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This Is Not a Fish: On the Scale and Politics of Infrastructure Design Studies

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Abstract. Interconnected workplace information technologies (information infrastructures) are distributed across user and system types, agendas, locales, and temporal rhythms. The term infrastructuring describes the design of information infrastructure not as a bounded phase but as a continuous collaborative and inherently political process. From the perspective of ethnographers, however, this conceptualization presents the practical challenge of dealing with the political work involved in infrastructuring and in its study. In this paper, I discuss the challenges of infrastructuring activities for ethnographic research. Based on a self-revealing account of my three-year ethnographic study of an oil company's project to design a platform for subsea environmental monitoring in the Arctic region, I discuss how my framing of infrastructuring was the result of my process of constructing the ethnographic field in my research. I combined four mechanisms to scale my ethnographic method to investigate infrastructuring across heterogeneous dimensions. Drawing on my practical experience, I discuss how my process of constructing the field let me discover richer possibilities for understanding the politics involved in the study of infrastructuring.

Keywords: Infrastructuring, Collaborative design, Information infrastructure, Ethnography, Scaling, Politics, Political configuration

1. Introduction

The Scandinavian oil company NorthOil[1] recently was involved in developing an ocean observatory that monitors the behavior of the marine environment in a portion of the Arctic region where oil operations are currently forbidden. Among the subsea sensors that have been installed are a hydrophone to register sounds and a subsea camera to take pictures of a coral reef every 30 minutes. Data are constantly sent to a publicly accessible web portal in real time via a fiber optic cable. The researchers involved in the observatory initiative were surprised to observe that a tusk (a cod-like fish) regularly floats between the reef and the camera, suddenly halts in front of the camera lens, emits a hissing sound, and then leaves. The researchers became so familiar with the tusk that they named him Bertil, a common male name in Scandinavia.

It could be interesting to study Bertil's behavior from many perspectives: as an example of human–animal communication, as a story of developing better subsea technology, as a story of how end users experience the open web portal, as an instance of collaboration between industrial and research actors for innovation, or as a form of political work for NorthOil to extract resources in the area. Bertil's

behavior is all that, and more. An extended network that includes all these technical, social, political, and economic aspects makes it possible for us to see Bertil in this way. How can we tell the story of that which lies behind and supports Bertil? Answering this question is pivotal to understand the design of the large-scale collaborative information technologies (information infrastructure) that let us see Bertil. In this article, I seek to provide a meta-level contribution between method and theory, to reflect on the techniques to study collaborative infrastructure design. By expanding on existing contributions in computer-supported cooperative work (CSCW) and drawing on Science and Technology Studies (STS), I subscribe to the stream of literature advocating an extended view on design in CSCW, urging 'analytical tools for capturing how technologies are shaped across multiple spaces and timeframes' (Monteiro et al. 2013, p. 596) spanning, for example, different locations (Pollock and Williams 2010; Almklov et al. 2014), and a changing range of actors with their own representations of the problem (Garud et al. 2008) and temporal rhythms (Edwards 2010; Karasti et al. 2010; Steinhardt and Jackson 2014). I focus on how this extended view on design can be achieved by adopting an ethnographic approach to CSCW (Forsythe 1999; Harper 2000; Blomberg and Karasti 2013).

An extended perspective on design tackles inter-related aspects. First, the design of infrastructures is a *process* made up of evolving interconnections and interactions among several distributed sociotechnical components (Pollock and Williams 2010; Monteiro et al. 2013). This understanding recognizes that it is not possible to bound infrastructure design a priori, but only by following the distributed and ongoing work of infrastructur*ing* (Star and Bowker 2002; Karasti et al. 2006; Pipek and Wulf 2009). Second, the interconnections and interactions that constitute infrastructuring and the researcher's whereabouts are the results of political relationships and power arrangements that play out in several dimensions, such as temporal, spatial, and social. Although politics—in a broad sense—is certainly inherent to all design (Bijker 2007), the accumulation of heterogeneous perspectives and interests, the distribution, and the obduracy that characterize infrastructure (Bowker and Star 1999) pose practical challenges for ethnographers and thus make uncovering the politics of infrastructuring work more demanding. I combine this political perspective on design qua infrastructuring with work in anthropology that ascribes a critical—and ultimately political—sensitivity to ethnography itself, considered a reflexive[2] self-conscious effort (Clifford and Marcus 1986). From this point of departure, the researcher/ethnographer has an active role in shaping the research field and the unit of analysis (Gupta and Ferguson 1997; Blomberg and Karasti 2013); see, for example, Bjørn and Boulus-Rødje (2015), Jensen (2006), Ribes (2014), but also Schultze (2000) in Information Systems. Thus, my research question is: *How can researchers craft a research field analytically to study collaborative infrastructure design? How does the field, in turn, influence ethnography?*

In answering this question, I discuss how researchers scale their (often solitary) ethnographic activity as they craft the field to study infrastructuring and in doing so, deal with its political dimension. 'Scaling' refers to the emergence of different types

of phenomena in different dimensions during the process of constructing the ethnographic field. This definition is agnostic to the nature of the dimensions, as they emerge and are mutually constituted by the ethnographic process (Amit 2000). In this way, the ethnographer can develop a sensitivity to heterogeneous (and potentially new) kinds of politics emerging in different forms, rather than the same type of political problems repeated at different sizes, and thus how new questions are constantly made thinkable. In sum, the possibilities through which politics plays out in the study of infrastructuring is a result of the ethnographic inquiry, rather than an a priori definition.

This paper is based on a three-year study of the design of an infrastructure for real-time subsea environmental monitoring in the oil and gas sector, a research problem that emerged as historical, distributed, and politicized, involving a large number of actors and stakeholders. The contribution is twofold.

First, I provide a self-revealing account of the way I crafted the field during my ethnographic activity and how I shaped its dimensions with the combination of four main scaling[3] modes, or mechanisms (cf. Ribes 2014), inspired by existing ethnographic methods. I show how Bertil emerged from (i) the unremarkable issues of getting access to a large infrastructure; (ii) the actors' approaches to navigate and scale access to their own infrastructure, spatially and temporally; (iii) the ongoing design controversies through which users and designers make sense of the infrastructure; and (iv) the shifting power structures encapsulated in the mundane data sources. These mechanisms and their combination emerged during my own research work, and different combinations might be suitable for other contexts. Thus, through these mechanisms my goal is not to demonstrate that infrastructure design in CSCW requires new methods. On the contrary, following the path set within anthropology, my aim is to argue in favor of an explicit consciousness of the means adopted by ethnographers of infrastructure, to move forward the discourse on the possible ways for CSCW to achieve a broader view on design in an mobile and deterritorialized world (Monteiro et al. 2013; cf. Gupta and Ferguson 1997).

The second contribution of this paper is a discussion of how a scaling approach to the ethnography of infrastructuring is an opportunity to discover the different and potentially rich ways in which politics plays out in collaborative design and its study. My use of Bertil to open this paper has the evocative function of showing how the work to make a fish *digital* shows how some marine creatures (thus, seafloor measurements used to talk about physically inaccessible creatures) emerged as more 'charismatic' than others as part of both the daily infrastructuring work and my own ethnographic activity (cf. Bowker 2000). Thus, Bertil is a metaphor for the dimensions I discovered in the field as I was following him. I discuss how the process of shaping the dimensions of the field emerged as an opportunity to discover heterogeneous arrangements of political work. I conclude this paper by briefly discussing how this perspective resonates with the tradition of Participatory Design. This resonance, I suggest, can be useful for drawing implications for the study of the politics of infrastructuring in terms of empowerment and inclusion.

2. Theoretical background

In this section, I frame the theme of this article by (i) unpacking the concept of infrastructuring and its political relevance, (ii) providing an overview of the relation between ethnography and the study of infrastructuring, and (iii) setting the stage for scaling up the inquiry into the political stakes in the study of infrastructuring.

2.1. Infrastructuring as political design in CSCW

In the early days of CSCW, Schmidt and Bannon (1992) defined a design agenda focused on the study of the way collaborative technologies could support and be supported by the fundamental yet invisible and often unrewarded forms of articulation work. This political aim holds true today, as we increasingly deal with distributed and interconnected information and communication technologies (ICT) characterized by a high degree of uncertainty in terms of functionalities, users, and strategies (Garud et al. 2008). To better account for the politics of design in such arrangements, I subscribe to the stream of literature that recognizes that ICT that support work practices and daily life should be addressed as *information infrastructures*, that is, distributed sociotechnical systems of systems that aim to facilitate collaboration and coordination across geographic, disciplinary, and organizational boundaries over the long term, *through* and *within* a bundle of existing systems and practices (Monteiro et al. 2013). Information infrastructures are not a substrate on top of which innovation happens but instead are an ongoing relational alignment between contexts, as their understanding changes with reference to different organizational practices (Star and Ruhleder 1996; Star 1999). This perspective brings attention to the fact that infrastructure is not a stable entity waiting to be discovered but is a process of enactment; infrastructure is always infrastructure-in-the-making (Star and Bowker 2002). Infrastructur*ing* is an analytical term that focuses on the recursive and reflexive work of designers and end users that lies underneath the imaginary of rationality and spatial and temporal order embedded with ideas of infrastructure. Thus, design is not a defined phase in the lifecycle of a system but the ongoing work to maintain and upgrade the infrastructure by keeping it flexible to balance the (sometimes invisible but always political) tensions between those who count as users or designers and between the historical and accumulated and the future and uncertain (Karasti et al. 2006; Pipek and Wulf 2009; Bossen and Markussen 2010; Parmiggiani et al. 2015; Steinhardt and Jackson 2015):

> 'In infrastructure there is a sense in which map and territory merge. To design something *is* to use it; there is no global testability. For these reasons, understanding commitment, object worlds and their paradoxes, and the myriad of trajectories involved is crucial.' (Neumann and Star 1996, p. 239)

Thus, design is a 'jigsaw puzzle' put together by multiple actors with evolving goals, perspectives, and degrees of engagement (Garud et al. 2008), Design is a

process to constitute and engage publics and stakeholders in the matters of concern embedded in the infrastructure. In this sense, *infrastructuring is political design*, because infrastructuring frames and challenges power relations and always makes new questions thinkable (Le Dantec and DiSalvo 2013; see also Edwards et al. 2013). Although scholars widely acknowledge that politics is always entrenched in the design of artifacts no matter their size (Bijker 2007), by analyzing the politics of infrastructuring, researchers uncover broader issues, such as the co-construction of politics and distributed practices over time, including the equilibrium between visible and invisible work (cf. Star and Strauss 1999). For example, the digitalization of work tasks does not merely substitute face-to-face interactions or manual operations but triggers the creation of new cross-disciplinary routines, the identification and new combinations of data sources, and the emergence of the role of stakeholders (Parmiggiani 2015). In sum:

> '[T]he material and political lives of infrastructure reveal fragile relations between people, things, and the institutions (both public and private) that seek to govern them. These more-than-human relations (Braun 2005) make infrastructure a productive location to examine the constitution, maintenance, and reproduction of political, economic, and social life.' (Appel et al. 2015)

On the methodological level, Monteiro et al. (2013) addressed a call for CSCW to develop a broader view on infrastructure design: 'An [information infrastructure] perspective … would contribute … what might be thought of as an 'extended design' perspective to capture how workplace technologies can be shaped across multiple contexts and over extended periods of time.' (p. 576) Based on this extended perspective, infrastructuring highlights that different dimensions (e.g., space, time, and sociality) are reconfigured in different ways and give birth to different phenomena if the design process is looked at from different perspectives. This is an elaboration of Star and Ruhleder's (1996) argument that infrastructure is always relational, because it means different things to different people based on their practices (implying agendas, temporal and spatial perspectives, objects of interests, and so on). These arrangements are inherently political, and the way they are accounted for depends on the researchers' (evolving) sensibility. The understanding of politics, therefore, might go through a reflexive effort by the researcher on the way she has been able to scale, viz. constructing a field of inquiry.

