Conclusion

Figure 1: A shipwreck from 1895 resurfaced on the Waal in the autumn of 2018 during extremely low water, as seen from the Tigris. The skippers knew about the accident that brought it there: the dynamite it was carrying exploded, allegedly caused by a steam engine hatch that had been left open.

The Rhine is a European river, one through which European integration—institutionally the earliest—was achieved, a process described in chapter one. What Schillmeier and Pohler write about the Danube once also applied to the Rhine. They argue that it is studying "the flow of a European river like the Danube that re-imagines Europe and Europeanization as a 'fluid space' (Baumann, 2000) enacting multiple, heterogeneous and highly disputed spaces of natures/cultures." (2010: 27) The confluence of nature and culture (cf. Latour 2007), is used by the authors because the "Danube never becomes socially relevant as an exclusive form of pure and unaffected 'nature', nor as a 'culture' solely produced by humans. Rather, it is always and at the same time a cultural and a natural object." (ibid.) For them, "new social, cultural,

political or economic relations occur that reach far beyond national configurations" (25).

Though they argue that a shift should take place from studying Europeanization on the level of "symbolic (b)orderings," (26) they do not propose a viable alternative level of study, a more concrete and empirical entry. This is where infrastructuring research comes in, offering a way beyond the physical structures that facilitate critical action (mobility, communication, commerce, etc.) to the everyday reproduction of infrastructures. In this book I show how, on the river, this reproduction of shipping lanes, of the exchange of up-to-date hydrological and geographical information, and ultimately of safety and mobility, takes place through shipping itself. If, compared to the Danube, the transformation of the Rhine seems to be a thing of the past, its current state requires a massive stabilisation effort on the part of all actors involved. Despite these efforts, it has become clear that with climate change as the ultimate unruly nature/culture, the stability was relatively short-lived.

Ships, guided by control rooms, are shaping the riverbed with their propellers, and they are constantly gathering and exchanging critical information. Therefore, the critical places to study the Rhine are the wheelhouse and the control room. Like the control room, the wheelhouse is a highly mediatised working environment. As a result, Rhine skippers have become less reliant on crew members to provide information from other parts of the ship (engine room, hold, bow) during navigation, resulting in a reduction in crew size. I have shown that the key to unlocking mediatised interaction in the wheelhouse is to study mobile and mobilising technologies as embodied practices. As such, they are a matter for media studies.

In this conclusion, I look back at 1) the presumed invisibility of the field, which is an important but sometimes misunderstood issue in infrastructure studies; 2) also list key contributions to various fields, including my own; and 3) review the practice theory insights I have produced, before looking forward 4) and outlining what a practice theory of navigation might look like.

1. Presumed invisibility

This book is an attempt to be methodologically versatile: it opens up, both diachronically and synchronically, a world of crucial importance that has long been overlooked, a world that is responsible for a large part of the transport of goods and raw materials between Germany—a major industrial producer and consumer market—and the Rhine, Maas and Scheldt delta, at the end of which lie the ports of Rotterdam and Antwerp, the main logistical hubs of the European market.

Much has been written about these rivers, but as far as I know, no one has delved into the daily lives of those on board, or into the places where waterborne traffic is coordinated, ships registered and supported. These control rooms often occupy a

prominent place in the landscape. So neither shipping nor infrastructure is invisible, but rather unnoticed, perhaps hidden in plain sight. Susan Leigh Star (1999) famously wrote that infrastructure becomes visible when it breaks down, and for the control room in Dordrecht, this was the case for me when I watched the public broadcast in 2015 in which the operators sounded the alarm: the control room was understaffed and underfunded. But for the local public in the Dordrecht region, the control room was never invisible. The control room is what Devil's Island is known for, Rijkswaterstaat made sure of that. But it was also these local people who demanded that Rijkswaterstaat take over the control of traffic on the waterways in the first place, as I described in chapter one.

