as the international border if it is located in a channel system. This means that the international border could move along with the channel dynamics in a river or estuary.

These examples illustrate the complications in the practical application of law and policy. The EU directives allow interpretation and customary implementation in the federal or national law of the member states, but the HD nevertheless states that areal extent needs to be constant or expanding. For the wider Wadden Sea area, some nuance as to fluctuating areal extent and dynamic processes for tidal habitats was added to the N2000 Designation Decree after public consultation (Ministry LNV, 2008). However, this shortcoming would best be resolved at the level of EU legislation. The extent of tidal area pertaining to the reference state of the WFD is a matter for the member states and might

therefore be adjusted at the national administrative level to better represent the natural hydro-morphodynamic processes.

The weighing of interests in law and policy

As for the degree to which the EU directives and the legislation and policy of Germany and the Netherlands protect nature, there are still clauses in the legislation that allow societal and especially economic interests to come before nature. There is no explicit vesting in Dutch or German law of the importance of natural areas and natural processes in their own right. Thus a loophole remains for economic and other interests in case of conflict with nature's interests, which should be protected under law (Wilk. et al., 2019). It is up to the authorities to weigh interests in any conflicting plans. The decision therefore depends strongly on society's view of nature.

For the Ems-Dollard, economic interests are anchored and warranted in legal and policy documents (e.g. Masterplan Ems 2050, E&E, ED 2050). This means, among other things, that large ships still need to be able to navigate the estuary and the Ems River, automatically entailing that the channels need to remain deep enough for navigation. Yet, the unnaturally deep channels are one of the most important causes of the disruption of the natural balance in the Ems-Dollard. If the aim is to renaturalize the river and estuary in the sense of ecosystem functioning, adjustments in the use of the waterways are necessary. The harbours in the estuary could adapt their activities so that ships with lesser draught are sufficient. In the river Ems, the construction activities are mainly related to the inland shipyard. The politically sensitive question is whether having a builder of very large cruise ships at a location 30 km upstream in a small river is sustainable. However, moving the shipyard closer to the coast has not been considered an option for economic reasons (Masterplan Ems 2050, 2015). The WFD eases some restrictions for artificial or heavily modified waters, but it appears unlikely that the aims formulated in the RBMP, IMP and MIRT of a more natural morphology are achievable with the current intensive use of the waterways.

The difficulty in law and policy in Germany and the Netherlands is that they do not bring economy and nature in balance with each other but prefer the interests of nature to fit within economic purposes. Elsewhere in the world, granting legal rights or personhood to nature is seen as a step forward in warranting the interests of nature and instigating restoration measures (Boyd, 2017; Cano Pecharroman., 2018; Daly, 2012; Garmestani et al., 2019; O'Donnell & Talbot-Jones, 2018; Stone, 1972, 2010; Suykens et al., 2019), but given the framework of legislation and management, this is not considered feasible for the Ems-Dollard (Gilissen et al., 2019; Van der Werf, 2019). Still, decision making on natural systems does require discussion of the underlying assumptions in nature restoration. The following conceptual dimension discusses the coexistence of naturalness and humans in the same system, as well as its practical importance for the 'reference state' required by EU directives.

What is a natural water system with human presence?

On the 'natural state'

If the aim of the restoration of the Ems-Dollard natural system is to reach a dynamic state in which the system keeps itself in balance, the 'natural state' of the Ems-Dollard needs to be defined first. This natural state would in theory be the 'reference state' for full restoration under the WFD. Definition is a difficult task, because the system has been

shaped by human activity for centuries. What is more, the Ems-Dollard would not even exist as it does, were it not for human intervention (Figure 2). After all, the sea ingressions that formed the Dollard would not have caused such a widening of the tidal basin if the hinterland had not subsided, a consequence of embankment by dikes and land reclamation.

The Dollard has been gradually silting up since the fifteenth century, except when shipping channels were deepened and sediment was extracted from the system, and it is expected that this process will continue until sea level rise exceeds the shallowing rate by natural processes. This sedimentation process may raise suspended sediment concentrations, even if the main causes of the high turbidity are mitigated (ED2050, 2017). A long-term vision on a natural Ems-Dollard should include the changing boundary conditions of climate change, sea level and changing freshwater input from precipitation.