2.2. Studying infrastructuring with ethnography

Given this perspective on information infrastructure and infrastructuring as unbounded arrangements at the social, spatial, temporal, and political levels, the challenge for the researcher is to study the infrastructuring process without an a priori definition of the process's borders. Ethnography is one of the main methods used in CSCW and neighboring fields to address the study of infrastructuring work (Dourish 2006;

Blomberg and Karasti 2013). As a research approach, ethnography was born and raised in anthropology to produce thick descriptions of distant cultures in which the researcher is required to immerse herself for an extended period of time (Amit 2000). In general, ethnography constitutes a reflexive in-depth understanding of real-world social processes. Ethnography emerges from the combination of data-gathering methods (including participant observations, interviews, and document analysis), the theoretical structure used to analyze the data, and a philosophical stance (Forsythe 1999; cf. Alvesson 2003). The ethnographic tradition has been imported in other domains, such as CSCW and Information Systems (Orr 1996; Myers 1999; Blomberg and Karasti 2013), to support the understanding and design of collaborative devices (Harper 2000; Bjørn and Boulus-Rødje 2015) or to conduct prolonged studies of the development and adoption of Information Technology (IT) in organizations (see for example Orlikowski 1991; Schultze 2000).

The way ethnographic stories are told, anthropology taught us, has an active role. Ethnography can be more than a mere method: Ethnography is a means of representation, because it performs what it seeks to represent by the ways fieldwork is conducted and is then put into words in an ethnographic account (Clifford and Marcus 1986; cf. Van Maanen 1988). Thus, ethnographic accounts can provide access to different materials than we might be able to work with otherwise, as they make visible the trials (or the foolishness) of the ethnographer in ways that are themselves informative. In addition, ethnography has a strong potential to unpack the complexities of infrastructuring due to its political sensitivity. A political impulse is not foreign to ethnography and was a constitutive part of the earliest ethnographic accounts, such as Julius Caesar's *De bello gallico*, aimed at gathering knowledge to achieve control (Kavanagh et al. 2015). Clifford and Marcus, along with postmodernist anthropologists, assign a moral or ethical role to the reflexivity of ethnography and describe fieldwork as a political process, a circumstantial and sometimes contradictory constant identity negotiation that gives unity to the ethnographer's movements. This view recognizes and does not elide the political forces at play in ethnographic reporting and the cooperation that field sites and participants offer.[4]

In recognizing the political nature of fieldwork, the tradition in anthropology that I refer to in this paper has taught us that the ethnographic field is not out there waiting to be discovered but is performed viz. is the result of a process of reflexive construction in which different emphases give birth to different conceptualizations (Gupta and Ferguson 1997; Amit 2000). The field, thus, consists of crafting dimensions that are politically constructed as the researcher goes on ethnographically—a reflexive mode of studying interlocking political locations (Gupta and Ferguson 1997). Accordingly and of relevance to the study of CSCW, labels such as 'local' and 'global' are understood as a result of the study and not as pre-given, relative perspectives that pragmatically emerge in practice instead of two distinct levels of infrastructure (Jensen 2007). An example of this is provided by Almklov et al. (2014), who studied the cooperative work of petroleum engineers and how they make sense of the sensor-based data of subsurface reservoirs. In Almklov and

colleagues' analysis the infrastructure becomes 'local' as the engineers' work practices and the knowledge inextricably depend on the infrastructure for them to extrapolate sensor data. However, the infrastructure emerges as 'global' as it co-evolves with engineers' work practices.

2.3. Toward scaling ethnography of infrastructuring in CSCW

In this paper, I discuss the way I adopted a combination of concrete approaches that have been proposed in the literature to scale the study of infrastructuring and craft an ethnographic field. Many ethnographers of infrastructure are inspired by the multi-sited approach proposed in anthropology by Marcus (1995), who listed different modes of fieldwork that can be used to shape the object of research by, for example, following a thing, a metaphor, people, a conflict, or a story. Practical ways to do so that have been proposed, as reviewed by Ribes (2014), include traveling across the different physical sites of the infrastructure (Ibid.), relying on a team of collaborators and students conducting parallel fieldwork (Pollock and Williams 2009), or developing historical reconstruction techniques (Edwards 2010). The common denominator for many of these contributions is that they recognize that the place of knowledge production and its penetration by the ethnographer are not—and cannot be—physically aligned (Beaulieu 2010). These approaches consist of an evolution of the 'follow the actor' approach proposed within actor–network theory, which assumes that knowledge production can be studied by assuming the existence of a physical laboratory, at least as a starting point (Latour and Woolgar 1986; Latour 1987). When dealing with information infrastructure, however, 'how can we use a lab studies approach, when there doesn't seem to be a lab to go to? We are therefore pushing the problem of how to follow actors around, within, and through infrastructures.' (Pollock and Williams 2009) On the analytical level, answering this call means shedding the light on the ongoing work to sustain infrastructure as a whole and making hidden relationships and references visible (Bowker and Star 1999; Edwards 2010). Thus, following the actors 'through infrastructures' is a useful approach for making sense of infrastructuring work at different scales, as it lets us see on several grounds the way infrastructure embodies and maintains controversies. For instance, Edwards (2010) drew the trajectory of global warming as simultaneously an epistemological and a political issue through an analysis of how weather simulation modeling has acquired scientific legitimacy by being associated with policy making agencies first and the general public after, revealing profound interdependences and conflicts among scientific, technological, social, and political factors. Within STS, scholars are insisting on the way temporal perspectives also shape the field. Infrastructuring involves different human and technological players, and thus emerges across changing temporal scales and rhythms (Edwards et al. 2013). Mukerji (1989) traced how the design process of the ocean science research infrastructure in the United States became inextricably linked not only with the (highly politicized) cycles of the State (e.g., disclosing secret military technology

after the Cold War), wars (e.g., the need to map the sea floor for U-boats during World War II), industrial advances (e.g., the mapping of the Atlantic Ocean floor to lay telegraph cables in the 19th century) but also with the rhythms of the academic calendar, the availability and cost of ships for offshore monitoring, and the rise of climate change concerns. Pollock and Williams (2009) cautioned that the consequence of failing to grasp this aspect is a tendency to emphasize the barriers to infrastructure evolution and overlook 'the gradual alignment and harmonization of organizational practices that may occur around the organizational templates embedded in the technology.' (p. 86) Among the few but significant contributions on this theme (Karasti et al. 2010; Venters et al. 2014), Jackson and colleagues vividly demonstrated how different temporal perspectives are made to coexist and evolve over time (Jackson et al. 2011; Steinhardt and Jackson 2015; Steinhardt 2016). These works have been important for recognizing the way future perspectives are handled as part of the mundane work of infrastructuring is a key strategy by actors not only to cultivate, channel, and bridge different agendas and expectations (see also Pollock and Williams 2015) but also to scale between local and institutional level policy. The implication of this conceptualization is that the field emerges not only as an interconnection of locations but also as an interconnection of different temporalities (Dalsgaard and Nielsen 2013). By looking at the practices to articulate and orchestrate temporal perspectives as part of the ethnographic site, we are better positioned to understand how value is constructed in design and how, eventually, some stakeholders are given a voice and others are left out:

> '[T]he ability to manage and orchestrate the multiple rhythms transecting any form of distributed collective practice may constitute an important site of authority, power, and control … Under conditions of dissonance and unequal distributions of authority and control, the question of which rhythms are adjusted to which (and whose rhythms to whose) turns out to be an important site for the exercise of power and control.' (Jackson et al. 2011, p. 252)

Although these conceptualizations have been fundamental to problematize the notion of the field in CSCW, researchers are left with the problem of translating this understanding into terms of practical fieldwork. Some scholars have recognized that there is a need to scale up the ethnographic inquiry and proposed using scaling (or scalar) devices, that is, mechanisms or strategies to account for the way distribution and historical accumulation unfold in practices (Ribes 2014). Pollock and Williams (2009, 2010) suggested combining temporal and spatial storylines by following the biography of an object of inquiry. This strategy involves discovering the short-term dynamics of incremental technological changes and tracing the lifecycle of specific artifacts during their evolution over time and across different locations, including the venues where technology is produced (e.g., technology vendors) and where predictions about the future of technology are being crafted (e.g., analyst conferences) (Pollock and Williams 2015). In STS, Beaulieu (2010) found that multimedia are a

useful example because they highlight that knowledge production is always mediated by textuality and technology (e.g., a telephone call or a website). In this sense, the field is constituted by social and temporal interactions rather than physical spaces, because 'different temporal forms – leaving messages on a machine, 'telephone tag' – and indeed synchronous or time-shifted interactions can be associated with different forms of presence.' (Ibid. p. 458) Ultimately, this point implies a gestalt switch for infrastructuring studies: The characteristics of infrastructure that make it difficult to frame (e.g., remoteness, digitality, and distribution) are not a difficulty but instead a resource for the fieldworker to leverage (Bowker and Star 1999; Beaulieu 2010). Moreover, these resources are simultaneously a concern for the designers of the infrastructure, who have to interact and find solutions as part of their daily job to scale access to their own infrastructure (Ribes 2014). These actors thus might become 'infrastructural allies' (cf. Holmes and Marcus 2008; Beaulieu 2010) for the fieldworker: 'The key insight in this method is the recognition that anytime there is a 'large' endeavor you will find actors tasked with managing the problems associated with its scale.' (Ribes 2014, p. 158)

The consequence of this observation is that the way scales emerge in practice and the way they get entangled with one another in an ethnographic account are ultimately the result of arrangements made by *both* the ethnographer and the actors observed. Such arrangements might be mundane but fundamental to construct the lens that we use to look at infrastructuring work.