What remains invisible to the naked eye, however, is the infrastructure as a whole. The challenge of scaling is central to *Paris: Invisible City* (2006), in scope an exceptionally ambitious book by Bruno Latour and photographer Emilie Hermant. They argue that the city is only visible in "small wholes" (45). One example is the control room for traffic and public safety in Paris, with its hundreds of CCTV cameras across the city and the Paris ring road, with its huge map of traffic flows controlled by automated traffic lights. They visited this control room and spoke to the senior police officer in charge, called Mr. Henry. It is not about the panopticon, they write: "Far from wanting to know everything [Mr. Henry] would like the millions of Parisians to stay as they are, composed of individuals that he never has to know personally." (56–57)

It sounds as if Latour and Hermant were given a tour. This is routine practice in most control rooms, many have deliberately built in the possibility, as we have seen, and the tours are (increasingly) not given by the operators themselves but by a designated member of the infrastructure organisation. From those who have stayed longer and actually done fieldwork in control rooms, we know that operators are preoccupied with ongoing sequences of events, often detailed and very local. Latour and Hermant never captured these daily routines, and as a result disruptions, congestion and malfunctions are absent.

But through text and photo collages of many small wholes, and by tracing the circulation of things, data, goods and people, they came very close to making Paris visible. In the sum of all their visits, wanderings and tracings, a comprehensive image of the city begins to emerge. This is in contrast to workplace studies of control rooms, which tend to stay inside and do not claim to capture the larger infrastructure. Like the operators, they are only interested in the next event to be dealt with.

This book does both, which is rare: it captures the work—the routine, the volatility—and ultimately paints a picture of contemporary North West European inland navigation. If the whole of Paris emerges when you digest the mosaic composed by Latour and Hermant and, as they put it, "refrain from looking outwards" (2006:11) and abandon the panoramas, then inland navigation, too, only becomes visible as a whole in these pages, a small whole itself. The nautical media that allow constant

scaling are crucial. I show that skippers-turned-operators are not looking for a panorama when they look out, but are trying to understand minute variables at a glance, provided by their skilled vision, in relation to what cargo databases, nautical charts overlaid with radar and AIS, and the chatter on the VHF frequency tell them.

2. Transdisciplinary

First of all, this study enriches media studies with perspectives from anthropology, workplace studies, sociology and mobility studies and adds to series of studies (cf. Passmann 2018; Ramella 2021; Willkomm 2022) that show what media studies can look like after the practice turn (cf. Schatzki and Knorr-Cetina 2000). German media studies already knew that there are many crucial media technologies beyond consumer culture. I explore the nautical media that are an integral part of everyday life, of work, of mobility, and I show that they need to be studied in situ and in motion. Before asking what media mean, one should ask what they do and what is done with them.

This study also contributes to the disciplines mentioned above, and in this sense it is transdisciplinary. In the case of sociology, I show in chapter two how rivalries between professions materialise. Existing relationships are consolidated in specially developed media (the traffic simulator) and change is provoked by the dissemination of a previously exclusive perspective (the subsidised introduction of AIS). Moreover, in the age of social media, the communication of the authority of the control room to the local public no longer takes place without the participation of the operators: public relations departments now deploy them for this task. As for anthropology, while a prominent perspective in several chapters, the fourth chapter explores the practices of gatekeeping as a socio-material practice, and the fifth chapter shows media as both cause, counter-strategy and coping mechanism of isolated life in the depopulated wheelhouse.

Building on workplace studies, nautical control rooms and shipping are brought into the same picture. I show that the coordination of traffic is an ongoing accomplishment by operators and skippers. By drawing on mobility studies, movement can be taken into account, although even in mobility studies the view from the water has been largely absent. By including more and more positions, both static and mobile—together involved in the work of mobilising and immobilising just in time—scaling became possible for me too.

I have adapted the Latourian adage of following-the-actors and tweaked it into following-the-action, seeking what binds different actors together. Scaling here is not a matter of zooming out, but of the sum of the intertwined action being observed. I argue that in order to understand such intensely networked work, it is not enough to stand still and trace the minute and critical interactions that actors have

with the outside world and with each other. It is necessary to include this outside world. This is why workplaces studies, plural, makes more sense, we do not call it medium studies either: this is not just because the variety of media out there, but because of the way in which media are so often intertwined in sociomaterial assemblages, even more so in the digital age. The same is true of our workplaces.

