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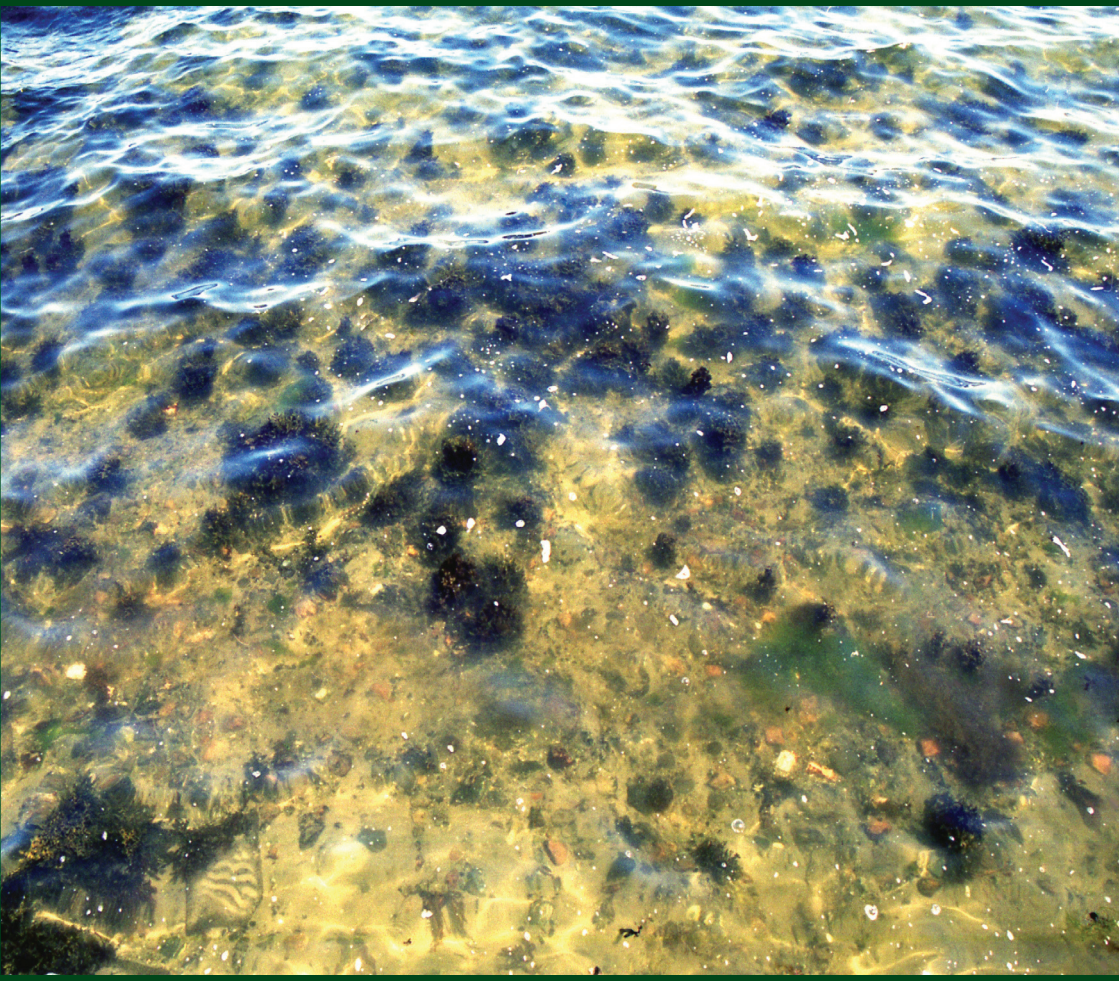
the gentle art of Coevolution



a complexity theory perspective on decision making over estuaries in germany, belgium and the netherlands

The Gentle Art of Coevolution

A complexity theory perspective on decision making over estuaries in Germany, Belgium and the Netherlands

De fijnzinnige kunst van co-evolutie

Een complexiteitstheoretisch perspectief op besluitvorming over estuaria in Duitsland, België en Nederland

Thesis

to obtain the degree of Doctor from
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and in accordance with the decision of the Doctorate Board

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In memory of Jenni

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"Now, watch me. I'll do the stupid thing first and then you shy people follow."
(Frank Zappa, You Can't Do That On Stage Anymore vol. 1)

Chapter 1: Introduction

1.1 A disappointingly large amount of mud

Seaports in Europe are constantly engaged in fierce competition over market share and one of the strategies utilised to survive this competition is to increase the capacity of the ports. Such a strategy can include the extension of quaysides, the building of new terminals and the construction of better road and railway connections between the port and the hinterland. The maritime connection between the port and the sea is another important factor that affects the ability of the port stay competitive. Since new ships are designed with larger drafts, port authorities are obliged to increase the dimensions of the navigation channel in order to allow the ships safe passage. After all, if ships do not fit into the channel, they can never reach the port.