3. Research approach

This paper is based on a three-year ethnographic study that I conducted as part of my PhD work at a Norwegian university (2012–2015). I started my fieldwork in April 2012. By the time I delivered my thesis to the evaluation committee (March 2015), it dealt with the co-evolution of information infrastructure for subsea environmental monitoring and representations of environmental risk in the oil and gas sector (Parmiggiani 2015). Although the empirical data focus on an oil company's attempt to design an information infrastructure for subsea environmental monitoring, the case in this paper is about my own ethnographic fieldwork and the process to discover the scales of the field. In this section, I outline the empirical background and the way the philosophical paradigm influenced the data analysis. I present my ethnographic work in detail in Section 4.

3.1. Empirical background: Bertil and the politics of Arctic oil

The development of real-time subsea monitoring platforms within the oil and gas sector was spurred by the digitalization effort the industry began in the late 1980s and has been evolving at a steady pace since the early 2000s, particularly in Norway, one of the world's top oil and gas exporters. In connection with the decreasing amount of oil available to drill, its fluctuating price, and stricter accountability requirements

following the Enron scandal, the Norwegian Oil and Gas Association (2005) has formally promoted an operations policy that seeks to make better use of digital real-time information. This policy triggered the installation of fiber optic cables, sensor networks, real-time alarm systems, centralized data repositories, and remote communication tools. Real-time technologies have paved the way for the development of collaboration arenas (Rolland et al. 2006) and more efficient work practices spanning different professional disciplines (geologists, drilling engineers, safety personnel, and environmental coordinators) and different locations (offshore platforms or onshore control centers; (Haavik 2014). These sociotechnical efforts have, not surprisingly, made it possible to operate in deeper waters and harsher environments. Following the national Petroleum Safety Authority's (2013) regulations requiring continuous and integrated environmental risk assessment, the technological advancements are also applied to the environmental monitoring domain. The approaches currently being tested include online remote access and analysis of biological parameters from the sea floor and the water column, reduction in data management fragmentation, and the implementation of cross-disciplinary work processes that integrate engineering and environmental surveillance (Rosendahl and Hepsø 2013; Parmiggiani et al. 2015).

These technical and normative transformations are happening against the backdrop of intense debates about the possibility of allowing oil and gas companies to operate far north into the arduous Arctic region, which is estimated to contain approximately 30% of the world's oil and natural gas reserves (Bird et al. 2008). Disputes span the countries that have territorial claims in those territories (Norway, Russia, the United States, Canada, Russia, and Denmark/Greenland) and materialize as highly politicized, cross-cutting a wide array of political and industrial interests. The Arctic area is also of interest to other industry stakeholders, including the fisheries, tourism, and marine transportation industries. Today, intense debates on the consequences of ice melt caused by global warming are inflaming national political landscapes, particularly in Norway. Environmental activists and research institutions have protested against oil operations in the Arctic, arguing that we know too little about the Arctic marine ecosystems and the long-term effects of not only major accidents but also daily operations (Blanchard et al. 2014).

Given the Norwegian government's focus on a knowledge-based approach to decide whether to allow industrial activities in sensitive areas (Norwegian Ministry of the Environment 2009), industrial players, and oil companies in particular, are increasingly involved in initiatives to design and implement cooperative platforms for real-time subsea environmental monitoring aimed at gaining permission to operate in the Arctic. During the work for my PhD (2012–2015), I conducted a three-year ethnographic study of the efforts in this direction by NorthOil, a pseudonym for an international oil company with more than 20,000 employees worldwide that is particularly active in Norwegian waters. One large-scale collaborative initiative was EnviroTime, a three-year project (2011–2014) to design and implement integrated technologies and methods for subsea environmental monitoring during

daily operations (e.g., well drilling, oil or gas production, and decommissioning). A significant part of the project was the creation of a web portal (the EnviroTime web portal) for drilling engineers and environmental coordinators to assess the status of the risk to the environmental resources (e.g., coral reefs and fish) near an operational area. Three industrial partners participated in the EnviroTime initiative: the quality certification and risk assessment organization QCB, the subsea technology vendor O&GSolutions, and the business intelligence solutions vendor ITCorp (Table 1).

At first glance, EnviroTime seems like a 'classical' case of technology design involving decisions about choosing technologies and configuring them, assessing which marine parameters can be monitored, and designing algorithms to turn the datasets into models of environmental risk to visualize on the web portal. However, EnviroTime is strongly motivated by political and economic reasons to position NorthOil as a technologically strong and knowledgeable operator in the Arctic. My own opportunity to delve into the interconnection between these 'global' agendas and more 'local' design instances was another NorthOil project, whose data EnviroTime began to use: the Venus Ocean Observatory, a smaller initiative by NorthOil for real-time environmental monitoring, conducted in collaboration with a technology vendor (MAS) and a research center (the Marine Institute). See Table 1. Venus consisted of the installation of networked devices (acoustic sensors, pressure and temperature sensors, a camera, and a hydrophone) on the seafloor off the coast of northern Norway (an area I dub Venus for simplicity), at the gateway between the Norwegian Sea and the Barents Sea. The sensor data feeds collected in the Venus area are sent onshore in real time through a fiber optic cable. Due to the high concentration of coral reefs and spawning fish, all oil and gas operations in the Venus area are currently forbidden.

After the EnviroTime project obtained permission to use the data sets generated by the Venus Ocean Observatory, funds were diverted to the Venus project to design a

Table 1. A list of NorthOil's partners in the projects examined in this paper.

Project	Company	Role and type of expertise
	NorthOil	International oil and gas company
EnviroTime	QCB (Quality Certification Body)	Third-party risk assessment and certification body; development of risk assessment methodologies
	O&GSolutions	Vendor and expert in oil and gas and submarine equipment and sensors
	ITCorp (IT Corporation)	Provider of business analytics; semantic data modeling; passive acoustics data analysis systems
Venus Ocean Observatory	MAS (Marine Acoustic Systems)	Subsea sensor technology vendor; marine acoustics expertise
	Marine Institute	Norwegian Institute for Marine Research; experience in and development of methodologies in marine biology and oceanography fields

All names are pseudonyms for confidentiality.

publicly accessible web portal (the Venus web portal) to display the status in the environment of the sensor network. By combining the pictures sent by the camera and the hydrophone logs in the Venus web portal, NorthOil and its partners became acquainted with Bertil. Behind the need to interpret Bertil's voice is NorthOil's goal to demonstrate the firm's ability to operate safely in the Arctic Venus area to the Norwegian government. How to do that in terms of designing a new infrastructure for environmental monitoring, however, is a question that sits on an unstable terrain of a changing political landscape, economic means and strategies, and technological development. My ethnographic study thus dealt with these 'dynamic jigsaw puzzles' inherent to design (Garud et al. 2008). My pragmatic approach to address the scales of these puzzles was not to define them a priori as either 'local' or 'global,' 'long-term' or 'short-term' but to focus on the way the actors constantly instantiated their own scales in practice in the spatial, temporal, social, and other dimensions (Jensen 2007; Ellingsen et al. 2013).

A note on the participants involved. In this paper, I use the term 'participants' to mean employees at NorthOil and its partner companies (see Table 1) who directly collaborated on the EnviroTime and Venus projects. The actors with whom I was in contact had different professional backgrounds: environmental advisors (educated in marine biology or environmental chemistry), marine acoustics experts, computer engineers, data management experts, and anthropologists. EnviroTime and Venus were highly collaborative projects in which the actors were engaged as co-designers with different roles in different moments based on the emerging purpose at hand. I followed the initial years of these collaborative endeavors, given that the real-time environmental monitoring infrastructure is still in its infancy if compared to the almost 50 years of history of the oil and gas industry in Norway. This immaturity aspect opens up the EnviroTime and Venus initiatives to a high degree of uncertainty that allows for a significant effort to explore connections between stakeholders, functionalities, and technologies—a blurred space that, as I discuss in the following sections, has implications for the ethnographer's activity.

3.2. Data collection and analysis

I had access to NorthOil for the duration of my PhD work. During the first two years (mid-2012 to mid-2014), I spent, on average, two to three days a week there, and then I decreased my presence to approximately one day a week during the third year (mid-2014 to mid-2015) when I was writing my PhD dissertation. There were short interruptions in 2014 when I spent a month and a half visiting foreign universities. During these periods, I maintained remote access to NorthOil's Intranet and my email account.

For this paper, I rely on the chronologically sorted empirical data reports that I collected during my PhD: 11 handwritten notebooks with field notes from my observations (spanning three years); 38 computer-based transcriptions of interviews (average

duration: 1 hour); and a wide chronological archive of documents, email exchanges, and other information available either confidentially on the NorthOil Intranet or publicly on the Internet. In addition, my field notes include extensive memos from my observations and tests with the software tools used or under development at NorthOil. I analyzed this large dataset inductively, aided by a backward reflection of my data collection. My unit of analysis was my own practice for approaching the field and gradually gathering more information, identifying new informants and locations, and making sense of the historical evolution of NorthOil's initiatives for environmental monitoring. I open-coded by hand my notes and interview transcriptions with colored highlighters and sticky notes. Color-based coding was useful to progressively make sense of my different strategies as belonging to different, yet interdependent, clusters. I thus began to group my codes, which I ordered chronologically due to the sorting of my field notes and interview transcripts collected during my PhD work.

Fundamental to the data analysis phase was an interpretive philosophical paradigm (Klein and Myers 1999), which, in addition to the sensitivity to the theoretical concept of infrastructuring and the combination of data-gathering methods, acted as the glue to frame my unit of analysis and to leverage the relationship with my informants. My adoption of the interpretive guidelines, thus, recognized that in my case study, I (the researcher) and the actors whom I observed were responsible for producing knowledge objects by constantly interacting (Klein and Myers 1999). Consequently, as a fieldworker, I pragmatically leveraged the intimacy developed with them as an investigative tool, especially in the early stages. My first scaling mechanism relied intensely on these insights to bootstrap my access to an unknown setting ('Following the small entry points to infrastructures').

