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Stone Aggregations or Reefs? Knowledge Politics Around a Transboundary Seabed Complex

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Abstract

This study analyses marine governance and knowledge politics of sediments in the Borkum Reef Ground from a historical and German perspective, as well as in the context of litigation against marine gas production from transboundary Dutch and German fields. The authors analysed interview transcripts, project documents, environmental media campaigns, and notes originating from participant observation and stakeholder engagement. The study employs the science and technology and sociology of ignorance approaches. It asks which implications for biodiversity protection and ocean governance derive from administrative fragmentation and knowledge politics by a diverse set of actors. National divisions and prioritised knowledge production led to a shift in perception of the area from a transboundary seabed habitat to two distinct national marine areas and resulted in a fragmented *Schutzgebietskulisse* including marine protected areas, restoration zones, and unprotected zones. The study illustrates how the prioritisation of mapping marine protected areas may backfire on knowledge gain in potential industrial zones and overall marine protection.

Keywords

Germany; knowledge politics; marine gas; marine protection; North Sea; ocean governance; the Netherlands

1. Introduction

This article originates from a naïve question: Where is the Borkum Reef Ground located? It was posed by the first author, a social anthropologist, when entering an interdisciplinary research project focusing on the German marine protected area (MPA) known as Borkum Riffgrund. Her task was to investigate the

governance of user conflicts. By the end of the first project period, many project colleagues, including natural scientists equated the Borkum Reef Ground with the MPA, which was incorrect. Though they knew about marine connectivity and the meaninglessness of human-made borders to marine life and processes, they underestimated the political importance of scoping and mapping the habitat. Imaginations, however, influence ocean governance outcomes when communicating to policymakers or judges, because how can they understand the ecological implications of their decisions over marine industrial projects with only a vague idea of the spatial extent and nature of the affected habitat?

The major user conflict, a contested gas extraction project across the Dutch–German border, was easily identified through a systematic analysis of newspaper articles (Ittner, 2022). Since 2019, the Gateway to the Ems (GEMS) project has evolved into the most important user conflict in the German North Sea—involving two countries within a wider region (the Wadden Sea), crossing local to global levels, involving several court cases, and many protest activities. The stakes were high. The Dutch gas industry had invested more than €600 million in gas exploration and in the production of the platform. The German government faced the consequences of the Russian invasion of Ukraine on national gas security, and harsh criticism by citizens who felt overwhelmed by climate protection measures, as well as by environmental activists pressurising for increased measures. GEMS opponents took financial risks when filing suits against the industry, inter alia, the Dutch Ministry for Climate and Economic Affairs (EZK), the Dutch approval authority, and against one German regional authority. They did so because they saw climate and biodiversity protection threatened by a new fossil fuel production site. Island communities and environmental actors placed the spatial extent and seabed properties of the Borkum Reef Ground on the political agenda when aiming to prevent gas extraction by the ONE-Dyas enterprise. A coalition of claimants (hereafter "claimants"), through several litigations in the Netherlands, had provoked a building freeze lasting more than one year. Despite various court cases, some successful and others ongoing, the EZK permitted the start of the GEMS project in July 2024. Drilling began immediately in the Dutch coastal waters. The permit to drill under the German seabed was granted at the regional level thereafter but was pending at the national level due to the need to sign a bilateral agreement over the exploitation of the transboundary seabed (Ittner, 2024).

From the German perspective, the case study examines the Borkum Reef Ground as a sandbank biotope complex (Rachor & Nehmer, 2003, pp. 21, 167; called "complex" hereafter), in which endangered benthic species require protection, contrasted by a view according to which the seabed should serve as a gas extraction site. It analyses how the industry, approval authorities, claimants, and other project opponents seek to deny or produce evidence about stone reefs. It asks what implications for biodiversity protection and ocean governance are derived from administrative fragmentation and knowledge politics by a diverse set of actors.

The study continues with the description of the concepts, which derive from science and technology studies and the sociology of ignorance. In Section 3, the authors present their research methods and describe the case study. The empirical analysis is organised as follows: Section 4.1 explains challenges in detection and the legal categorisation of stone reefs, Section 4.2 highlights governance outcomes of administrative fragmentation, and Sections 5.1 and 5.2 analyse the production of counter-knowledge and knowledge politics in the context of the GEMS litigation. Section 6 discusses knowledge production and ignorance in the context of industrial projects taking into account the evidence of the case study. Section 7 provides conclusions.

2. Conceptual Approach

Scholarship of environmental contestations emphasises the relevance of scientific knowledge and the production of "unofficial," bottom-up counter-knowledge and studies the role of different types of knowledge in legal contestations over nature. Comparing shale gas contestations in European countries, for instance, Cantoni (2022, p. 350) underlines the fact that "in many environmental disputes the only factor influencing the outcome is the ability to produce knowledge." While "official" knowledge is produced by, for example, universities, research institutes, think tanks, and research units of public administrations, the origin of "unofficial" counter-knowledge is manifold. It includes specialised staff of civil society organisations and consultancies, lay experts, or local communities. Information exchange among various opponents across national borders can be central here. With regard to shale gas contestations in Europe, it allowed the evolution of a "genuinely transnational, science-based anti-fracking movement" (Cantoni, 2022, p. 351).

Derived from a review of 77 studies on contested pipeline projects, Hess et al. (2023, p. 7) found that litigation was one effective, institutional tactic which, as "an accumulation of small victories [,] can slow-down the approval process and result in a no-build outcome." Litigation, however, required considerable technical and legal knowledge and resources. Opponent coalitions needed to first weigh up potential risks and possible gains and then to prepare a convincing argument of evidence.

Based on a review of studies on science–policy interaction around the cockle fishery and gas exploration controversies during the 2000s in the Netherlands, Floor et al. (2013) investigated the roles of natural scientists in various fora, including courts. Knowledge about the ecological effects of these uses was essential for ocean governance though other variables, such as power relations and economic interest, also played an important role. The legitimacy of scientific knowledge became contested when stakeholders, including gas opponents, politically engaged scientists, and government staff, strategically used the available knowledge. The independence of the scientific knowledge-producing process was questioned. Who commissioned research for what purpose, and who carried out the research, thus became political. The authors emphasised: "Different interpretations of knowledge explain why producing more scientific knowledge is insufficient in finding consensus between stakeholders" (Floor et al., 2013, p. 174).