For all their attention to detail, workplace studies of control rooms tend to portray them as rather sterile. Not only do they often reinforce the isolation of the control room, they also contribute to the largely immaculate reputation of control rooms. Contingencies are just challenges, eventually solved and the outside world—the organisation, particularly neoliberal managerialism—hardly ever spills over. It is telling that, despite decades of studies of air traffic control, the tensions between air traffic control operators and management that persistently seep into the popular press have hardly been covered by workplace studies. We had to wait several decades for an in-depth study of the labour dispute between air traffic control operators and the Federal Aviation Administration that raged in the 1970s and 1980s and led to the firing of 11,000 operators by the Reagan administration in 1981 (cf. Nordlund 1998). It seems no coincidence that it was ultimately Diane Vaughan, an organisational sociologist working in historical anthropology, who produced a monograph on the relationship between current practices and the labour history of US air traffic control. Ironically, workplace studies has a blind spot for labour disputes.

3. Theoretical contributions

Before and during the research I had no a priori theoretical ambitions. The key here is the order of things: theory follows observation. The method, not the theory, provides the framework. I have been able to make valuable contributions to practice theory by integrating sources of very different epistemological quality. The key is to treat everything as a field in the anthropological sense.

Mediatisation is a key concept that I have tried to rewire into a much more focused, empirically grounded concept in chapter two. As it turned out, it runs through the field historically, linking past and present. In chapter five, the detailed study of the present led to the conceptual development of different orderings and the mapping of their interplay. This can help future research to better conceptualise mediated mobility. But it also enriches our understanding of the past.

By acknowledging, as Wietschorke put it, the "epistemologischen Verklammerung von Geschichte und Gegenwart" (2012), I could travel between the present and past. It was only as I was writing these final pages that it occurred to me that perhaps the intimate ordering, the families living on board and then settling ashore, was a market ordering after all. In chapter one I described an early manifestation

of a four-step pattern: 1) economic growth tempts 2) a boom in shipbuilding, then 3) economic recession leads to 4) overcapacity. This is what brought families on board in the first place, selling their home on land in the late 19th century. Then, post-1945, compulsory education was essentially a regulatory ordering and stood at the beginning of the end of family life on board, as kids left the ship for school. In this way, this study takes a much more analytical look at the longue durée of inland navigation and the efforts made since the nineteenth century through media from the shore to organise transport on a daily basis. The two key publications on river infrastructuring in recent decades in the Netherlands, by Halma (2004) and Filarski (2014), are brought together in a new way by integrating them into the field and locating them in a power dynamic: one officially sanctioned, the other largely ignored.

Similarly, it took me a while to realise that another kind of order was also being maintained. There are many examples in this book of attempts to reproduce a mono-ethnic, even white, male ordering. On the one hand this is a widespread phenomenon in western European societies, but on the other hand it is also linked to the specifics of inland navigation. Here, it was mainly men who stayed on board, and who were able to observe societies that were often beyond their reach and onto which norms could easily be projected. These types could be seen as bordering—as quoted above, Schillmeier and Pohler added a "b"—as they are about who is allowed in and who is to remain "not one of us"—something for which rivers themselves are also used (cf. Thomas 2021). The control room is involved in various bordering practices, some of them quite unsubtle and racist, such as the episode with Malik described in chapter three. More generally, every control room has a territory—even nautical control rooms follow the terrestrial logic (cf. Steinberg and Peters 2015; Peters and Steinberg 2019) of a state. The way in which the control room in Dordrecht inserted itself into a national narrative and showed itself to be part of a system capable of monitoring whether *Sinterklaas* has already arrived from Spain, as the story goes every year, can be placed in the same category of bordering, although not with the same malicious intent as some other bordering practices.