The goal of my data analysis was to understand how I had gradually managed to make sense of the field (or to *scale* it). I realized that the actors I was following were—in my understanding of their job—responsible for solving these same problems every day (Ribes 2014).[5] In addition, I was following these actors in venues to discuss technologies and industrial strategies, such as conferences and special groups of interest where global and historical information was gathered for a few days (Pollock and Williams 2015). Inspired by the work of Latour and the subsequent developments, my second scaling mechanism recognizes that these actors might become useful infrastructural allies (Beaulieu 2010) for the fieldworker ('Following the actors: Finding infrastructural allies').

As I was following my infrastructural allies, I was involved in increasingly controversial situations[6] regarding my role (I began to look very much like a 'native' at NorthOil, and this caused confusion) and the EnviroTime and Venus projects. Disagreements and a lack of shared understanding among the stakeholders involved were the norm, but EnviroTime and Venus were proceeding more or less according to plan. The scaling mechanisms I was putting into practice to make sense of these situations, I realized, were different from the mechanisms I listed above. Looking at my field notes, I noticed that, at that time, I was becoming more skilled in stepping out of the controversies when making sense of my own data. I began to understand these controversies as

a process that the actors were undergoing to make sense of the infrastructure that they were designing and using ('Following the design controversies').

Finally, toward the end of my data analysis I began to question my data sources, viz. apparently unremarkable, such as an interview, a document, or my observations. I realized that these data sets were snapshots of the environmental monitoring situation at a specific moment, which, if seen chronologically, could provide a moving picture of the evolution of the situation over time, at least in the Norwegian context, in line with the notion of infrastructuring discussed in Section 2. Consequently, my fourth and final mode of scaling consisted of looking at the apparently mundane data sources as syntheses of the infrastructuring process ('Following the mundane data sources'). Looking at mundane data sources is a common practice in ethnography. However, I subscribe to Ribes' (2014) finding that they can be conceptualized and used as scaling devices. By looking at how such sources were synthetizing the work of infrastructuring, I realized that they also provided an account of the changing political relationships in the field. This realization, finally, yielded a round of data analysis to understand how shifting political reconfigurations could be discovered throughout all my other scaling mechanisms, too (Section 5).

In the next section, I present the way I gradually discovered and navigated the dimensions of the field site with my four scaling mechanisms. I list the mechanisms in sequential order, following the way they emerged from my data analysis; however, they often overlapped and informed one another. For example, 'Following the mundane data sources' (Section 4.4) was often adopted in parallel to and as a tool for approaching the following the design controversies strategy (Section 4.3). I describe how I addressed, defined, framed, questioned, and re-framed the field throughout my ethnographic work. I also try to show that in this process the object of investigation co-evolved with the definition of the field, thus allowing me to sharpen my data collection method. To unearth this process at the rhetorical level, I adopt a self-revealing and self-reflexive narrative approach (Van Maanen 1988). I adopt this style mainly because it vividly conveys that what the researcher can see is colored by the type of access and her interactions with the surrounding context. I use excerpts from the field notes I made during my ethnographic study. I mostly wrote these excerpts up after a day of fieldwork or at the first available moment after a meeting or a social interaction, aided by memory recollection and quick notes scribbled when possible. To increase readability, I added the labeling for each excerpt when I wrote this paper.

4. Being *in* the field: Discovering the scales of infrastructuring

4.1. Following the small entry points to infrastructures

My first step consisted of getting access to the subsea environmental monitoring project, without these words having a defined meaning for me at the very beginning of my research. The 'obvious' candidate site was NorthOil, one of the major operators in Scandinavia and now involved in EnviroTime.

The literature reviewed in Section 2 conceives of information infrastructures as large-scale processes. However, the entry point for ethnographers is often a small-scale, pragmatic effort. This is what happened for me: My co-advisor had been working at NorthOil for almost 20 years and facilitated my access. Through this collaboration, we identified EnviroTime (which had just started) as a suitable case study for my research. Relying on the mediation of my advisors, I got in touch with the leader of the department in the NorthOil R&D section where most EnviroTime participants were located. In April 2012, I was granted an identification badge and access to the department. I was initially allowed to use a shared desk in the hallway of the department, not far from the office where six participants in EnviroTime worked. Among the focus areas of the EnviroTime project was the development of formal data models (ontologies) to represent the environmental data sets. Given the convenient timing and my background in conducting research on the Semantic Web, the opportunity initially seemed relevant for me. I was received positively as someone knowledgeable in that research area who could potentially provide them with help and suggestions.

Happy with my badge that allowed me to enter the NorthOil R&D department anytime Monday through Friday from 07:00 to 17:00, I initially assumed that the field corresponded with the physical location of the NorthOil R&D center, so I focused my efforts on giving a shape to my research field by generating a network of connections inside NorthOil's building. Almost unconsciously, I began not only equating the field with the physical location of NorthOil but also with the network of informants. Although I was allowed to attend many meetings, I struggled initially to find my position in the NorthOil environment, as I was trained as a computer engineer and had no prior experience in the oil and gas domain. Thus, I strived to make the best use of what I had (my academic background) and began by identifying several computer engineers who would feel comfortable sharing their perspectives with me due to our common background and in a technical language to which I was accustomed. These professionals were important during that initial stage to make sense of the context and introduce me to other people. I became good at networking internally and maintaining my connections; therefore, getting to know relevant individuals after a few weeks seemed almost effortless.

Serendipitous networking. It's an unusually sunny Thursday in January, and I am at NorthOil R&D center, having lunch with one of the participants in EnviroTime, Henry. Once we are done eating, on our way to the coffee machine, Henry stops by a table; he has seen a man he knows. He greets him, sits in front of him, and tells me to go grab my coffee in the meantime. He'll join me later. By the time my coffee is ready, he is still sitting at the table. I thus walk toward him to say I am going back to the office. He stops me and introduces me to his interlocutor, Tom. Henry explains that Tom is a senior IT architect at NorthOil's headquarters, visiting the R&D center that day to attend some meetings. He also recommends that I have a chat with him, since he is one of the main architects in charge of setting up a real-time data-transfer architecture for daily offshore operations. I

think that it would be an interesting opportunity to understand how real-time data management works during normal oil and gas operations, to understand what sort of existing systems and practices a real-time approach to environmental monitoring will rely on. Tom seems really friendly. I do not even have the time to ask him directly if he has some spare time when he tells me that he has an hour available right now, so we can sit for an informal chat in one of the meeting rooms. While we talk, he draws a map of the typical data transfer architecture at an offshore oil platform on the whiteboard and lists the most common challenges. Finally, he also provides me with the name of a few people I could talk to about that topic.

The initial period was also useful on the social level to let the project participants get used to my presence. In turn, establishing these interactions in serendipitous and immediate moments was useful for me to gain further access to future and past information, and to additional informants during the whole duration of my ethnographic study. This is also why I first met Bertil, as NorthOil's efforts to monitor commercial fish species, such as cod (and tusk), became evident to me.

My first meeting with Bertil. November 2013. We are sitting in the office of an IT advisor, Hans, at the NorthOil R&D center. Hans is leading the development of the Venus web portal, used by the company to display several real-time environmental parameters measured from a subsea observatory on the seafloor offshore northern Norway. The data indicate the salinity, temperature, chlorophyll level, pressure, and depth of the water. There is also a graph representing the biomass concentration in the water column, which is updated every few minutes, and a video made from pictures over the last two days. These pictures are obtained using a camera placed next to a coral reef. Hans has an Internet browser open on one of his two PC screens and an instant messaging program on the other screen. While explaining something to us, he is suddenly distracted by the blinking of the messaging program. One of the programmers working on the web portal wants his attention, because 'the fish is back.' Hans turns to the browser, opens the web portal, and looks at the video frame, where a fish has just appeared in front of the subsea camera, coming out of the coral structure. It floats calmly, looking at the camera lens for a while, and finally leaves. The advisor explains that it is not the first time that fish has behaved in that way. An analysis of the acoustic measurements previously indicated that that fish also speaks to the camera:

'And that's what happens, he gets really angry. So he says, "Shshshshsh!" (…) Or maybe he gets annoyed. Maybe he gets used to it. And that's also one of the things. Will we [have an] influence? Will the local fauna get used to the sounds when we do the stuff?'

(Excerpt from field notes adapted from Parmiggiani and Monteiro 2016).

4.2. Following the actors: finding infrastructural allies

Many spaces, many months, many interpretations: How to spot Bertil's kids? In November 2013, my first advisor and I interviewed two environmental experts at QCB headquarters. Toward the end of the interview, we discussed the Venus project. One of the two interviewees remarked that the acoustic sensors used to detect marine biomass in Venus are placed on the sea floor. This makes it difficult to spot eggs or larvae which are small and float further up, close to the sea's surface. The expert pointed out: 'the fish experts… they do not have any experience about having the sensors [placed on the seafloor].' To make sure I understood correctly, I asked again: 'So there is no experience whatsoever of using acoustic sensors from the bottom to the top?' And he firmly replied: 'No.'

Several months later, I was attending a joint seminar in another Norwegian city with all the EnviroTime participants. An expert in marine acoustics from O&GSolutions gave a speech supported by many PowerPoint slides with complex mathematical formulas to explain to the others—all with different background expertise—the difficulties of spotting small resources, such as eggs or larvae, from a long distance with the devices available in Venus. He confirmed the QCB expert's statement.

Almost one year later, I visited the headquarters of MAS, the company that produces the subsea sensors used in Venus. The original plan was to obtain better insight into the function of subsea sensors based on their experience. When I introduced my research and some of my findings to them, I also showed a PowerPoint slide of a summary of the information I had received earlier about eggs and larvae detection. When the head of the company saw it, he stopped me and commented that it was not true. Their company is capable of doing that and has experience in environmental monitoring with subsea acoustic devices. I was puzzled; I was sure I had heard the opposite on other occasions.

Back in the office, I went through the official documentation delivered by QCB for EnviroTime, in which a group of environmental experts explained mathematically why detecting eggs and larvae is complicated in Venus with the devices available to them.

This excerpt exemplifies that after a few months, my field started to expand in the spatial and the temporal dimensions. As I started to venture out of NorthOil to find new informants, I realized that the work to design the infrastructure to detect and measure Bertil spanned several years and several spaces: in a room at QCB headquarters, in the slides and the mathematical formulas shown at O&GSolutions, in the experience developed by MAS experts, and in the technical documentation for the EnviroTime portal. Infrastructure design was also happening across contrasting opinions: The project participants never agreed on something that appeared to be as basic as the capability of sensors to detect eggs and larvae. Nevertheless, the participants' collaboration pragmatically continued, and the EnviroTime

infrastructure was actually designed. In addition, their scientific work (e.g., modeling mathematically the movement of eggs and larvae) and political work (getting all partners to collaborate in EnviroTime despite discrepant interpretations) were mixed in action. How to navigate these facets at once, in practice?