Historically, the most obvious location for the development of a seaport has been at the mouth of a river. However, rivers tend to meander and seldom run in a straight line from the port to the sea. This obstructs efficient sailing to and from the port. In some instances, this problem has been solved by constructing a completely new channel, such as in the case of Rotterdam. However, in many other cases there is a large transition zone between the river and the sea, thus rendering the idea of building a new channel out of the question. Such transition zones are often marked by tidal changes and a dynamic morphology that compromises and complicates maritime access to the port. For instance, the capacity of the port of Le Havre at the mouth of the Seine could only be increased through the drainage of the surrounding wetlands and by channelling the course of the river. Such extensive and costly measures have been deemed necessary but while they promote the growth of the port, they also damage the natural environment. This, in itself, is very costly as the port authorities are obliged to compensate for the damage and regenerate nature areas (Boët, Belliard, Berrebi-dit-Thomas, & Tales, 1999; Mesnage, Bonneville, Laignel, Lefebvre, Dupont, & Mikes, 2002).

While such problems can be solved by investing considerable amounts of money, the main problem lies with the erratic dynamics of natural systems that marks the coastal zones and the mouths of the river within. These dynamics have such complex causations that a single type of operation, such as the channelling or deepening of the waterway, could lead to adverse effects that compromise

the reason d'être of that particular operation. The port authorities in Hamburg faced such a problem after they deepened the Unterelbe between Cuxhaven and Hamburg. Once the deepening operation was completed in 1999, the amount of sediments accumulating in the harbour basin doubled from 4.5 million cubic metres to 9.0 million cubic metres in the following years. This forced the port authorities to intensify their dredging efforts in order to keep the port at the desired depth. Perhaps a connection can be made between the decision to deepen and the sudden accumulation of sediments. Meanwhile, ships continue to wait to call on the port and the port authorities busy themselves by responding to this unfavourable physical change.

At first glance, one may wonder why no one could foresee this unfavourable effect and why the port authorities went ahead with the operation in the first place. However, this kind of thinking does not take into account the unpredictable nature of physical systems. Even the most elaborate studies and models are unable to capture this unpredictability to its full extent. This is problematic because uncertainty over future developments does not allow for the clarity that is required to make an informed decision. As stated by Otter in the context of coastal zones management: "a fully deterministic approach [as required in the political arena – LG] cannot handle the uncertainty related to the management of many environmental systems." (2000: 110). Taking this further, the actors themselves could be the cause of developments that turn out to be unfavourable for them.

The example of the sudden increase in the amount of suspended material in the port of Hamburg shows that such uncertainty continues to exist despite all good intentions to comprehend the physical dynamics of the river systems. It is important to understand the dynamics of physical systems, such as estuaries and tidal rivers, in relation to the actions from authorities rather than attempting to understand them as isolated phenomena. One must always bear in mind that the authorities do not make policy decisions on passive physical systems; such systems respond dynamically and unpredictably to policy decisions, which could yield unfavourable results. Such as a very large amount of mud in the middle of a port.

1.2 A systemic way of understanding and coevolution

The first step in understanding how seemingly sound decisions can lead to adverse effects on physical systems is to understand that decisions and the actors who make these decisions are an integral part of a chain of causes and consequences that drives physical change (Hooke, 1999; Turner, 2000). Knowledge of the way a physical system works and the interactions between the physical system, such as an estuary or tidal river, and the groups of people who make decisions is required. There is growing interest within the natural sciences in understanding physical changes in coastal zones as features of system dynamics rather than regarding these coastal changes in isolation from their environment (cf. Turner, Lorenzoni, Beaumont, Bateman, Langford, & McDonald, 1998). This kind of scientific approach could, in turn, shed more light on the uncertainties of decision making (Nicholls & Branson, 1998).