Knowing that the Ems-Dollard system was formed under the (indirect) influence of humans, that the system was heavily modified by human intervention over the past two centuries and that the future holds changes in boundary conditions that can only partly be predicted, would it be sensible to look to the past for a 'reference state' of what the system should look like, as is carried out under the WFD? The risk here is to force the Ems-Dollard into a new straitjacket – a well-intended one, but still an image of a natural state governed by boundary conditions of the past and by the desire to create certain specific ecological habitats that do not necessarily fit the current natural development of the system. Evolution through time is inherent in natural systems, and defining what a dynamic equilibrium with human presence entails is difficult, let alone quantifying such a complex interplay. In any case, target images and decisions on measures, whether construction or removal, are a product of how society views nature. It is this view that has started to change in the past decades as awareness of the consequences of intervention in the environment grows (Van Heezik, 2006).

A view of nature

Looking at the centuries of adjustments, alterations and construction works that humans have undertaken in their natural surroundings, it appears to be the general conviction that nature could be adjusted and shaped for the benefit of society and economic use, as exemplified by the Ems-Dollard system. The 'battle against the water' is well known in the collective memory of the Dutch people, and engineering works have been going on for centuries, in line with the policy that water needs to be contained and redirected as humans see fit (Van Heezik, 2006). The heavily deteriorated state the Ems-Dollard system is in now is the result of human actions, and the question is what to do about it. Any attempt to renaturalize the system requires consideration of the interaction with human activity in the area. Can the system be natural only if humans are in no way involved, and thus essentially would have to move out of the river basin entirely? In this scenario, there is still a division between human and environment; in contrast, instances of granting rights to nature advocate that humans are part of nature (Grear, 2011). An ecocentric approach regards the well-being of a natural system as a whole, but the degree of human presence depends on the definition of 'ecocentric' (Washington et al., 2017). The right of existence falls to the combination of humans and nature, recognizing the interconnectedness of their existence. The choice for the future of the Ems-Dollard system and the natural state that is envisioned in policy making, based on scientific understanding of the system and the value that

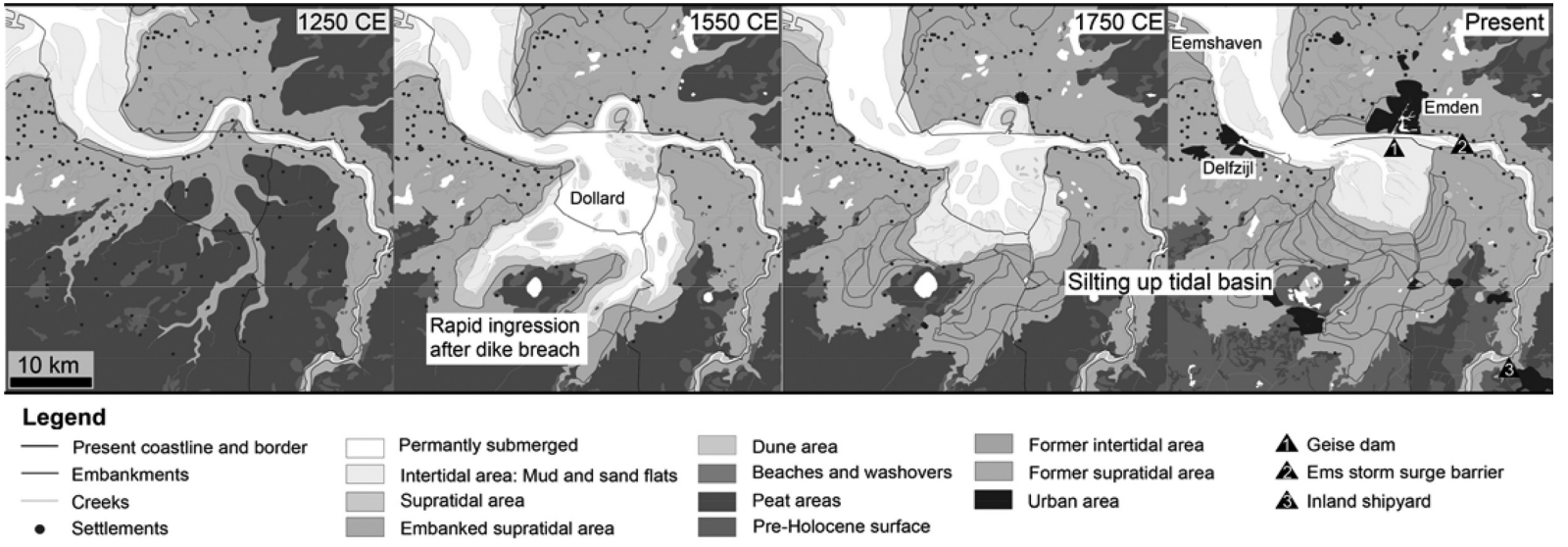

Figure 2. Evolution of the Ems-Dollard estuary over eight centuries (after Vos & Bungenstock, 2013; De Haas et al., 2018). The Dollard embayment in the estuary was formed after a series of floods in the thirteenth and fourteenth centuries CE. It then decreased in size due to embankments for land reclamation and deposition of sediment (silting up). The shape of the water system is thus a consequence of human activity. Locations of present-day harbours and several other major works are included (colour image available in online supplement).

humans put on nature, is therefore one that needs to find a balance in reciprocal coexistence, without attempting to overpower the functioning of nature.