The strategy of befriending the actors I had relied on since the start was perhaps the most important key to unlocking such a complicated story and to gain access to other locations, events, and information of which I was not aware or to which I did not have access. I began by observing what was going on in the open space where my desk was located and then by following the people with whom I was becoming acquainted into meetings, seminars, and workshops. A very important data source at the time were informal chats over a coffee or at lunchtime, which I regularly relied on to double-check that what I understood during, for example, a meeting was correct. Given that EnviroTime was in a very early stage and thus characterized by frustration about where the project was headed, people seemed to be comfortable sharing their opinions with me, as if to vent, off the record, thoughts they could not share. Once again, the field was taking shape through my social connection. Nevertheless, I became gradually aware that these people were now becoming my infrastructural allies—using Beaulieu's (2010) vocabulary, allowing me to access and see new events, things, systems, and issues to which I would otherwise have been blind.

The fact that I was allowed to participate actively in meetings, workshops, and several other events was, in my view, a sign that my strategy of investing in building relationships with the EnviroTime participants was rewarding. Several times, I was also invited to join in meetings and workshops held at the headquarters of NorthOil and the partner companies, all located in other Norwegian cities. I admittedly could do this owing to the generous travel grants associated with my PhD project. In addition to letting all this money flow to airline companies, these frequent trips allowed me to get acquainted with the other companies (especially to schedule interviews with relevant professionals there). In addition, I realized that I was gathering important information by chatting with the project participants traveling with me on a plane, a bus, a train, or a taxi. During those seemingly unremarkable moments, such as the train ride from an airport to a company's headquarters, I had the chance to sit near people I seldom met during my days at NorthOil. Thus, I learned to consider all unremarkable and routine social situations as potential parts of the ethnographic field. The setting of these situations, importantly, was often digital. With some of my infrastructural allies, I maintained conversations through chats, emails, or Twitter, LinkedIn, or Facebook outside my fieldwork days. We did not exchange confidential information; however, we would, for example, discuss a newspaper interview by a famous IT expert. This approach based on following my infrastructural allies and building a relationship of friendly mutual trust between us meant that my field not only extended outside NorthOil's physical offices but also spanned many digital networks.

Infrastructural allies became fundamental when some information was too difficult to discover, locate, browse, and study on my own. For example, I wanted to get a better understanding of the current work practices at NorthOil and how they could be

modified by the introduction of real-time environmental monitoring tasks. To do so, I needed to find, browse, and not the least interpret the company's 30,000 formalized work processes. In addition, I would need to identify and interview the representative of each department in the company to discuss the possible integration of new routines. By the time I encountered that problem, however, I had developed a good relationship with two participants in EnviroTime who performed similar work as part of the EnviroTime project: writing a set of guidelines to direct the integration of environmental monitoring routines at NorthOil, a task they called 'data governance.' Thus, I was able to follow them for a few months as they mined the work processes and identified, contacted, and interviewed the representatives of other departments at NorthOil. By relying on the participants' mining work, I could see the relevant documents, discuss them with the EnviroTime participants, and take notes and ask questions during the videoconferences and meetings that they had arranged with the representatives of each department. As a result, a problem with an apparently global size took the shape, in practice, of a local issue. A research field that could have spanned, at a minimum, all NorthOil's departments, in other words, ended up corresponding to my office mates' and NorthOil's digital resources.

The data governance meeting: Discovering Bertil's stakeholders. I am sitting in a window-less meeting room at NorthOil on a Monday morning together with three participants in the EnviroTime data governance task, Henry, Hans, and Michael. It is my sixth meeting on data governance, and I begin to feel comfortable with the setting and the topic.

Henry begins by reporting on his meeting in another city with an expert in coral risk assessment who provided him with detailed suggestions for implementing guidelines in EnviroTime for mapping risk in coral-rich areas on the Norwegian continental shelf. He gives us a copy of the minutes taken during the meeting. Henry and Michael agree to implement the suggestions as part of their duty in the data governance task.

We then move on to the next topic, planning a one-day trip to NorthOil's Online Data Center at the company's headquarters to discuss the possibilities and challenges related to real-time data management during oil and gas operations. I ask timidly if I can join, and Henry warmly invites me to go and to reserve the same flights.

Finally, Henry skims through one of his draft documents listing all the stakeholders involved in EnviroTime, mapped by domain, discipline, and organization (e.g., NorthOil departments, environmental agencies in the European Union, Canada, and the US). For each stakeholder, Henry has indicated who the contact person is, whether they have agreed to support EnviroTime, and comments and feedback from them. Henry then stops looking at the file and complains that he cannot find other people directly involved in data governance tasks within

NorthOil. Hans, who often visits the company's headquarters, interrupts him and explains that what is called 'data governance' in EnviroTime goes under the label 'information management' in the rest of the company.

The meeting ends with the participants agreeing that Henry will start listing the missing stakeholders for the next round of interviews.

As this vignette shows, by participating in the data governance meetings I was able not only to sit where important decisions were made but also to access important information about other meetings that I had not attended in person and other locations and informants who would have been difficult to identify as relevant on my own. Moreover, while sitting in a chair, I had a very broad overview of the global stakeholders that influenced the design of the EnviroTime infrastructure, including North American environmental agencies that were providing EnviroTime with real-time data sets for testing purposes. In this way, I also had a hint of the way the same practices were labeled differently across the same company, which would give me an advantage to formulate better questions when I got in touch with other potential informants.

In addition to the events directly associated with the EnviroTime or other NorthOil or partners' corporate initiatives, a secondary but important data source for me to make sense of subsea environmental monitoring in general in the oil and gas sector were 14 conferences on oil and gas technology and special groups of interest meetings where practitioners from oil and gas companies, technology vendors, and consultants gathered to present (and advertise) their latest solutions. I initially did not consider these events directly relevant to my ethnographic work but as an indirect means to be increasingly recognized and accepted as a member of the oil and gas reality by relevant informants, particularly outside NorthOil. I later realized that these condensed arenas were also part of my field. They were valuable devices for getting access to data from all over the world outside the initiatives in which NorthOil was involved. On one of these occasions, I realized that NorthOil's approaches to the development of systems for offshore environmental monitoring made sense only in reference to the Norwegian political system. Listening and talking to representatives from abroad, with different traditions and regulations, made me realize that the Scandinavian sociopolitical context was a major reason why NorthOil was so interested in Bertil and in sharing his pictures openly in real time. Had NorthOil been an oil company headquartered in, for example, North America, a strategy of open data sharing would not have been the first choice, perhaps. Conferences and similar events, thus, became an invaluable part of my field because they provided me with co-located access to global, historical, and political data, in addition to new potential informants.

4.3. Following the design controversies

A side effect of my approach to navigating the field was the increasing ease I had in being 'in' it. During the first two years of my PhD work, I spent more time at

NorthOil (and sometimes at the partner companies) than I did at my university. As my access to the field through infrastructural allies grew, I was increasingly accepted by the actors in the field as one of them. The side effect was that my access to contrasting opinions and (sometimes harsh) debates related to infrastructure design also increased.

In November 2012, my first infrastructural ally in the EnviroTime project resigned. I was worried, because he was one of my key informants at the time. However, he left an empty desk in the office where five key EnviroTime participants were located. The department leader talked to me shortly after and proposed that I sit with them. She also arranged a computer that I could use. I, of course, accepted, and this move gave a spin to my data collection. Within less than a year and a half, I was actively enrolled in a number of sub-tasks in EnviroTime, such as giving feedback about the minutes of a meeting or draft technical documents. I could comment on documentation and support the person responsible for the specific sub-task.

Looking like a NorthOil employee. In April 2013, a workshop was organized at the NorthOil headquarters (in another Norwegian city) to discuss the possibilities of setting up a collaboration with research institutions on the topic of semantic technologies. A few NorthOil employees from the IT department would provide their insights and the company's experience with semantic data modeling. When I was informed about the event, I was eager to participate, given my experience with semantic technologies and as a valuable data collection source for my PhD. I was soon informed, however, that I could not participate because my university was not directly involved in the project proposals. I did not give up, and asked Hans, one of my infrastructural allies in the IT section—whom I knew would participate in the workshop via the videoconference system—if there was any chance I would be allowed to participate. He looked at me with a surprised expression and said, 'Of course you can, you count as a NorthOil employee!' I did not expect this reply but thanked him and joined the workshop. During the first round of presentations by the participants, he introduced me as one of his collaborators.

My ease in being in the field made it so that actual NorthOil employees often mistook me for a full-time NorthOil employee. I then had to explain my actual position, but I did not experience a change of attitude toward me. Overall, my growing resemblance to a regular NorthOil employee and the fact that I always attended the general meetings along with NorthOil employees had two unwelcome side effects: First, as a result of my almost daily presence at NorthOil, it became somewhat difficult for me to remember that I was not a co-worker of the actors I observed. Second, I was afraid that the employees of the partner companies might have felt uncomfortable when they shared their thoughts with me, because I could reveal everything to NorthOil afterwards—something that I never did. On several occasions, interviewees were uncertain about my role, and once, I was asked directly

if I would go back and report everything to NorthOil. After I clarified my position as a researcher from an independent institution, however, the interviewees generally felt more comfortable speaking to me.

Balancing the roles that I played in the field is important because although looking like one of the 'natives' at a physical site might be a crucial strategy to get access to useful information, avoiding espousing the points of view of given informants as uncontested facts became an important strategy for me. As my access to informants improved along with my ability to handle my identity in the field, I increasingly found myself juggling their different, sometimes contrasting points of view on the design, outcome, and agendas involved in the ongoing projects. In many cases, different actors (often from different companies) expressed incompatible narratives or accounts of particular events or motivations. One example is the workshop arranged by NorthOil, MAS, and the Marine Institute to present the first version of the Venus web portal to a community of fishermen. Given that the portal was meant to display, among other things, real-time information about the concentration of fish in water, the participants hoped that the portal's design and usability could be improved by relying on the fishermen's feedback based on their experience tracking fish.

One event, multiple interpretations: Interpreting Bertil's voice. Toward the end of 2013, an environmental expert and an IT advisor from NorthOil participated in a workshop to present the Venus web portal to a community of fishermen from a small town in northern Norway near the Venus onshore data center. In addition, marine acoustics experts from MAS participated in the event. Since I could not join them in person for the workshop, I had to rely on my informants' narratives of the event and on an article published in a local newspaper. The newspaper article provided an enthusiastic account of the event, presenting the Venus web portal as something that was 'useful for the local fishermen' to get a better overview of the number of fish in the water column.