In the present case study, we assess a similar interplay of knowledge production (as well as different types of knowledge) by diverse actor groups and the use of these different types of knowledge as epistemic and political resources in court rulings over nature. For analysing the case, we consequently draw conceptual inspiration from science and technology studies and the sociology of ignorance (see Wehling, 2021, for an overview of the latter).

Lachenmann (1994), for instance, points to the systematic production of "non-knowledge" or different degrees of uncertainty and ignorance in contestations over using and working with nature. These "systems of non-knowledge" (in German, *Systeme des Nichtwissens*), also referred to as "systems of ignorance," have in common that certain types of knowledge and their representatives are systematically either excluded or delegitimised in decision-making processes. More recent discussions speak of "knowledge certainty" or "clarity" (Senanayake & King, 2021) as forms of knowing that differ from "uncertainty" and "ignorance" (Birkenholtz & Simon, 2022). Yet these recent reflections increasingly underline the non-binary relationship between knowledge, uncertainty, and ignorance (Birkenholtz & Simon, 2022), as well as risk and ambiguity

(Scoones & Stirling, 2020; Stirling, 2010). The authors empirically show the co-existence and parallel use of knowledge and "non-knowledges" or forms of ignorance, partly to strategically master situations of uncertainty or deliberately uphold forms of ambiguity, depending on the political arenas in which the actors find themselves. While, as Proctor (2008, p. 1) rightly points out we "know a lot about knowledge," the study of uncertainties and ignorance is less pursued. We are referring to all types of (not-)knowing and political strategising that are just as relevant in understanding decision-making over how we govern nature, inter alia, the Borkum Reef Ground. We assess this production of ambiguity, uncertainty, and ignorance that makes informed court rulings nearly impossible with a focus on the interactions of epistemic practices (or practices of knowing) and litigations structured by institutional settings (Hornidge et al., 2020). In particular, we draw on the concepts of "undone science" and "unseen science" (see Table 1) that Hess (2020) and Wehling (2021) have developed at the intersection of science and technology studies and social movement studies.

Table 1. Basic concepts of the sociology of ignorance.

Undone science	Unseen science
Social movements/NGOs conduct research in understudied fields, with substantial potential for societal reform processes: **Epistemic form**: scientific habitus defines which problems can be researched and which not **Controversial science**: for example, difficulty in translating science in policy action. This is a new problem area with little research yet **Undone**: contrarian and substantially better financed (private and/or public) research stirs public controversy and systematic forms of delegitimising the civil society-based, self-funded research	Circulation of scientific knowledge across social fields/arenas reduces visibility: **"Forbidden" knowledge**: politically sensitive knowledge and knowledge that stands against the vested interests of larger (i.e., industrial) lobby groups **Strategic science translation:** translation of knowledge across various social arenas **Unseen**: political pressures lead to a systematic self-censorship by researchers who do not want to get entangled in political controversies

The concept of "undone science" focuses on fields of (non-)knowledge in which the qualitative and quantitative lack of knowledge in a given field means that the status quo in society (including the division of power between social groups) is maintained and strengthened. Public or industrial investments in these fields of research are usually not (or only marginally) given. Research financed and conducted by NGOs or other civil society groups remains shallow and can easily be contested in larger public debate. Examples include research on the interactions of science–technology–environment, for example, regarding the risks of nuclear energy production, genetically modified organisms, or certain applications of artificial intelligence. Here, scholars such as Hess (2020) and Frickel et al. (2010) stress that the "structured absence" of knowledge and expertise springs from unequal power positions of reformers and social movement leaders on the one side and industrial and political leaders on the other (Hess, 2016). This allows for a systematic "undoing of science." The concept of "unseen science" builds further on this, but places the emphasis more on making science "unseen" through processes of (deliberate) sequestering or not sharing data, for example, on the health impacts of certain drugs, as well as processes of self-censorship among the individual researchers involved, due to hierarchised, possibly authoritarian, systems of knowledge (Frickel, 2014).

3. Accompanying Research and Case Study

3.1. Data Collection and Analysis

The data collection by the first author (February 2022 to July 2024) began with the analysis of literature, project documents, maps, media, and campaigning material. It builds on semi-structured interviews and informal talks with environmental activists and organisations, staff of public authorities, and a marine geologist from the research project. Quotations from German interview transcriptions were translated into English. Impressions from participant observation and stakeholder engagement were recorded in research diaries. A timeline on gas extraction, and resistance to it in Germany and the Netherlands (1960–2024), and an exhibition were co-produced with GEMS stakeholders.

The position of the first author was comparable to that of the claimants. She had to familiarise herself with marine ecology, the research community, and their language and data sources, to learn about gas extraction, assess GEMS project documentation, and establish contact with experts in natural sciences and public authorities. As she had access to scientific events and networks closed to the claimants, she forwarded relevant information to them and documented their uptake. She accompanied them and documented the GEMS approval process since January 2023. Content analysis and discourse analysis of secondary data, notes, and interview transcriptions were complemented with a spatial-temporal analysis of the chronology of events. A project colleague supported mapping.

3.2. The Case Study: The Contested Description of a Seabed Habitat

The Borkum Reef Ground covers an area of 1.225 km^2 (Álvarez et al., 2019) in the territorial waters and the exclusive economic zones (EEZs). A part of the seabed habitat complex is protected in Germany and a larger Dutch area was recently placed under protection (see Figure 1). European flat oysters contributed reef structures to the complex before it became extinct in Dutch and German waters. Its reefs are restored on both sides of the border (Bos et al., 2023; Pogoda et al., 2023). The habitat complex is thus unprotected, protected, and restored at the same time.