This study not only offers a new perspective on the past and the present. The notion of 'media of separation'—to focus on the control of distance through media—can serve as a frame of reference for the increasing reliance on media in mobility. Mediated separation will increasingly be a key phenomenon to understand for geographers, sociologists and media scholars alike. The automation of cars and ships relies heavily on sensors, for which the assemblage of navigation is being rearranged. Current practices of maintaining safety margins need to be translated. In the near future, these automated processes will be monitored by humans who will have to intervene at any time. Furthermore, automated, sensor-based mobility will coexist with less automated separation practices. Keeping separate what would otherwise collide is also a communicative process. Giving and taking space, assessing

margins, ensuring minimal separation will be a hybrid practice, where some assemblies will still be dominated by humans, while in others we will be out of the loop, probably also depending on labour costs relative to other operating costs (the former being marginal for the largest ocean-going vessels).

In the early days of workplace studies in the 1990s, Lucy Suchman managed to bring together the first wave of control room studies under the concept of 'centres of coordination'. Since then, the concept has lost much of its coherence. This book aims to contribute to the return of a comparative perspective on mobility-oriented control rooms. Conceptually, this is also done by introducing 'rule-based traffic' and 'schedule-based traffic' as the outer ends of a scale.

I show that while media are involved in massive changes, a media revolution is nowhere to be found: whether it is the history of mediated control and the early history of nautical control rooms in the first chapter, the mediatisation of work in the second, the efforts to establish an alternative regime of representation as analysed in the third and fourth chapters, or the media of separation critical to the multiple orders disentangled in the fifth chapter. Instead, the media assemblage of the control room is as much a way of coping with change, a means of catching up, and thus a by-product as it is an instigator of change.

Yates showed how this worked for the organisation of transport and large companies in the form of communication through control in the 19th and early 20th century in the USA, a study that has been modestly replicated in the Netherlands by Ketelaar (2006). Otherwise, however, it has hardly been studied historically and ethnographically in Europe. Furthermore, this book takes into account the fact that the control room is often presented as revolutionary in public, in a quest for organisational legitimacy. This has allowed me to argue that this has had serious implications for the workplace and the work itself, and increasingly so. Control room work and its discursive reputation have been discussed in separate debates at the expense of a broader understanding.

This points to a challenge for the practice turn in media studies: the danger of throwing the baby out with the bath water. My background is in the Utrecht tradition of media studies: where the emphasis at the time was on materiality and discourse, often in a comparative and historical perspective. In Siegen, where the Graduate School Locating Media has funded most of this research, the focus is on practices, building on work in Science and Technology Studies. In this book I have been able to show where practice and visibility meet as symbolic power—through design, through visitor regimes, through sanctioned Twitter work—and then turned to the sociological literature on professions and organisations to better understand the intersection of practice and representation. This book therefore presents an approach that bridges the study of the promise and politics of infrastructure (cf. Larkin 2013) and the study of its practices, an approach that is on the rise (cf. Anand, Gupta, and Appel 2018; Schabacher 2022).

The final theoretical contribution of this book is made in the following section. As 2025 marks the 30th anniversary of Hutchins' seminal Cognition in the Wild, it is time to revisit navigation.[1]

4. Revisiting Cognition in the Wild

By bringing together detailed accounts of navigation at sea, in deltas and on rivers, I aim to reassert how navigation can be theorised. Navigation is a practice. Edwin Hutchins' book has long been, to use a common term in practice theory, an "obligatory passage point" (Callon 1986: 204) for a project like mine, although in the final part of this conclusion I argue that perhaps it should no longer be. I argue this primarily through two ethnographies of navigation, Laura Bear's *Navigating Austerity* (2015) and Penny McCall Howard's *Environment, Labour and Capitalism at Sea* (2017), in relation to my own fieldwork.