Back at NorthOil, one of those who participated in the workshop reported during a weekly debriefing session with his colleagues that the fishermen had commented that the chromatogram displayed on the Venus website was difficult to understand (a chromatogram is a graph based on acoustic sensor reading where the fish concentration is plotted with reference to time and depth and colored in different ways based on density). I duly noted this remark, until during a meeting at the MAS a marine acoustics expert who had participated in the Venus web portal workshop told me the opposite: The fishermen quite liked the chromatogram, because they usually adopt commercial acoustic sensors to track fish. At this point, I was a little puzzled, as the two accounts did not match.

Therefore, I asked a NorthOil IT advisor who attended the workshop to give me his personal opinion of what happened. He told me that the fishermen liked the chromatogram; however, they found it a little difficult to read because they use

portable devices to display the acoustic sensor readings, so the chromatograms they generally have to interpret are smaller and visualize narrower areas of the water column that gives a more pointed indication of what is fish and what is not fish. Nevertheless, they understand the Venus chromatogram as well.

At first, I was upset after these events, due to the personal connection I felt with all my informants with whom I was spending many days a week. With time, however, I learned not to take these situations emotionally but to leverage them as a source of data. Discussions, disagreements, and arguments became important leads to follow to trace where the actors were taking the infrastructuring process. Thus, it proved very important to tune my sensitivity to the possible differences in interpretations expressed by different actors to understand how they constitute and direct the infrastructuring process despite a lack of shared understanding. This point has consequences for the unit of analysis that the ethnographer of infrastructure design can adopt in practice: looking at infrastructure design as infrastructuring means focusing on the process through which actors reflexively make sense of and negotiate their infrastructure. For instance, initially, many discussions were held in the EnviroTime project about the need to develop a comprehensive data model (or ontology) to represent all the current knowledge about the submarine environment and real-time environmental monitoring. For example, the Semantic Web experts discussed and sometimes even quarreled about the need to formalize a full description of the operations area and the sensors deployed or to import existing vocabularies through a Linked Open Data approach (see Parmiggiani and Hepsø 2013 for additional details on this case). At the time, I thought I was looking at the development of an ontology (ultimately a single artifact), although I was having difficulties framing my unit of analysis more precisely. I soon understood that the scope of EnviroTime was difficult to grasp not for me but also for the project participants. As time went on and owing to the conversations with my research group and other researchers, I realized that due to my training in semantic technologies, I was missing the bigger picture: NorthOil and its partners were not only negotiating the development of a data model. What they were producing, negotiating, and validating was their own representation of the available and possible tools, systems, and expertise to conduct real-time subsea environmental monitoring. In other words, they were discussing a representation of their information infrastructure-in-the-making. They were, very recursively, conducting infrastructural work by talking about the infrastructuring process. These design controversies constituted an additional important dimension of my field.

4.4. Following the mundane data sources

Despite all the strategies that I was developing to make sense and give shape to my object of inquiry, I was still often frustrated at being one researcher facing what I perceived as a ‘large’ infrastructure. Gradually however, I realized that the ‘mundane’ data sources that are usually listed briefly in research articles were an important

scaling tool to explore how actors deal with this problem along heterogeneous dimensions in infrastructure design and, in doing so, negotiate power relations. Interviews were a useful device for me to understand how this process was unfolding. As time went by, through participant observations, I identified key informants for semi-structured interviews. I often left the interview guide as flexible as possible to give space to my informant to recount the story from his or her perspective. To gain a better understanding of the events before my entry to the field site, I often asked my informants to provide a narrative of their involvement in environmental monitoring projects, the events they could recall, and their perspective on how the various players related to each other. To familiarize myself with the project, I initially conducted interviews with NorthOil employees. In total, I conducted 23 interviews with NorthOil employees, some located in other cities and contacted remotely via Microsoft (MS) Lync. As soon as I became more acquainted with employees of the partner companies participating in EnviroTime, I could schedule interviews with them, either via MS Lync or by traveling in person to their offices elsewhere in Norway. For instance, following a suggestion from a NorthOil employee, I first interviewed the vice president of O&GSolutions. Later, I contacted EnviroTime participants from QCB and held nine interviews with them. Overall, my approach to access informants and thus perspectives did not always work. During the last period of my PhD work, I tried to contact other EnviroTime members from O&GSolutions, but due to delays introduced by additional requirements in the EnviroTime project, this path did not prove feasible, and I gave up. Thus, I turned my attention to another sensor technology vendor, MAS, a small company involved in the Venus project and other environmental monitoring programs run by NorthOil. That road proved easier, and within a week, I was invited to the MAS headquarters and held three interviews. Given that MAS is located in the same city as the Marine Institute, I exploited the trip to conduct last-minute additional interviews with two environmental experts there.

Discovering the scale of Bertil's story through interviews. Frustrated by the lack of response to my requests to visit O&GSolutions, I ask one of my informants at NorthOil for a suggestion about whom to talk to in order to get a clearer overview of the sensor technologies adopted in environmental monitoring practices in the oil and gas sectors. He recommends MAS, a company located in another Norwegian city, and lists a couple of people I can contact directly. One of them answers my emails quickly, and we agree on a day for my visit.

The following day, he sends me another email to clarify things: 'Just so that we put things in place. We deal only with the design and production of units, maintenance, and integration of specific data. You should also maybe speak with the Marine Institute [which has a branch in the same city]. It is they who deal with the sampling regime and what data should be included in the data collections, together with their storage [in the Venus project].' He then lists a person I could contact,

which I do. I agree to visit this person in the second part of the afternoon the same day I visit MAS. I had very little time to plan that trip, so I was more than happy to have the chance to interview more people from different companies during a one-day trip. Once at MAS, I realized that the meeting with three experts in marine acoustics has been set for three hours. Without me asking, they prepared a very detailed presentation of their experience with subsea environmental monitoring in Norway and with NorthOil in the last five years.

In the afternoon, I take a taxi and head to the Marine Institute branch. I have to wait half an hour before my contact person is ready to talk to me. When he calls me, we take a tour of the unit, grab a coffee, and sit on a comfortable sofa for an informal chat to get to know each other and share insights into the Venus project, that they are also part of. He seems critical of the oil companies' goal to operate in Venus.

After approximately one hour, he has to leave, but he introduces me to his visiting PhD student who is working with sea-floor acoustic devices to detect fish. He says that he would be happy to talk to me, because he is too tired to work the rest of the day. We sit at his desk, and he shows me his latest experiments and findings, in addition to providing me with many details on how marine acoustic sensors work. Fresh from the meeting at MAS, I am ready to ask him many specific questions about the sensor technologies deployed in Venus.

In sum, the narratives elicited during interviews can be helpful to tackle the temporal unfolding of the infrastructuring process; in addition, through the scheduling of interviews, the researcher can also tackle the spatial dimension of the field by exploiting extemporaneous suggestions and geographic proximity. In this respect, digital sources are also fundamental. In parallel to allowing and improving access to informants, digital sources often embody a map of the temporal and political dimensions of the infrastructuring process. During my fieldwork, I often enjoyed silent moments in the office (e.g., when no meetings were happening or when everyone else had left) when I had time to explore NorthOil's Intranet and project team sites and the software that the companies were developing (including the Venus web portal). I had access to the internal MS SharePoint team sites where all the documentation related to EnviroTime and other environmental monitoring programs was uploaded, in particular project deliverables, reports, email exchanges, photographs, videos, and PowerPoint presentations. Documents were generated by NorthOil and by all the partner companies. Temporally, the web-based sources were useful for reconstructing the path that led to projects similar to EnviroTime before I formally entered the field. I could run queries and searches on NorthOil's Intranet and fetch internal documentation, statements by the management, and information about past projects.

Moreover, the Intranet-based sources, together with the software under development, were also a symptom of the politics of the field. First, NorthOil's Intranet

proved to be a scaling mechanism that I used to map the company's activities and business strategies. For example, it was a valuable tool for keeping track of the reservoir discoveries and drilling activities going on in the Arctic and how apparently small initiatives, such as the Venus project, embodied the unfolding of these global events, particularly in terms of accountability. The more attention drawn by the Arctic operations, the more Venus was becoming a political tool for NorthOil to demonstrate to the authorities the company's ability of to operate safely in those areas. The Venus web portal, then, was increasingly adopted as a catalyst to attract new stakeholders to develop better subsea environmental monitoring technologies. Thus, the portal could be analyzed as a site of political relationships. It was a partnership between NorthOil, the fishermen, and the Marine Institute. The latter used the portal to show that operations should not be allowed in such a sensitive region. The Venus web portal, however, was a terrain for all parties to cooperate to develop new scientific methods for subsea environmental monitoring in spite of contrasting agendas rather than a tool to achieve consensus about the opening of the Venus region to oil operations (see Parmiggiani and Monteiro 2016 for further details).

The politics of software was also embodied in the EnviroTime web portal. In this case, software emerged as the mirror of evolving relationships. The EnviroTime web portal was composed of two parts: One was for the environmental coordinators (environmental experts in charge of assessing the environmental viability of oil and gas operations in an area) to visualize and assess the real-time risk for resources, such as the cold-water corals. The other was integrated into the system used by drilling engineers to display the online data streams from all the subsea environmental sensors. Thus, I became aware of the space that environmental knowledge was carving out for itself inside the space of one of the core businesses of NorthOil, well drilling. This development was matched by the increasing involvement of environmental coordinators in the discussions and negotiations to design and develop the portal and its content during drilling operations. The environmental coordinators do not often have—if ever—a very visible role within oil and gas corporations. In the EnviroTime project, however, the coordinators emerged as powerful figures sharing the spotlight with the drilling engineers.

5. Infrastructuring as a political configuration: implications for the study of collaborative design

The politics of infrastructuring emerges from the intertwining of the infrastructure design process and the researchers' endeavor to construct an ethnographic field to study the design process. In the case I presented in this paper, it took harsh debates about Arctic oil and gas extraction, several years of sociotechnical evolution in the oil and gas sector, many international companies, and national laws for Bertil to become a fish of interest to the debates about oil and gas operations. For me to see Bertil, it took a few scaling strategies to construct my research field and discover phenomena

in different dimensions involved in an oil and gas company's projects to design an infrastructure for monitoring Bertil and his fellow fish in real time. My reflexive account of these strategies for constructing the ethnographic field also reflected on the way the ethnographic field has emerged as a set of political (re)configurations—or political locations (Gupta and Ferguson 1997). This reflection opens up a space for reflecting on issues of inclusion or exclusion that emerge during the design process.