Dutch scientists emphasise the need to document "the last remnants of a once more extensive [oyster] reef community in the North Sea." They found that "the reported area [in historical accounts] varies broadly and often lacks mention of reefs west of the German-Dutch border" (Coolen et al., 2015, p. 85). Scholars in the Netherlands assume a triangular shape of Borkumse Stenen, based on Lindeboom et al. (2005), which ends at the national border, while scholars in Germany usually refer to the MPA limits. The geological description highlights the unity of the area but questions the term "reef":

> Geologically seen, this is a continuous system consisting of post-glacial drainage channels. When looking at the topography of nautical charts, you recognise ridges hinting in a northwest-southeastern direction along the complete East Frisian coast. These deep lines practically lie in a zigzag, which characterises these reefs, the so-called tongue reefs. That's the technical term. It is not a *real* reef in the geological sense. These stone ridges are covered with sand. Sometimes, they look out, sometimes, they don't. Because sanders are also mobile, stone ridges are uncovered or covered. (academic geologist, personal communication, July 31, 2024, emphasis added)

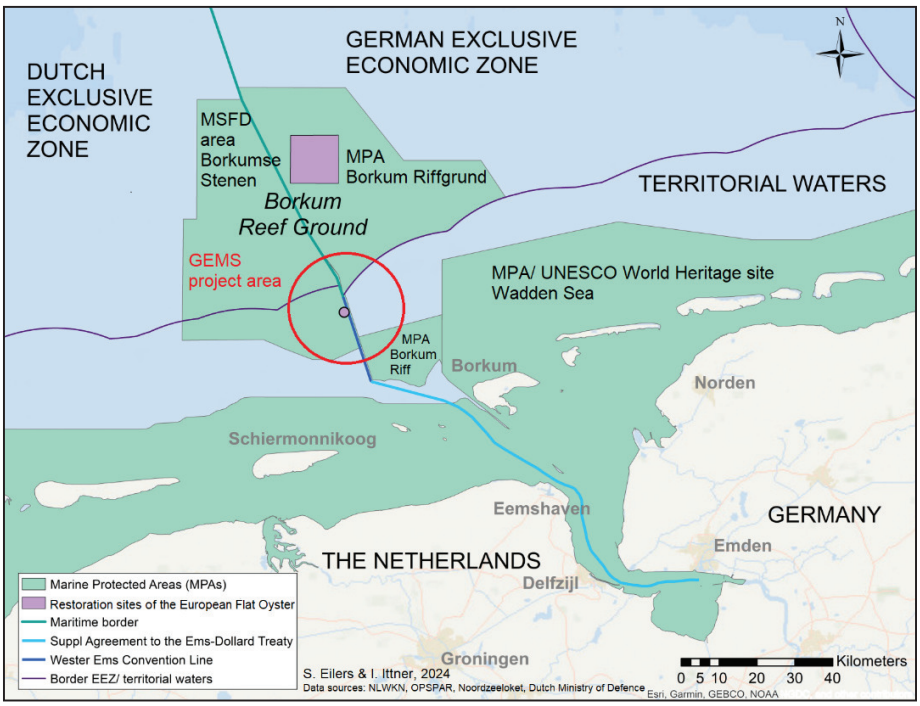

Figure 1. Location of the Borkum Reef Ground. Note: MSFD stands for Marine Strategy Framework Directive.

In the Netherlands, the complex is located in shallow waters, where the seabed consists of hard substrates in the form of cobbles, pebbles, and large stones. On top of this lie sand and gravel, resulting in multiple spatial niches and habitat types accommodating diverse benthic communities. Sandbanks are prevalent in some parts (Álvarez et al., 2019). In Germany, the complex is a large sandbank of 18–33 m depth with interspersed stone fields (Bundesamt für Naturschutz [BfN], 2017). The Federal Agency of Nature Protection (BfN) argued that the Borkum Reef Ground was special due to its close intersection of habitat types defined by the EU—sandbank and reef, as well as the biotopes of gravel, coarse sand, and shingle grounds (BfN, 2017, 2020). International and Dutch scientists stressed the peculiarity of the complex as having the second hard bottom seabed in the Dutch North Sea, besides Cleaver Bank, with coarse sediment and large boulders (Álvarez et al., 2019). Most readings of the complex underline the higher biodiversity of benthic communities compared to neighbouring seabed habitats, as well as the peculiarity of biogenetic reefs erected by the sand mason worm and the ross worm. The Borkum Reef Ground also supports endangered fish and mammal species.

The seabed complex is a mosaic of habitats in occasional flow with an approximate contour. The currents influence the temporality to detect stone formations and the opportunity for benthic species to settle on the boulders. Very strong currents may move cobbles over the seabed. Sand movements and changing stone locations may result in newly assembled piles of boulders and cobbles on top of the seafloor, which may evolve into inhabited stone reefs (Michaelis et al., 2019, p. 83). GPS points of these stone reefs do not necessarily indicate permanence.

In the following, we turn to the analysis of empirical evidence by first showing how legal and administrative fragmentation and strategic science translation produce knowledge gaps. Thereafter, we will investigate the production of knowledge, ambiguity, uncertainty, and ignorance by GEMS supporters and opponents.

4. Legal Implications of Fragmented Mapping

4.1. Are Stone Reefs Real Only When They Are Legally Defined Reefs?

The location of the stone reefs was essential for the presentation of evidence in court, as stone reefs in the GEMS project area would eventually stop the construction of the gas platform and cables. ONE-Dyas and the EZK ministry attempted to convince the judges of the low ecological value of the seabed in the project area and the lack of risk by drilling and laying undersea cables. It was easy to claim that there was nothing worthy of protection. The challenging giving of evidence about the reefs was the task of the claimants, who could not rely on a map showing the contour of the Borkum Reef Ground, and the location of stone reefs in the project area. Such a map did not exist. The claimants consulted dozens of maps and studies for the compilation of evidence. Nobody was a marine geologist or ecologist. Nobody was skilled in professional mapping tools or knew about marine scientific repositories at the beginning of the process. The claimants presented points of evidence, which Dutch judges found difficult to follow. One acknowledged geo-based map issued by a public authority or research institute would have been more powerful. While winning the case and getting the dismissal of the first construction permit established in April 2024, the reasons given for the judgment neglected the question of whether stone reefs could be destroyed by the gas project. This is why the claimants appealed in May 2024.

Why was there no comprehensive, "official" map? The answer is administrative fragmentation within Germany and between the two countries. A German consultancy hired by the public authority Niedersächsischer Landesbetrieb für Wasserwirtschaft, Küsten- und Naturschutz (NLWKN), during the environmental impact assessment (EIA), drew attention to the regulation gap in the EU Code 1170 of the Natura 2000 Interpretation Manual of EU Habitats (BioConsult, 2022). It defined reefs based on the occurrence of hard compact substrata larger than 64 mm (European Commission, 2007). Following the code, the enduring occurrence of benthic communities on the boulders, though typical, was not necessary for its categorisation as a geogenic reef (BfN, 2018, p. 8).