In chapter five, I could formulate that inland navigation is the repetition of three steps in ever-changing conditions: 1) separating hull-water-riverbed, 2) determining the current position, and 3) linking the current position with the near-future position. A picture emerged of skippers deeply enmeshed in sociomaterial assemblages. How does my analysis of navigation on the waterways of north-west Europe relate to other practical theoretical descriptions of nautical navigation? Hutchins' book shows a detailed understanding of collective practices. It reached many scholars, not least through the then emerging field of workplace studies, many of whom had little interest in nautical practices. Many referenced the book, including Lucy Suchman's seminal text "Centres of Coordination" (1997), but even when they were interested in mobility, it tended to be rail, air and urban mobility (cf. Harper and Hughes 1992; Heath and Luff 1992; Gras et al. 1994; Sanne 1999). It could therefore happen that Hutchins' book was perceived from the outside as the classic book on the subject, even though many people read it for other reasons. Having been recommended to me so often, I was surprised that the book proved to be of so little use during my studies of nautical mobility. Until I read Laura Bear's *Navigating Austerity* (2015), I thought it was mainly my fault, hoping that if I returned to the book at a later stage in my research, it would make sense to me. Laura Bear spent years doing fieldwork on the Hooghly. The Hooghly is an Indian river on which most goods from eastern India and Nepal must travel to reach the ports of Singapore and Colombo and then the rest of the world. It is only in her fifth chapter that Bear turns to the

1 Parts of this section appeared in 2022 in *Navigationen* under the title: "Mediatisierte Wahrnehmung, infrastrukturiertes Wasser, situiertes Wissen: Entwurf einer Praxistheorie der nautischen Navigation."

actual navigation, after taking the time to show how the political and economic history of the Hooghly has shaped the organisational and commercial dynamics that restrict, even threaten, navigation. Referring to Hutchins, she writes that "most forms of navigation cannot be understood by focusing solely on technical skill and utility" (131). Bear saves the actual point for a footnote, which I will quote in full:

> This makes Hutchins's analysis of navigation problematic: he focuses on a context for navigation that is purified of its usual contradictions—that is, the making of profit and manipulation of technical objects and data in relation to a recalcitrant world. It is only because he chooses such a context that his discussion of navigation can remain one about cognitive practices and devices. His contexts helps to produce his theory that ultimately technologies, including that of navigation, are simply part of a project of cognition, a human will to know certain things and achieve certain crystallizations of practical knowledge about the world. (216)

There is a lot going on here. A necessary first step is to look at the context that Hutchins has chosen by zooming in on the cues as to what happened to the 'usual contradictions' in Hutchins' field.

The US Navy was Hutchins' employer at the time, and as such most of the legitimising work to gain access had already been done. In this way, he overcame a triple challenge. Firstly, it is difficult to gain access to a workplace where the ongoing safety of many people is at stake. For the bridge of a seagoing vessel, more so than a control room; as we saw in chapter three, visits are built into its design. Secondly, the very mobility of a ship presents a challenge to the researcher wishing to conduct fieldwork on board, as it is difficult to leave the field once on board. Therefore, access must be granted for the duration of a voyage, or at least for a whole stage. In the case of shipping, this would mean living on board, using scarce resources, and being integrated into a closed community. Third, it is almost impossible for anthropologists to study military activity independently. Hutchins spent a total of 11 days on board over a period of 4 months (cf. 22). This does not seem much, as he admits (ibid.), but it is probably more than anyone else has ever got and can already produce a wealth of data. This is compounded by a common practice in workplace studies: making video recordings to be transcribed and studied in detail later.

One of Hutchins' recordings captures two crew members discussing Hutchins' presence on board. It is to Hutchins' credit that he included such a passage. The senior crew member said

> He's studying navigation on big ships. He's the guy, he makes computer programs for teaching stuff. Like they got a big computer program thing they use in ASW school to teach maneuvering boards. It's all computerized. He is the one that makes it. He is the one who makes things like that. He's a psychologist and an-

> thropologist. Works for the navy. He's a PhD. Makes all kinds of strange things. (23)