In practical terms, research of design and implementation design in CSCW is often constrained to one or a few locations and short temporal widows. Despite these limitations, 'extended' views on design (Monteiro et al. 2013) can be achieved by decoupling the physical access and the research field and the temporal span of design and the research period (Beaulieu 2010). A way to do so in practice is to develop a few scaling devices on the analytical level, with which the researcher can scope the scales of the field without any presumptions about size or access (Ribes 2014). Decisions about what to follow are ultimately political, as they eventually emerge from the reflexive process of uncovering and questioning assumptions and practices. The way the dimensions of the field 'pan out' during the ethnographic inquiry (whether temporal, spatial, or otherwise) varies accordingly. Taken singularly, my scaling devices were inspired by common ethnographic practices. However, through their combination and the explicit reflection on how the combination evolved, I discovered emerging dimensions of infrastructuring work, and I constructed my research field.

I pragmatically began by finding a suitable, physically situated entry point (one office at the NorthOil R&D center) to a distributed research setting (the development of an underwater environmental monitoring platform by several industrial partners). Being explicit about the initial stages of the ethnography is important because the researcher's definition of the boundaries of the site might depend inextricably on the researcher's entry point—sometimes granted very pragmatically (Karasti et al. 2016)—and on how the researcher's interactions shape the framing of the object of inquiry, for example, by introducing herself as a troubleshooter rather than as an analyst (Jensen 2006), or a computer engineer with experience in Semantic Web technologies like I did. New to the field, I initially relied heavily on a subset of actors with whom I became friends through social networking mechanisms. In this way, I developed good relationships with informants, also, when possible, during apparently insignificant moments of relaxation, such as during a break, or while traveling together. This approach requires investing a significant amount of time and focus but might turn out to be advantageous to build enough mutual trust to be granted access to further scaling devices, such as additional meetings and debates in my case. Social networking strategies are also an important lever to understand the type of sociality that goes on in the field, a tool for the researcher to craft her research field in specific directions (Beaulieu et al. 2007). Based on my experience, digital tools and social networks should be recognized as useful scaling tools. They constituted an important part of my field site: LinkedIn, Twitter, and Facebook were useful arenas for

engaging in conversations with my informants and in turn, improving the degree of their trust in me. However, CSCW scholars seldom recognize and discuss the importance of these 'side channels' in the research process.

The kernel of my lens on the study of design work takes inspiration from Latour's (1987; see also Latour and Woolgar 1986) strategy to follow the scientists during their daily practice. The work of scientists (but we might as well say the work of designers) is not to hide in bunkers, ready to produce and defend new claims. Scientists (read: designers) must instead build and maintain a web of connections by seeking funds, aligning interests, and sharing their claims with heterogeneous audiences through media channels. In a similar vein, I strived to follow the EnviroTime and Venus designers while they were constantly engaged in navigating connections, negotiating, seeking to align interests, and broadcasting their claims to heterogeneous audiences through different channels. Whereas Latour first described his strategies in the 1980s, in the mid-2010s, researchers should remember to follow actors and their negotiations across digital sources, such as social networks, restricted documents on local Intranets, and public information on the Internet.

However, there are shortcomings and downsides in following actors either in person or digitally. For instance, this might prevent researchers from drawing complex connections in time and space, as the researchers might end up sharing the same blindness of the actors in the field (Williams and Pollock 2012). Nevertheless, particularly in new settings, the actors, in their very blindness, are useful allies for discovering workarounds and other scaling mechanisms that the actors have developed in many years of experience (Beaulieu 2010; Ribes 2014). Anthropologists such as Holmes and Marcus (2008) recognized that 'subjects are epistemic partners,' and it is thus useful for the researcher to draw on the subjects' strategies to solve comparable problems. Factors contributing to the unboundedness of infrastructures, such as their increasing digitalization, are also matters of concern for the subjects on the field, opening up new opportunities for analytical tools developed within anthropological ethnography in the last few decades. Therefore, looking at the way the actors deal with the digitalization process in practice might be instrumental for researchers to draw the trajectory of infrastructuring. What I did in practice was to explicitly follow the actors' blindness (Bowker and Star 1999). For example, I realized that NorthOil's concerns revolved around Bertil (a small tusk), but the company was blind to big marine mammals. This observation prompted the question, why was that the case? Bertil, more than marine mammals, is metaphorically pivotal to NorthOil and its partners in the Norwegian context to frame their conversation with important stakeholders, such as the fishing community that represents the other main industrial sector in the country and has deep knowledge of—and interest in—fish behavior (see Section 4.4). By making Bertil digital, the design of the Venus web portal thus emerged as a space for NorthOil to gradually discover new epistemic and political opportunities to appeal to the fishermen and to understand how to do so.

Among the ways to follow actors' understanding of the digitalization process is to follow the artifact (Pollock and Williams 2009; cf. Marcus 1995). In my case,

however, it was difficult even for the actors themselves to identify one or a few clearly defined artifacts to follow. First, the development of a data model was the focus; as that conversation died out, subsea sensors became the focus and finally, web portals and parameters visualization. I gradually evolved my method by following the actors dealing with the artifacts while also following the controversies that were going on around them, such as the discussion on how to monitor fish eggs and larvae (Section 4.2) and the workshop arranged to enroll the fishermen (Section 4.3). These controversies were the meeting points of the daily work carried out by the actors in their own effort to scale the infrastructure-in-the-making and make sense of it. Due to the relevance to an understanding of design as a precarious balance of different concerns as recognized by the social construction of technology tradition (Pinch and Bijker 1984), a strategy rooted in following controversies has proven a very useful instrument for crafting the research field. Controversies (even if disguised as formal and mundane events) were also very visible in those venues where several actors from the oil and gas–related world gathered: conferences, workshops, and various social events. These venues were all important parts of my field as they were the locations where predictions about the future of ICT in the oil and gas sector were being produced that would shape digital technology development, although they would perhaps not eventually come true, as Pollock and Williams (2015) vividly illustrated in their study of how Gartner generates predictions of the future of ICT by engaging different audiences. By participating in such events, I blended in a network of industries and research institutions related to the oil and gas world, which had the effect of not only putting me in touch with more informants and helping me contextualize and map NorthOil and its partners' initiatives but also helping me understand how controversies are orchestrated and (new) expertise comes to the fore as relevant. Ultimately, this approach can be useful to counterbalance the side effects of following the 'blindness' of specific infrastructural allies.

Following controversies is a powerful tool because it invites the researcher to see that the controversies are often due to contrasting and non-overlapping temporal perspectives. Managing contrasting temporal flows requires collaborative and distributed endeavors of infrastructuring (Jackson et al. 2011) and thus should be recognized as an active organizing principle in networked systems (Dalsgaard and Nielsen 2013; Venters et al. 2014; Steinhardt and Jackson 2015). The different interpretations of Bertil's digital voice through the chromatograms (Section 4.3) illustrate that the models on the Venus web portal such as the chromatogram—although real-*time*, are intended to represent at least four perspectives: environmental cycles spanning decades and centuries; Bertil and the other fish, migrating cyclically back and forth along the Norwegian coast to spawn around the Lofoten archipelago every March and April; NorthOil and its partners' framing of temporal windows to match their operational phases; and the fishermen's short-term goal of identifying fish to catch during the day. In terms of what I could see during my ethnographic inquiry, the adoption of the chromatograms in the Venus web portal revolved nevertheless around the way these dynamic graphs were displayed on the screen. This framing was thus telling of the fact

that my informants were not explicitly aware of the mismatches between their temporal concerns. Accordingly, I did not realize until later that the underlying controversy was temporal, rather than merely representational. Useful tools for me to gradually make sense of the field's temporal fluctuations were traditional or mundane data sources, such as documents and information systems. Often, no extra access is required for researchers to probe these sources. These items bring together the imbrication of the different narratives of different actors, an amalgam of not only corporate and national agendas but also different scientific disciplines and roles in the corporate hierarchy. The same applies to information systems in the field: The web portal and the software used and developed by NorthOil and its partners put together two apparently incompatible worlds within a corporate world: environmental science, following the cycles of the environment over years or centuries, and industrial interests (including the fisheries), dependent on short-term decision gates and regular quality assessment. Specific to NorthOil's dynamics, as I have shown elsewhere, the evolving narratives of different disciplines, such as the environmental coordinators and the drilling engineers, were brought together (Parmiggiani and Monteiro 2016). Although these differences were never really resolved (the chromatograms were never changed), they served the purpose of highlighting the importance of gathering knowledge of acoustic signal interpretation and marked the importance of eliciting the fishermen's expertise (Ibid.) toward answering the government's requirements to operate in environmentally sensitive areas. This perspective resonates with Steinhardt and Jackson's (2015) concept of anticipation work, which addresses how the controversies associated with CSCW work are handled by building bridges between the temporal frames of daily practice and institutional perspectives, and particular agendas and policy-related issues.

In summary, what follows from the analysis of the combination of my scaling strategies is that the politics of infrastructuring work and that of its study are closely related, if else because infrastructuring work is simultaneously the researcher's and the actors' space of inquiry and concern. As recognized by the literature in anthropology that I draw upon, the ethnographer herself is acting politically because she has to constantly balance concerns and draw boundaries. The ethnographic account is a political story, because it involves active choices about her identity, what should be included, and what should be left out. For example, my decision to follow specific actors legitimizes their role in my account (cf. Bjørn and Boulus-Rødje 2015). In accounting for these choices, I aim to be honest about moments of failure or workarounds. An example was my inability to visit O&GSolutions. I cannot speculate what my account of Bertil's story would have been like if I had had access to O&GSolutions. However, a lack of physical or virtual access to a site or an actor might imply overlooking other perspectives and important instances of infrastructuring work (Pollock and Williams 2009). Seeking access to MAS as a comparable (although smaller) vendor of subsea technologies was a workaround aimed to map the stakeholders involved in the design process. However, because MAS was collaborating with NorthOil only on the Venus project (where Bertil first

popped up) and not on EnviroTime project (in which O&GSolutions was involved instead), I would have probably not have had access to Bertil in the first place if I had accessed O&GSolutions instead of MAS. Ultimately, my account obscures the work done by O&GSolutions and brings that of MAS to the forefront.[7] This legitimizing or obscuring role of the ethnographer invites a further reflection on the way the collection of mundane ethnographic data sources such as interviews actively constitutes the researcher's field. These sources actively shape the researcher's access to the site and can be used to probe complex social situations (Alvesson 2003). The researcher's role is often, even if implicitly, recognized as political by the subjects (e.g., during an interview), who might prevent or allow access to specific information based on how they perceive her mediating role between different actors, such as competing organizations. In my case, I became aware of this as I was being recognized as a 'NorthOil employee' (Section 4.3), something that was useful inside NorthOil but a potential showstopper outside. Having a seemingly more neutral role, instead, helped me use interviews and interview scheduling to map the distributed actors involved in NorthOil's projects (Section 4.4).