When BfN prepared the designation of the MPA based on the presence of geogenic and biogenic reefs, it faced various legal and other challenges in implementing Natura 2000 in offshore waters, as well as in defining reefs. Boedeker et al. (2006) and Krause et al. (2006) documented details of the long and complex process and decision-making rationale. The authority finally drew up a supplementary mapping guide supported by the project Sedimentkartierung AWZ von Nord- und Ostsee (SedAWZ). In 70 pages, including annexes, BfN, scientists, and private sector experts refined the criteria for minimal reef areas and reef borders in contrast to their environment. The diversity of reef habitats in the southern North Sea clearly informed the document, all of which, according to BfN experts, demanded somewhat different mapping standards. The guide described geogenic reefs as follows:

> The recording and spatial delimitation are based on hydroacoustic geoscientific methods…and include the following criteria and parameters. Criterion 1: The minimum size of individual stones to be digitised is oriented towards the currently smallest detection size for individual objects in the evaluation of side scan sonar data (resulting stone size of approximately 30–50 cm). Such individual stones or blocks are [displayed on maps with] buffer areas with a radius of 75 m. Criterion 2: If the distance between adjacent single stones…or blocks is ≤ 150 m, i.e., if their buffer areas either touch or overlap, these are

> combined to form a "stone or block aggregation." Criterion 3: If such a "stone or block aggregation" has at least 21 individual stones…or blocks with an average distance to their nearest neighbour of ≤ 50 m, it forms a geogenic reef of the type "stone field/boulder field." (BfN, 2018, pp. 13–14, translation by the authors).

Despite BfN's obsession with detail, the consultancy criticised the lack of taximetric criteria based on its work requirements within the context of the litigation (BioConsult & Submaris, 2021). Moreover, the validity of the mapping guide is limited to the German EEZ because it was developed as a reference for MPA designation.

The claimants hired the same enterprises for a critical assessment of the project application documents focusing on the habitat around the anticipated gas platform. This report concluded:

> Following the mapping guidelines of the BfN (2018), geogenic reefs of the type "boulder field" are present in the vicinity of the platform location N05a and also in the area of the planned power cable….Available data from 2019 and 2021 result in a different reef demarcation…the lower number of boulders in the year 2021, it is likely that they are still present in the area but covered by sediment…side scan sonar contacts classified as "objects" in the Appendix are not all boulders….Since further differentiation is not possible based on the available data, all side scan sonar contacts are classified as "boulder" by precaution. (BioConsult, 2022, pp. 6–7, 18)

The habitat assessment for the GEMS EIA was prepared by the Dutch consultancy Geoxyz and the British consultancy MarineSpace (company of the Environmental Resources Management Group; MarineSpace, 2022a, 2022b). They considered the EU Code 1170 for describing seafloor properties around the planned offshore platform in Dutch waters and found no structures that they categorised as reefs. The gas fields and prospects in Germany are located mainly in territorial waters, also outside BfN authority, where coastal states are sovereign. In Lower Saxony, however, no mapping guide apart from the EU Code 1170 was yet in place. A scientific diver, who investigated seafloor properties for the GEMS opponents, stated: "You can always argue, if you are a gas drilling company, that there is no reef, because what is a *real* reef? Legally, it is a bit difficult (staff of Submaris; Greenpeace, 2023, translation and emphasis by the authors).

In line with the European Flora-Fauna-Habitat (FFH) Directive and according to the German Federal Nature Protection Law (BNatSchG, § 30/2), stone reefs—if legally categorised as such—are protected, even if situated in unprotected areas. Non-categorised reefs legally remain assemblages of stones and are unprotected. The BfN guideline was applied in EIAs for projects outside the EEZ (BioConsult, 2022). This practice has no legal backing because the NLWKN did not declare the validity of the BfN guide in territorial waters despite knowing its relevance for the GEMS application. The government of Lower Saxony stated that authorities were developing a mapping guide (Greenpeace, 2023). Why distinct administrative processes were set up to refine a European regulation for mapping reef habitats in the German North Sea seems beyond common sense, but can be explained by the administrative culture of German federalism. The diversity of mapping guides, including some not mentioned in this text (cf. BioConsult, 2022), was rather confusing for non-experts.

4.2. An Incomplete Schutzgebietskulisse

The German term *Schutzgebietskulisse* describes all protective measures relevant to a particular area in a complementary, enforcing way by drawing on multi-level legal frameworks and laws (Krause et al., 2022). A cross-boundary habitat perspective on the Borkum Reef Ground rather suggests a fragmented *Schutzgebietskulisse* as the Natura 2000 network remained incomplete until recently. Figure 2 gives an overview of knowledge production in the context of science, marine protection, the gas project, and resistance to the gas project.

Before 1992, seafloor research was motivated by either industrial or scientific agendas. This changed with the EU FFH Directive, which triggered "official" knowledge production on the complex in both countries due to the obligation to present ecologically valuable zones to the European Commission. The period of the early 2000s was characterised by data inventories. Germany produced new seabed and taximetric data and analysis. German reports (e.g., Rachor & Nehmer, 2003) refer to the map by Jahrke which, to our knowledge, is the most recent published sediment map (apart from nautical charts) showing the habitat complex irrespective of national borders. Borkumse Stenen, however, was not displayed on the map. The reason is probably that munition and wrecks from World War II located off the Dutch coast prevented data collection at this time (Jahrke, 1956). After portions of Borkum Riffgrund were sonar-scanned, scientific divers combined the ground truthing of sonar data at the seafloor with the collection of taximetric samples, photography, and video in selected parts of the habitat complex.

The identification of potential protected assets resulted in the suggestion of 625 km^2 (about half of the total complex) as a Natura 2000 site and the designation of the MPA Borkum Riffgrund in 2018. The legal framework for protection, conservation, and restoration emphasises seabed properties and benthic communities as well as twain shads, harbour porpoises, grey seals, and seals (NSGBRgV, 2017). Since 2016, measures for oyster restoration have been prepared and are in the process of implementation. The management plan of the MPA followed in 2020. Bottom trawling was excluded in 2023. Then the BfN published rules about the sinking of blocks to create artificial stone reefs in the MPA to support oyster restoration, including suggestions for detailed sediment studies within the MPA (Westphal et al., 2024).