How this coexistence of humans and nature should be regarded and when the presence of humans becomes a disruptive interference in natural systems can be illustrated by the example of beavers building a dam in a river, as they do in their natural way of living (Jones et al., 1994). If the river is only to follow its own natural course, the beavers can be seen as a disruption, for their actions cause the development of a lake upstream of the dam; the river may also change its course. On the other hand, if the beavers are viewed as a part of the greater ecosystem of nature, which also encompasses the hydromorphodynamics of the river, the beaver dam is also part of the ecosystem, where beavers and river together find a new balance of coexistence. The extent to which humans build their more intrusive version of a beaver dam (including all adaptations and construction works) goes beyond coexistence, for it disrupts the functioning of the river and the ecosystem that the river supports. If problems such as the deteriorated ecosystem and the hyperturbidity of the Ems-Dollard are to be solved, the challenge for present and future restoration projects is to find a way of interconnected coexistence where both humans and the natural system can function in a healthy balance. Defining the 'naturalness' of the system should include not only the ecological components it is commonly limited to (Dussault, 2016) but importantly also the abiotic components, and even the interconnectedness with humans. The answer is not straightforward nor easy to accomplish, but a dynamic process towards an interactive equilibrium, just as the natural functioning of a natural system always demonstrates.

Conclusion

The Ems-Dollard example was discussed from two angles, the natural functioning of the system, and law and policy to improve the poor state of the natural system. This has brought to light a field of tension between dynamic naturalness and static regulation. Because of the underrepresentation of hydro-morphodynamic functioning and the strong economic components in legislation and policy, current regulation is not sufficient to achieve the aim it was designed for, namely to ameliorate the state of the Ems-Dollard towards 'good' ecological and chemical status under the WFD, and meeting the 'conservation goals' of the HD and BD. Current legislation still allows activities that harm even protected natural systems if there are 'overriding reasons' of public interest, by warranting economic interests in an at times unbalanced way.

Practical implementation of the EU directives and national legislation and policy in the Ems-Dollard water system has revealed shortcomings of water governance at the operational level, including the standards for preservation of the areal extent of habitats such as mudflats, and the fact that the abiotic characteristics are considered only in terms of an aspect of the creation of habitats for flora and fauna. The static boundaries required for the designation of HD habitats, e.g. tidal flats, are not suitable for a dynamic system such as a river or estuary. The river or estuary would be in violation of itself if its own natural erosion and sedimentation processes destroy or create tidal flats, for example. The focus of policy making lies on the goal of an envisioned habitat, but the intricate interplay of hydro-morphological processes (flow, sediment, salinity, tide) ultimately determines the types of habitat a system will develop, and its importance should therefore be

acknowledged. Adjustments in EU legislation are recommended to better accommodate natural processes and system interconnectivity. Renaturalization plans and projects for the Ems-Dollard require weighing the interests of the natural system and of society and economy, which has proven to be a sensitive matter. The present socio-economic use of the waterways, for which an increased channel depth is required, prevents hydro-morphodynamics from returning to a natural balance.

The conceptual issue of what a natural system actually entails is relevant for determining the 'reference state' that is to serve as the blueprint for a naturally functioning water system under the WFD. Currently, the reference state for the Ems-Dollard still incorporates certain artificial modification measures, such as deepened channels. Restoration of the water system to meet the 'good status' aim of WFD is therefore not achievable under current legislation and policy. The development of the Ems-Dollard over centuries has shown that a defined natural dynamic *state* does not exist, or at least is ever changing. This is a challenge for regulation and policy, which prefer delimiting or quantitative definitions. Restoring the natural functioning of a water system requires contemplating the role of humans in the system, and the extent to which restoration can be achieved depends on finding a balanced coexistence between humans and naturalness. In any case, it involves a transdisciplinary debate to enrich the integrated approach to studying nature and living in a natural environment.

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