Apparently, the legitimacy of Hutchins's research lay in its perceived applied nature, in the fact that it tangibly changed conditions in the world of the people it observed. It is likely that such accounts of research follow the author's efforts to explain what the purpose of the research was. However, it is not mentioned how this was done, although in such a strictly hierarchical structure there may be fewer questions asked: Hutchins recorded more than one instance of crew members discussing the reasons for his presence, and in each case a senior officer explaining it to a subordinate. Hutchins in fact made explicit use of the hierarchical structure to fit in, and many of the crew members he interacted with "were also aware that I had lunched at least once in the captain's quarters, an honor reserved for visiting VIPs." (22) How this related to his ambition to be a "colleague and friend" (ibid.), while in the pilothouse "I tried not to participate, but only to observe" (25), remains unclear. So there is a context that has been left out, ignored. Moreover, he goes on to write that "[m]any aspects of the military culture go unreported here because I am not confident about their organization and meaning on the basis of such a short exposure." (25) So not only was the field that Hutchins chose "purified of contradictions" by the military organisation itself, as Bear wrote (as quoted above), but Hutchins himself deliberately chose to leave out quite a bit of context.

It is also because of the above that a 'purified' account of navigation could emerge. What could be seen as a detour in this respect—the kind of research (see chapters one to three) one does when one's presence is suspected and/or restricted—often becomes the basis for a new and provocative understanding of the field. Ultimately, Bear joins pilots on board seagoing vessels, but everything—the shape of the waterway, the pattern of traffic, the pressure on the pilots—only makes sense because she was 'parked' in an archive of the local maritime authority, which was thought to contain utterly meaningless documents, but which contained vital information. Like Hutchins, the mainstream publications on workplace studies begin with full access, drawing on ethnographic methods but largely concealing socialisation in the field and failing to adopt the reflexivity of the anthropological tradition. In this sense, it is not surprising that workplace studies as an academic field hardly covers (the everyday politics of) working conditions. An academic in a field called human factors, who specialises in maritime shipping and land-based traffic coordination, told me that he left out of his publications his only fieldwork on board a seagoing vessel because the data were "too messy", contaminated by complicated and "disturbing" social dynamics on board (Interview 17.7.18).

For Bear, the usual contradictions are rooted in "the making of profit and manipulation of technical objects and data in relation to a recalcitrant world." (216) Of course, the U.S. Navy is deeply embedded in global capitalism through the state that

funds it and whose (commercial) interests it protects, but perhaps this does not drive most decisions about navigating a ship as it does elsewhere. In Bear's work on the Hooghly, as in my own presented in this book, the drive to reduce costs and increase speed tends to trump everything else. In this quest, as I shall explain below, the shore plays a crucial role.

Every field its own question?

"Where am I?" should be the central question of navigation (Hutchins 1995: 12). Bear argues that there are actually two questions in navigation. The first is still Hutchins' question, but the second is "How can I make a profit in shortest amount of time?" (131). I have described how, in the case of inland navigation in Western Europe, the first question is a relatively casual one because of the familiarity with the confined riverine waterscape compared to the open sea.

In my field there is a question in between: where are the other ships? There are two ways of answering this question: the first relates to the continuous linkage between current position and near-future position, and is focused on avoiding collisions, a process I have described in detail in chapter five. The second way in which skippers answer this question is by locating their active competitors on the waterway, which is tied to the profit-making question Bear emphasises. This is illustrated by the episode discussed in section five of chapter five. There, a story told by the skipper and owner of the container ship *Sunrise* highlighted the pressure to know where others are whilst they know where you are (Field note 30.3.17). It showed that navigation is a mutually constitutive practice, both in direct passages and in decisions about speed or rest.

Penny McCall Howard has written an ethnography of navigation called *Environment, labour and capitalism at sea* (2017). She does not cite Bear, which is indicative of the fact that there is no scholarly debate about what navigation looks like in practice, apart from Micronesian navigation, which has received plenty of attention. There is no debate about Western navigation, writes McCall Howard (cf. 121–2), simply because it has hardly been studied ethnographically.