The spatial extent of the complex informed the boundaries of the German MPA in the north and east. To the south, the MPA ends at the EEZ border while it borders the Netherlands in the west—thus indicating the limits of BfN sovereignty. Stone reefs occur at four distinct locations within the MPA (Pogoda et al., 2023, p. 12). A project colleague remembered having mapped boulders for the Natura 2000 area/MPA designation. These maps are available in public repositories (Bundesamt für Seeschifffahrt und Hydrographie [BSH], n.d., 2013). The focus on the MPA, however, resulted in lower data quality in territorial waters:

> There is no comprehensive modern detailed mapping for these coastal areas. That's the problem. What we have are the so-called Figge and Laurer maps. This is a sampling map with relatively large grids generated in the 1980s, which was slightly updated in the early 2010s. Data density refers to km grids, while more recently recorded data show a considerably higher resolution due to sonar data and denser sampling with a focus on the Natura 2000 areas (academic geologist, interview, July 31, 2024).

German *Borkum Riffgrund* (BRG)	Period	Dutch *Borkumse Stenen* (BS)
Sediment studies in the German Bight (Jahrke, 1956)	1950s	Munitions near the Dutch coast prevent research
1964 Inauguration of the Geneva Convention of the Continental Shelf (establishment of EEZs)		
1980s Research: Sediment maps (Figge, 1981)		
1992 European Flora–Fauna–Habitat Directive calls for MPAs		
Research for Natura 2000 designation: sonar scans, taximetric sampling, photography, video	early 2000s	Indication of approximate limitation/ BS triangle, little data on BS (Lindeboom et al., 2005; Witbaard et al., 2008) NGOs and scholars lobby to include BS in Natura 2000 and OSPAR frameworks
Since 2012 Research by SedAWZ project: sonar scans mainly within the EEZ Update of sediment maps (Laurer et al., 2014) **2014** 625 km² of BRG (in EEZ) = Natura 2000 area **2017** Natura 2000 area = MPA **2018** BfN mapping guide for reefs in EEZ	2010s	Research: sonar scans, taximetric sampling, photography, video (Bos et al., 2014; Coolen et al., 2015) **2017** Plan to protect 108 km² of BS = prohibition of bottom-trawling (VIBEG Akkoord) Research by OCEANA: sonar scans, taximetrics sampling, photography, video (Alvarez et al., 2019) Suggestion to Germany to create a transboundary Natura 2000 area (rejected)
Since 2017 Preparation of the application for approval of GEMS gas extraction project by ONE-Dyas **2019** Public participation in Germany and the Netherlands		
2020 Management Plan for MPA Sediment and seafloor studies within MPA **2020** NLWKN (with NLPVW) commission diving study (report unpublished) **2021** Marine Spatial Plan **2021–2024** DAM-sustainMare research **2023** Bottom-trawling excluded from MPA	2020s	**2021** Government designated 653 km² of BS as MSFD area and plans to exclude bottom-trawling from parts of BS until 2023 (not realised), decision about a bird sanctuary until 2025
July 2022 EZK issues first construction permit; start of litigation / unofficial knowledge production by GEMS claimants on coastal parts of BRG		
Claimants commission study (BioConsult, 2022) **2023** Greenpeace commissions diving study (submaris & BioConsult, 2023) **May 2023** Greenpeace enforces publication of NLWKN study (BioConsult & submaris, 2021) Greenpeace releases a transboundary map and diving study (submaris & BioConsult, 2023)		
September 2023 Claimants present evidence about stone reefs in court		
2024 BfN develops methodology for site selection and sinking of stones to create artificial stone reefs **July 2024** Exhibition "The Reefs off Borkum" co-produced by first author and claimants **September 2024** Greenpeace detects additional stone reefs in the project area		**July 2024** ONE-Dyas starts construction of gas platform in the North Sea

Abbreviations: OSPAR – Convention for the Protection of the Marine Environment of the North East Atlantic, VIBEG – Visserij in Bescherming Gebieden (Dutch agreement on fishery in protected areas), MSFD – Marine Strategy Framework Directive of the European Union, NLPVW – Administration of the Lower Saxony Wadden Sea National Park

Figure 2. Chronology of knowledge production and protection in the Borkum Reef Ground habitat complex.

The German Marine Spatial Plan excludes territorial waters due to there being different public authorities in charge. Within the MPA Borkum Reef Ground, the plan prioritises marine protection but reserves more than half of the MPA area for the hydrocarbon industry and pipelines/cables (BSH, 2022) because valid exploration licences granted by the coastal state authority Landesamt für Bergbau und Geologie were considered. Consequently, BfN anticipated gas projects in the MPA (BfN, 2020).

MPA regulations prohibit the exploration and extraction of resources but allow for exemptions if an overriding public interest is to be safeguarded, if no alternatives exist and when a threat to protected assets can be ruled out (BfN, 2020). German Federal Nature Protection Law provides another back door to the industry because the law must not prevent the realisation of projects of overriding public interest. In the event of an application for an exception, the Federal Nature Conservation Act guides approval decisions. Under current political conditions, marine gas is not an overriding public interest. The GEMS application, however, sets a precedent for gas drillings affecting German MPAs.

In the Netherlands, Natura 2000 research focused on the Cleaver Bank seabed habitat. Borkumse Stenen were not pushed to the forefront because there was little and outdated data available (Lindeboom et al., 2005). New data collection began in the 2010s (Bos et al., 2014; Coolen et al., 2015). Uses in Borkumse Stenen include gas and sand extraction, telecommunication cables, fishery, and shipping (Álvarez et al., 2019). Since 2005, Dutch scientists and European environmentalists suggested the integration of Borkumse Stenen into the Natura 2000 network and OSPAR protection framework (Hugenholtz, 2008). This and later initiatives (Álvarez et al., 2019) faced political opposition in the Netherlands after the seafloor of Cleaver Bank became protected under the EU Habitat Directive.