5.1. The heritage of participatory design for the study of the politics of infrastructuring

Reflecting on the way the politics of the design process emerges resonates with the discourse in Participatory Design (PD). The PD research agenda is set on problematizing the status quo of sociotechnical systems at the political level, for example, toward promoting inclusion and democratization. PD scholars are currently applying the infrastructuring lens to inform design (Neumann and Star 1996; Björgvinsson et al. 2010; Le Dantec and DiSalvo 2013; Karasti 2014). For CSCW researchers, this perspective has the potential to reveal pathways for uncovering and questioning power structures hidden in the spatial distribution and temporal evolution of infrastructural relationships. A PD-inspired perspective invites the ethnographer to follow the trajectories and influences of various stakeholders in matters of concern (Le Dantec and DiSalvo 2013); that is, collaborative design often unfolds through evolving alignments of stakeholders around pragmatic means for design, rather than shared understanding of common goals (Garud et al. 2008; cf. Barry 2013). These imaginaries and commitments might often be observable in temporary venues, such as conferences and special interest groups that serve as theaters to manage and modulate consensus (Pollock and Williams 2015). For example, the workshop to introduce the Venus web portal (Section 4.3) showed that NorthOil, the Marine Institute, and the fishermen managed to cooperate successfully in the Venus project because they centered the design process on the pragmatic need for shared methods for real-time environmental monitoring, rather than on the goal of allowing oil and gas operations in the Venus area (Sections 4.3 and 4.4; see also Parmiggiani and Monteiro 2016).

Looking at design as constant political work sensitizes the ethnographer to questioning and tracing how 'facts' (ranging from Bertil's appearances to risk

assessment calculations) are constructed in design, at the crossroads of technological, organizational, social, political, and epistemological concerns (Bowker and Star 1999; Edwards 2010). My core tool to make sense of this entanglement in EnviroTime and Venus was to trace the controversies (cf. Pinch and Bijker 1984), although I would not have had access to any controversies without the preliminary ground work to follow the actors and the pragmatic entry points. That was the case during the discussions and contrasting interpretations about the presentation of the Venus web portal to the fishermen (Section 4.3). Even if mismatched opinions about that event were reported, I did not focus on finding a truthful sequence of events. Instead, I focused on the paths that led to those interpretations, which came from actors with different organizational backgrounds (a popular newspaper, an oil operator, and a marine technology vendor), different disciplines (popular news reporting, IT, and marine acoustics), and different ends (attracting readers, improving the development of the web portal, and promoting the use of acoustic equipment). In this way, the more I inquired into the event with the fishermen, the more I got access to further information, interpretations, and relationships of which I was unaware. Asking questions about that event was the trigger for the interviews I conducted with MAS employees (Section 4.4), which enabled me, almost by chance, to also visit the Marine Institute and gather a better understanding of their political goals and roles in the Venus project: The Marine Institute promotes the project to demonstrate that operations should not be permitted in the Venus area. By following mundane data sources, such as official documentation by the Norwegian authorities, I then traced the reasons for this surprisingly successful collaboration in the need to fill the gap in knowledge about the Arctic marine ecosystems, which are becoming very relevant for several industrial stakeholders, due to the possibility of finding oil and natural gas there. Triggered by new norms and technical strategies, many of these stakeholders are rushing to become pivotal technological and epistemological players in such a politically relevant area as the Arctic.

Tracing the construction of the ethnographic field as a political arena with a PD-inspired sensitivity has three analytical implications. First, it might allow researchers to investigate how design can empower (or silence) specific categories of stakeholders, even non-human ones, over time. In the story I told in this paper, NorthOil and their partners gave a prominent role to a fish, Bertil, and to the cold-water corals and other non-human elements that have been at the center of almost all conversations, interviews, and documentation. This is certainly the case for reasons of publicity. These creatures perform very well in front of a camera and therefore might attract the attention of external stakeholders, from the fishermen communities interested in fishing Bertil's lookalikes to the general public interested in the destiny of the coral reefs (cf. Bowker 2000). However, I do not assume that Bertil can speak for himself (Latour 1999). In practice, the infrastructuring process decides what sort of 'voice' Bertil might have in his digital form and includes him for consideration in the oil and gas business (cf. Jackson et al. 2011). The infrastructuring process, in other words, includes specific material actors and gives them a specific 'voice' and in so doing excludes many other inhabitants

of the marine ecosystem. Methodologically, we can follow the sociotechnical configurations that sustain Bertil and his fellow fish (either via the scaling mechanisms that I applied or others) to trace how the elements that are physically absent during the design process (e.g., Bertil or the coral reef) are made present through the enrollment of stakeholders' interests (the fishermen and the subsea technology vendors) and the use of technologies to measure and interpret them (acoustic sensors).

The second consequence of embracing a PD-inspired perspective on the study of infrastructuring as a political process is that the more the power structures are explored and problematized, the more the importance of mundane and taken-for-granted work is brought to the fore (Bowker and Star 1999; Graham and Thrift 2007; Jackson and Buyuktur 2014). From the point of view of the ethnographer of infrastructuring, this might become evident by taking the 'follow the actor' strategy to its (political) full potential. As we follow the actors in their daily, sometimes boring, and unremarkable whereabouts to deal with the size and duration of the infrastructure they are building, we are also acknowledging the importance of unrewarded daily maintenance work for design. An example is the work of contacting each department at NorthOil and setting up a meeting with its representatives as part of the data governance task (Section 4.2). Apparently a routine consisting of sending emails, making phone calls, and sitting in long meetings, it was an essential source for EnviroTime (and for me) to inquire into the status quo of a large organization and create a necessary space for the design of the real-time monitoring infrastructure. A similar example of the cardinal importance of mundane infrastructuring is Ribes and Polk's (2015) study of the 30-year work of collecting, curating, and analyzing specimens to understand the nature and genesis of AIDS. This work is vital to the ability today to fight HIV with a medicine cocktail and to the investigation of the behaviors associated with HIV transmission and co-morbidity.

Finally, an implication of bringing the mundane work of infrastructuring to the forefront while studying collaborative design is that we might discover that technology does not always mean that human work disappears or that humans are deskilled. We might witness a reconfiguration of their tasks over time. Introducing a real-time and partly automated approach to environmental monitoring in oil and gas operations does not mean that the environmental coordinators are no longer useful. On the contrary, it means that their role is shifting to a more visible decision-making one, sometimes clashing with the status of the drilling engineers. In terms of researching this apparently large-scale issue, I became aware of it by being left alone at my desk looking at a web portal under development. There is a whole political world behind something as seemingly simple as a web portal.

6. Conclusions

Bertil is but the result of an infrastructuring process. How can the ethnographer craft a research field to study the collaborative design efforts that sustain him, when infrastructuring highlights the unbounded nature of collaborative design? Thus, I

proposed to reflexively target this problem by adopting a self-revealing and self-reflexive approach, with the goal of discussing the strategies that I deployed to discover and make sense of the politics underlying the design of an infrastructure for environmental monitoring. In following the connections between my ethnographic method and the design methods that I observed, I presented how, behind Bertil, hides an unbounded infrastructuring process whose scales the researcher should discover by adopting pragmatic mechanisms. In my ethnographic study, I uncovered Bertil's scaffolds by following people, events, and things: pragmatic entry points to the case study, actors serving as my allies to access further data, controversies around design issues, and apparently mundane data sources, such as interviews and software tools.

However, it is impossible to draw universal strategies that hold for every case at hand, due, empirically, to the high degree of uncertainty or incompleteness that characterizes infrastructures-in-the-making (Garud et al. 2008) and epistemologically, to the complex interplay among theoretical commitments, ethnographer and setting relationships, and philosophical paradigms that generate ethnography (Klein and Myers 1999; Dourish 2006; Beaulieu et al. 2007). Being explicit about the way this latter factor has played out in my case has hopefully served to propose a means to investigate something that transcends the here and now. My strategies have been an analytical tool for understanding how the scales of design are constantly re-worked by the designers in the field and by the ethnographer through a continuous political process, in which a voice is given to specific categories of human and non-human stakeholders. To conclude, my strategies relied on the way the designers I observed were navigating their own infrastructure-in-the-making. In so doing, I acknowledged that infrastructures are necessarily constituted by the apparently unremarkable work conducted by designers to cope with the infrastructures as part of their daily job.

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Notes

1. All real names used in this paper were anonymized.
2. As recognized within the tradition in anthropology, the term 'reflexive' refers to the relationship between the researcher, the surrounding context, and the

research process, and underlines that the researcher is part of the world that she is studying; attention should be paid to the way different social, political, and theoretical aspects 'are woven together in the process of knowledge development, during which empirical material is constructed, interpreted and written.' (Alvesson and Sköldberg 2000, p. 9)

3. I call these ethnographic mechanisms "scaling" to draw attention on how the (solitary) researcher enacts the field across different dimensions at once and discovers new phenomena – inspired by the work of David Ribes (2014). Other scholars have discussed this activity along a similar vein as, for example, 'constructing the field' (Karasti and Blomberg forthcoming).
4. I am grateful to one of my anonymous reviewers for his/her precious clarifications on the origins and role of ethnography in anthropology.
5. This point is related to the concept of paraethnography, recognizing that 'our subjects are themselves engaged in intellectual labors that resemble approximately or are entirely indistinguishable from our own methodological practices.' (Holmes and Marcus 2008)
6. My use of the term 'controversy' in this paper is inspired by the social construction of technology (SCOT) model (Pinch and Bijker 1984), recognizing that scientific facts and technologies are always socially constructed. The SCOT approach, in short, reconstructs the development of scientific facts and technologies by following the controversies, namely the alternative interpretations, the underlying agendas, and the problems and conflicts among different groups of stakeholders that these interpretations generate. This approach is useful to draw the relations between groups, problems, and designs.
7. As recognized by the ethnographic tradition, lack of access per se (e.g., a male researcher not accessing women's activities in some societies) does not yield wrong accounts, but generates different accounts, and should thus be reflected upon explicitly. I thank one of my anonymous reviewers for this comment.

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