McCall Howard describes the practices of Scottish fishermen, into which she immersed herself completely. Even more so than Bear, she argues against Hutchins, as his "generalisations about Western navigation practices are like observing the walking practices of a US Army drill squad and using them to generalise about Western walking practices." (122) Interestingly, she found a snippet of organisational context in Hutchins' book that might explain the practices he observed differently. Hutchins quotes a navigator who says "You can go into San Diego by eye. But legally, you can't." (Hutchins quoted in McCall Howard 123) Thus she concludes that "[t]he elaborate navigation procedures Hutchins describes may be a greater reflection of the pro-

cesses of accountability within the US Navy and between the US Navy and American society as a whole, than they are about finding position at sea." (123)

She suggests rephrasing Hutchins' central question as 'where is that?' because she "did not observe anyone using a chart or digital plotter to orient themselves in the traditional sense of having to discover their position" (124). Like on the ships I joined, when McCall Howard saw a crew member emerge from below, they could often tell where they were. When sailing closer to the coast and around islands, there are often visual markers. McCall Howard makes it a relative question, which is a similar but more radical step than I have taken with my 'where are the others' question, in that it replaces Hutchins' question altogether. Her question is not only spatial but also temporal. The fishermen have invested in GPS chart plotters that show not only their current position but also their past course. One of her best examples is when she tries to tell another captain by radio frequency where they caught so much shrimp while she was at the helm. 'Where is that?' is about much more than GPS position, because the vessel is in one place, but the nets are somewhere else. Depth finders are just as important. In this case they are integrated in an assemblage not primarily aiming for minimum separation, as with Western European inland navigation, but seeking connection with the ground whenever the characteristics of the seabed afford this, though trawling is also done midwater.

Looking at McCall Howard's study—together with Bear's, one of the most important ethnographies of navigation to date—it is clear that navigation is a situated practice where the many local variables make it difficult to generalise. Navigation is a situated practice, and what needs to be situated is different. Pilots on the Hooghly navigate spatiotemporal tidal restrictions and the interplay of erosion and sedimentation in relation to the clearance under the keel. Inland waterway skippers navigate heavy traffic while trying to find just enough draft at lower water levels. In the case of fish and crustaceans, the constant and often complex problem is not to locate oneself, but to locate something else in relation to one's own position. Although there is a great deal of overlap in the critical variables that those at the helm have to take into account, they are prioritised differently in different fields.

Embodied navigation of risk

Here, I would like to highlight an element that persists in all of the fieldwork discussed above, and has also been identified in other relevant studies (cf. Pálsson 1994; Carse 2020): embodiment. In terms of skills, these are difficult to reduce to the level of the individual, as they are learned in communities of practice, and are often embedded in collectively performed tasks that require close coordination, as Hutchins and many other workplace studies since the 1990s have shown. Ashley Carse (2020) describes how Panama Canal pilots struggle to get a 'feel' for the new generation of giant ships, three times the size they are used to. In fact, all these studies, includ-

ing my own, show that the mediatisation of the wheelhouse, the digitisation of instruments and the automation of the helm do not make intangible, embodied skills redundant. Rather elegantly, McCall Howard describes how actors in the field have developed "techniques to extend the body and its senses" (89). Here she shows how feeling underwater through the cables of the nets, to "feel the depth" (95), is integrated into a whole range of sensory techniques, including new technologies such as GPS chartplotters. The trick is integrating oneself into this assemblage, to learn "how to anticipate, understand, deflect and control the motions, tensions and forces involved in working at sea instead of simply being subjected to them," thought the risk of "over-extension" always remains (100, 97).

Although markets rely on them, the risks of embodied labour are not usually borne by large commercial entities. In practice, this is experienced on board, where market orderings lead to risky navigational orderings, or where market orderings trump regulatory orderings, leading to personal risk. In the Hutchins study, it was already clear that these legal and financial risks remain an issue when returning to shore. Navigating into the port of San Diego with instruments, documenting every detail, is not only an expression of responsibility, but also of risk, as the same navigator is quoted as saying: "Boy, you better have everything covered here, because they are going to try to hang the captain. They will try to hang him. Unless he can prove with data that everything he did was right" (Hutchins 1995: 38). What he 'did' here is what others did under his watch, with his approval.