Dutch policy documents considered Borkumse Stenen as a potential protected area without taking further steps in this direction. In 2017, Dutch authorities intended to place a part of it (108 km^2) under protection as compensation for crab fishing in the Dutch MPA Noordzeekustzone (Álvarez et al., 2019). The Dutch government envisioned the designation of a Marine Strategy Framework Directive area (653 km^3), and the exclusion of bottom trawling until 2023, which indicates the will to protect benthic species, while underlining the intention to exploit all domestic gas fields in the North Sea. Gas is an overriding public interest. Until 2025, investigations will evaluate whether Borkumse Stenen will qualify as a special protected area under the EU Birds Directive (Government of the Netherlands, 2022, p. 101).

5. The Production of Counter-Knowledge and Strategic Science Translation

5.1. Preparing the Arguments for Evidence

The production of "unofficial" knowledge gained first momentum at the end of the 2010s when ONE-Dyas hired consultants to compile information and data for the application for project approval. ONE-Dyas submitted extensive documentation about GEMS to Dutch and German approval authorities, including technical descriptions, maps, legal contextualisation, and expected environmental implications. Most of them are publicly available. These documents provided the knowledge baseline for further assessment. ONE-Dyas was initially very open to communication with claimants, decision-makers, public media, and researchers. This changed during the process of the litigations, which significantly delayed the start of the construction and resulted in high financial losses. The company developed and successfully spread counter-narratives to the arguments of the GEMS opponents (Ittner, 2024)

In 2019, during the public participation in Germany, environmental experts, organisations, municipalities, and individuals submitted more than 400 counter-knowledge reports, mostly anticipating negative environmental impacts. The reports were documented by the Landesamt für Bergbau und Geologie. In 2022, the second momentum occurred after the EZK issued the first construction permit and civil society actors prepared the argument for evidence in court to hinder the construction. A coalition made up of Bürgerinitiative Saubere Luft Ostfriesland, Mobilisation for the Environment, Environmental Action Germany (DUH), and the island communities of Borkum and Juist filed lawsuits in The Hague.

Opponents and later claimants assessed the project documentation by ONE-Dyas and screened it for errors and missing data, especially on pollutants, emissions, noise, and the probability of hazards. The Landesamt für Bergbau und Geologie forwarded their findings to the EZK, who asked ONE-Dyas for corrections and technical improvements. Soon the question of stone reefs in the project area arose. Finding data on their location and pollutant–benthos interactions turned out to be problematic, as the environmental officer of Borkum remembered:

> There was this section between Riffgat [the offshore wind park planned to provide electricity to the gas platform], where the cable is laid….I wrote to the BfN at the time to see whether there was anything [a stone reef]. Because it is strange. In the north is Natura 2000 [MPA Borkum Riffgrund]. In the south is Natura 2000 [MPA Borkum Riff]. Borkumse Stenen lies to the east. Why didn't they connect the two [MPAs]? Because Natura 2000 tells us to create corridors to allow for connectivity. Then I [the authority] just leave a very small strip like this [unprotected]? Why? Funnily enough, we once put this [image] over the map and really hit the spot where this reef was. I asked what it looks like. Is there anything worth protecting? Why hasn't it been put under protection? Then I got the answer [by BfN]: "We are not responsible [for territorial waters]." In addition: "if there was a reef, then, of course, it would be protected." However, it was along the lines of "we do not know anything." Now the study [commissioned by NLWKN, see section 5.2.] has revealed that reefs have been reported to them [the BfN] since 2019 [actually 2020]. That there is one [a stone reef]. That there were investigations. (Borkum Municipal Administration, personal communication, May 17, 2023)

To clarify the situation, the DUH used its right to information and formally requested the full documentation of the administrative process, including MPA planning documents and letters, from the NLWKN. The DUH analysis indicated that Dutch authorities had suggested a transboundary MPA under the Natura 2000 framework, which was rejected because applications for the German Natura 2000 site had already been submitted to the European Commission (DUH, personal communication, November 23, 2023).

While finding their way through the maze of public responsibilities, claimants continued to pose their questions during stakeholder workshops on the author's marine research project. Hiring private experts was costly and challenging due to the limited number of marine consultancies. Some enterprises already worked either for ONE-Dyas, against other industrial projects, or on behalf of BfN. Others aimed to avoid being seen as pro- or counter-industry because this would damage their business model. While members of the coalition suggested an enterprise, other members said that hiring their expertise would be implausible because the same enterprise had supported the industry in a previous litigation. Approaching marine scientists at universities also did not offer the expected insights:

> I wrote to so many universities in Germany, including various faculties. I hardly ever received a reply…someone might say I cannot make a statement or something. I am sorry. However, no feedback. Nothing received. I have sometimes asked about publications….Sometimes I did not even mention the words "gas extraction." We did not get anything. That is disappointing. (Borkum Municipal Administration, interview, May 17, 2023)

> I have the impression that there is not so much expertise in gas drilling, especially offshore. We have also approached other research institutes. I just have the impression that a lot of the expertise is with the industry itself….If the oil companies reported, we would like to have it checked again by an independent institution. But if all people who are familiar with oil and gas drilling, who have studied it, work in the industry…and nobody leaves [this job] and uses this knowledge to carry out research that might shed light on the risks, it is also difficult. (DUH, personal communication, November 23, 2023)

> There is one specific field of research where we have often reached our limits…the chemicals discharged into the sea from the gas-drilling platform…how high are the levels of mercury and radioactivity? We have comparative data, but unfortunately, it is only from land drilling. They show high levels of mercury discharges, which also shows that there is a lot of radioactivity. ONE-Dyas installed a carbon-activated charcoal filter in the discharge pipes. At least they say so. They say that almost no mercury gets in [to the sea]. However, there is a ban on the discharge of mercury. Every drop that gets in there is banned….We are still in the process of gathering information. However, we do not have such a good overview of data, on comparable wells. (DUH, interview, November 23, 2023)

Despite various public data repositories, it was difficult for non-experts to access the relevant scientific findings and knowledge products. It would have needed a guiding hand from marine experts to identify the relevant repositories, studies, and maps. We observed their neglect to clarify technical questions in the context of litigation, which turned out to be a crucial decision-making forum in the user conflict. Their science and their expertise became unseen during the litigation. The denial of support by marine researchers is incomprehensible, as the support provided under scientific principles is always open-ended. Scientists at public institutions would need a new understanding of their role, and perhaps an explicit official mandate to offer their expertise in contested political arenas.