In *Navigating Austerity*, risk-taking is not an individual choice, but the result of systemic neglect and deficit, making the river an "austerity timespace" (Bear 2015: 130). As a pilot devastated by an accident blamed on him puts it: "You are dealing with the consequences of things that are destined to happen already before you start to do things." (ibid.) As for skill, Bear found that it is culturally linked to risk, since institutionally the "invocation of skill, individuality and the excitement of danger" dominates, while practically it means "the ability of a pilot to overcome the omissions and contradictions created by predictive technologies and work practices that tie together the conflicting rhythms of trade and capital generation on a recalcitrant river" (135). When things go wrong, official investigations only "determine if the pilot was at fault" (136), which is the flip side of what river pilots have internalised as their "heroic, individual agency" (140).

McCall Howard also encounters fishermen who have embraced risk as an individual quality, a test of character rather than market logic (189–191). However much risk was encouraged, the rewards went mostly to the owners, who were often not crew members; overall, she concludes that "exploitation is embodied in the social structure of fishing" (167). In practice, it meant that "constant pressure and competition encouraged poor vessel maintenance, boats staying out in bad weather, crew pushing past the limits of fatigue" (190). As was the case on the rivers where I conducted my fieldwork, the extreme "working hours led to crew exhaustion and falling

asleep at the wheel", although for fishermen, accidents seemed more likely: "It was not uncommon for boats to crash headlong into completely familiar rocks, cliffs and islands" (ibid.). Importantly, "[t[hese wrecks had nothing to do with navigation problems or being 'lost' – these boats would have passed these hazards hundreds of times before and known exactly where they were." (ibid.)

Navigating is infrastructuring

On the water, much more than with terrestrial logistics, the basis for mobility and thus for profit is to account for the fluctuations — tides, sedimentation and erosion, currents, height of waves, weather — as many of these cannot be stabilised. The Rhine seems to be the exception here, but centuries of infrastructural efforts were not enough when skippers encountered the extreme low water of 2018. Other major waterways such as the Mississippi or the Panama Canal face similar water shortages. Knowledge of critical variations is the basis for risk assessment. It allows Rhine skippers to push the limits of how much cargo they can carry, even if it is more than legally defined as safe at that particular water level. On the Hooghly, the state's efforts to better account for fluctuations allowed the minimum clearance between ship and riverbed to be reduced. Here it was the state that redefined the minimum clearance to allow more ships to pass through during a particular tidal window.

Knowing the margins the critical fluctuations allow and exploiting them during navigation is a matter of nautical media. This knowledge is not only provided by external public institutes, but is increasingly produced on board and between ships, so that there is a constant exchange of what is measured and detected. There are many informal processes in which this is done, in oral exchanges, but is also done via AIS, as discussed above, and through distributing the measuring and measured depths along the commercial fleet, as the Dutch state agency Rijkswaterstaat has introduced on the Rhine. Ultimately, this points to a fundamental feature of mobility, perhaps in general, but at least in sea and river navigation, to an interdependent, mutually constitutive logic in which traffic and infrastructure are immanent practices. There is no traffic a skipper has to navigate, but the joint organisation of passings is what makes traffic, by distributing shared space skippers are traffic. This seems rather obvious, but it is also true for infrastructure. Skippers do not use nautical infrastructure as if it were something external to them, but they are constantly infrastructuring by navigating: they have more influence on the shape of the waterway through the patterns of erosion and sedimentation their propellers (and nets) create as a result of the course they choose (which is more detailed than the institutionally defined shipping lane) than dredgers can keep up with. If navigation is based on defining one's position in relation to something else (ships, competitors, submerged rocks, sandbanks, shore, quay, shoals, nets, authorities, currents, weather

tides, etc.), the difficulty is that very few of these are stable. Acting on these definitions sets everything in motion again—drifting, evading, redirecting.