5.2. How to Become a Knowledgeable but Neutral Mediator in the Political Arena

Greenpeace did not join the coalition of claimants but initially pursued an independent anti-GEMS protest. They strategised ambiguity, made an "unseen" study visible, and created "unofficial" counter-knowledge to fill knowledge gaps by "undone" high-quality sediment mapping in territorial waters. After the first court decision on the building freeze in April 2023, Greenpeace acknowledged on its website that the claimants had succeeded. The text neither claimed that Greenpeace was part of the coalition nor clearly stated that it was not—leaving some room for interpretation from the side of the readers. The claimants were not quite sure of what was happening within Greenpeace:

> Greenpeace, they don't say anything, do they? They keep very tight-lipped, even among themselves…one does not know what the other is doing under certain circumstances. Depending on what they are working on, they have a very specific information policy….It is also very centrally

> controlled….I think they just do not want things to be published beforehand. (BI, personal communication, May 23, 2023)

In May 2023, about 40 Greenpeace activists climbed onto the roof of the parliament of Lower Saxony demanding the delivery of an unpublished study. The NLWKN and the administration of the Lower Saxony Wadden Sea National Park (NLPVW, both under the authority of the environmental ministry of Lower Saxony) recognised the lower quality of sediment mapping in their coastal waters. They commissioned research in territorial waters, where they suspected a stone reef. In 2020, the coastal research unit of NLWKN and private scientific divers explored a seabed area of two hectares situated 10 sea miles northwest of Borkum Island. NLWKN hired a private consultancy for taximetric analysis. The environmental ministry of Lower Saxony supported the research. The joint report and documentary film, delivered to the NLWKN in February 2021, reasoned as follows:

> The short film was primarily intended for public relations work and the external presentation of this special habitat at public appearances of the NLWKN and the Lower Saxony Wadden Sea National Park and therefore shows the fauna of the reef in beautiful, format-filling shots. (BioConsult & Submaris, 2021, p. 21, translation by authors)

And yet, publication plans seem to have changed. The report and documentary remained unpublished until 2023, respectively 2024. Their content and informal discussions with NLWKN staff, however, did not indicate any intent for non-publication— on the contrary (NLWKN & NLPVW, 2024).

When the NLWKN did not respond to the request by Greenpeace, despite the right to information, the organisation claimed that the study was intentionally hidden because of GEMS. At this time, Greenpeace had already employed the same enterprises to dive at four locations to document stone reefs, including at the site previously investigated for the NLWKN (Submaris & BioConsult, 2023):

> A previously *secret* report from 2021 on rocky reefs off the coast of Borkum that are worthy of protection is bringing new wind into the approval process for the controversial gas drilling in the North Sea—and putting the state government of Lower Saxony in a tight spot. Greenpeace has now carried out its own dives and is contributing additional findings about the magical underwater world near the planned drilling sites. (Greenpeace, 2023, translation and emphasis by the authors)

> Because [Greenpeace] made their request [to NLWKN] they did not get the article. It was actually necessary to literally climb onto the roof of parliament to get the [study]. [Greenpeace] applied for it with a deadline and everything. It is the law. They didn't get it….Scandal….It was only because of this public pressure that [the study] actually came out. (Bürgerinitiative Saubere Luft Ostfriesland, interview, May 13, 2023)

The new government of Lower Saxony claimed to not have been informed about the study. The new environmental minister released it after gaining access to it on its premises (Greenpeace, 2023). The documentary film was finally presented to environmental organisations in 2024. The text of the YouTube post from August 2024 talks about one *recently discovered* reef off the coast of Borkum, which reveals a diverse, fascinating world of flora and fauna (NLWKN & NLPVW, 2024)

To gain expert and insider knowledge, Greenpeace also engaged in background research, commissioned investigations on political dynamics and legal conditions (Horenburg & Verheyden, 2023) and conducted a drifter study to visualise the risk of industrial pollution. Starting from May 2023, after the claimants succeeded in provoking the building freeze, Greenpeace published information in short sequences, starting with a legal opinion piece and another diving and taximetric study on stone reefs in the GEMS project area (Submaris & BioConsult, 2023), while the claimants unsuccessfully tried to hire the same enterprises for support in the litigation. Later, the organisation established itself as a knowledgeable but "neutral" mediator between the NLWKN and the environmental ministry of Lower Saxony (Bürgerinitiative Saubere Luft Ostfriesland, informal conversation). This was possible because they were no claimants.

The claimants gladly embraced the counter-knowledge published by Greenpeace and the enforced publication of the NLWKN study. While Greenpeace's reports supported their argument of evidence, beautiful underwater photography (Figure 3), a podcast, and an interactive map helped to mobilise additional protesters and draw media attention. Information exchange and close cooperation between the claimants and Greenpeace Germany began before the court hearing in January 2024.

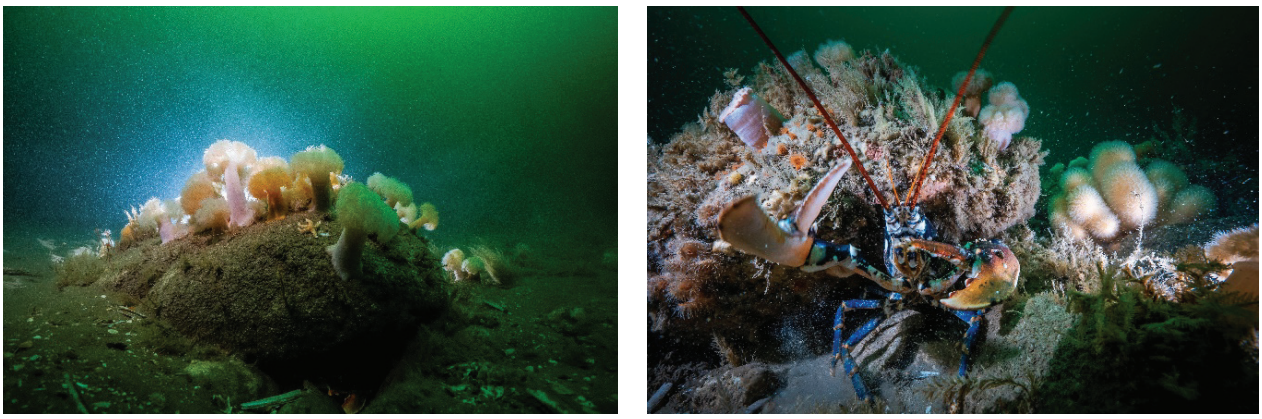

Figure 3. Stone reef in German territorial waters. Note: These photographs were taken by Uli Kunz of Submaris. Source: Greenpeace (2023).

The map was emphasised in some reports. It was difficult to trace it on the Greenpeace website on other occasions. It was interactive at times and static at others, not providing a reliable source of information to other activists. In court, ONE-Dyas claimed that Greenpeace had not granted access to the spatial data on newly detected stone reefs upon request. Greenpeace responded that data were published openly on their website. They had also informed the respective public authorities (Greenpeace, 2023).

The marine natural research community completely missed opportunities for transdisciplinary co-production of knowledge in the context of the German approval procedure and litigations, partly because of ignorance and partly due to the wish not to engage in contested political areas. They remained distant observers, cutting them out of ongoing knowledge production by the GEMS opponents and the political processes.

6. Discussion

Knowledge fragmentation about the transboundary habitat complex began in 1964, which also earmarked national sovereignty over marine knowledge production, planning, and management. Industrial and scientific

interest informed research in the subsequent decades. The EU FFH Directive first encouraged and later pressured the countries to suggest marine sites as Natura 2000 areas. Authorities set pragmatic research priorities to come to relatively quick and affordable suggestions. Germany prioritised parts of Borkum Riffgrund situated in the EEZ and neglected part of the habitat in territorial waters. The Netherlands prioritised Cleaver Bank, which also had a hard substrate seafloor, and initially neglected Borkumse Stenen. Since 2012, sediment mapping in Germany focused on the EEZ (SedAWZ project). Later adjustments and unification of data qualities remained a challenge in fragmented marine governance settings (Heinicke et al., 2024). The article illustrates how national divisions, and prioritised knowledge production about seabed properties, first led to a gradual shift in its perception as a transboundary seabed habitat complex to two distinct national marine areas.

Secondly, many years later, during the approval procedure for an industrial project, the industrial enterprise, German authorities and project opponents faced insufficient documentation of seabed properties in the project area, which they were unable to close by their own means. The potential for an ad hoc, applicable production of knowledge at sea was limited because of a lack of resources. The actors had either no access to ships able to perform comprehensive seafloor detection, shipping time, and permissions (valid for two countries), considerable funds, expertise, or—importantly in the context of the litigation—sufficient time, although the latter is debatable, considering the public authorities. None of the actors had all these resources to provide new baseline data for decision-making. Of course, there were different stakes as well. The "undone science" in the form of low-resolution sediment maps was not intentionally produced. It was caused by initial pragmatic approaches and future neglect of "unpurposeful" research, which was not applicable in the context of marine protection schemes. Of course, the authorities could have anticipated future EIAs for industrial projects in non-protected areas and taken timely action.

The counter-knowledge about reef locations supported the mobilisation of opponents. It convinced neither judges nor authorities because the evidence was patchy, not based on scientific standards, and did not originate from "official" knowledge sources. "Official" marine geology in Germany and the Netherlands was limited by national borders, determination by research proposals, extensive administration for shipping trips, and the focus on MPAs in Germany. It could not respond in a timely fashion to knowledge needs in the context of the litigations. Perhaps the production of counter-knowledge and the translation of knowledge to other social fields, such as the legal field, are especially challenging in the context of transboundary marine industrial projects because of highly specialised knowledge, costly research logistics, and administrative hurdles.

The example of stone reefs underlines the fact that marine protection and ocean governance rely on definitions and criteria by "official" ocean governance actors to be legitimate and legally sound, even if these, like in the BfN mapping guide, were co-produced by an authority, scientists, and private sector consultancies. Besides providing transparency and clarity to experts, regulation may entail ambiguity related to the question of validity in other administrative areas. Over-regulation and parallel regulation for different administrative areas resulted in the disorientation of non-experts, and therefore in the lack of transparency of ocean governance rules to civil society.

The study has illustrated how knowledge about the material manifestation of the biodiversity hotspots did not enter the shaping of regulations, inter alia, remained a legal uncertainty. A revealing aspect is also that the lack

of regulation at the coastal state level practically cancelled out national and European protection measures, although the sub-national level is subordinate to the latter two.

Another issue is remarkable. While project opponents invested substantial time and private money to clarify seafloor conditions in order to prevent a fossil fuel project and the loss of benthic biodiversity in territorial waters, the BfN invested public money in rule-making and the preparation of the sinking of artificial reefs in the MPA to support oyster restoration. This required more detailed seabed studies to identify suitable sinking spots. Obviously, marine research and protection were organised along the lines of administrative and MPA logic and did not fully consider marine habitats.

7. Conclusion

We identified four motivations for marine knowledge production: scientific interest, industrial stakes, knowledge requirements to respond to EU marine protection schemes, and political interest to prevent industrial projects. Knowledge production occurred in waves related to upcoming stakes. Under conditions of accelerating industrialisation, the quality of available knowledge and knowledge products for unprotected areas gain relevance, as does the flexibility of public science and authorities to respond to knowledge needs in order to support approval decisions. As such, the portrayed analysis sensitises for "unseen" and "undone science" and for giving nature some rights. High-resolution mapping of industrial zones will play a crucial role in this, as well as data on accumulative pollution.

Contemporary marine science has all the technical measures at hand to detect detailed seabed properties and the distribution of benthic taxa (Beermann et al., 2023; Michaelis et al., 2019) but it is elaborate and costly with many administrative requirements, which make transboundary research difficult. One wonders how countries with fewer resources or larger EEZs than Germany and the Netherlands will be able to completely map their EEZs, particularly non-protected areas. The case study has illustrated how the prioritisation of funding for MPA mapping may backfire on knowledge gain in potential industrial zones and, therefore, on overall marine protection.

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Conflict of Interests

The authors declare no conflict of interests.

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