However, decision making is still generally regarded as a black box from the perspective of the natural sciences as little is known about the dynamics of (political) decision making and the impact of these dynamics on physical systems. On the other hand, while the dynamics of (political) decision making are the core subject areas in the domain of public administration, less is known from that perspective about the physical effects of decisions on the systems and how these effects in turn influence decision makers. In the field of public administration, it is the physical system that is the black box.

While there is clearly a need to understand the connections and dynamic interactions between physical systems and decision making in social systems, a thorough understanding of these relationships has hitherto been lacking (Folke, 2006; Kotchen & Young, 2007; O'Sullivan, Manson, Messina, & Crawford, 2006).

Some have attempted to understand these patterns through advanced modelling (cf. Otter, 2000; Wilson, 2006). These attempts are valuable in mapping the complexities of the patterns that emerge, but suffer from the consequences of the means. That means, no matter how good a model is, it remains a computational construction lacking in the inherent day-to-day dynamic practices of decision-makers.

Others have attempted to understand these patterns empirically at the macro level (cf. Krause & Glaser, 2003; Malanson, Zeng, & Walsh, 2006). While such an approach delivers pertinent information about macro patterns of societal change in interactions with physical systems, it is, again, not very functional in

explaining what happens at the actual concrete level of decision making when choices have to be made.

Thus, in order to achieve a systemic understanding of the interactions, it would be beneficial to pursue an empirical approach that takes the concrete level of decision making as its starting point. This book starts from the premise that a hierarchical and unilateral relationship in which policy-makers fully determine the changes in a physical system is an insufficient explanation for the dynamics between political decision making and physical systems. When a physical system on the one hand and policy-makers and policy processes on the other hand both evolve through mutual interaction (Hooke, 1999; Klein, Smit, Goosen, & Hulsbergen, 1998), this is a form of coevolution. Coevolution, its drivers and its consequences for decision making are the core themes of this book.

1.3 Estuaries and tidal rivers

The empirical focus of this book is on estuaries and tidal rivers that are subject to competing claims such as the development of a port, the regeneration of ecological areas or protection against floods. Estuaries are "[…] semi-enclosed coastal bodies in which tides propagate freely and in which freshwater drained from land mixes in a measurable way with the seawater" (Pritchard, 1959, in Peters, Meade, Parker, & Stevens, 2000: 5). Because of tidal workings and the constant influx of both fresh and salt water as well as sediments, the river bed or morphology of the estuary is often dynamic, with intermittent deep, shallow and intertidal areas. Sediments are eroded and disposed of in the estuary or tidal river and form shoals, sand bars and other types of intertidal areas. Sediments also have an effect on the geometry of the water body and the formation of floodplains. A complex pattern of relationships between water flow and transport of sediments exists (Bridge, 2005).

The cycle of generation, degeneration, regeneration and migration of intertidal areas, shoals and sand bars is of great importance to the ecology of estuaries and tidal rivers. These areas are the feeding grounds of many types of birds and provide areas where organisms can develop. For a number of animals and plants, these areas are the sole habitat available to them. In addition to the ecological dimension, a safety dimension must be considered. Estuaries and tidal rivers have the dissipative capacity to absorb extreme tidal changes because of their varied and dynamic morphology. They often act as safety valves against

storm surges.

As noted earlier, port authorities are constantly searching for ways to expand their ports and to create deeper, more efficient channels through estuaries or tidal rivers in ways that often clash with the ecological and safety concerns described above. Navigation requires a clear and fixed route, which is contrary to the dynamic riverbeds of these kinds of bodies of water. While these characteristics raise challenging dilemmas for policy-makers, they provide researchers investigating the coevolution of decision making and physical systems with interesting cases for study.

1.4 Outlook: research scope and questions

The goals of this research are two-fold: first, to analyse the complexity of coevolution between physical systems and policy systems and second, to identify which disposition of coevolution yields favourable effects for both systems. The main research question is as follows:

How can the management and development of physical systems be understood as coevolution between physical systems and policy systems, how do actors within these systems deal empirically with the dynamics of coevolution in their decision making processes and which kinds of interactions between physical and policy systems promote a type of coevolution that is considered favourable to both systems?

A number of steps must be taken in order to answer the main question. Firstly, it is important to take a theoretical step in order to transform the general idea of coevolution, which has appeared in many disciplines, into concepts that are operational for research. This research approaches coevolution from the perspective of complexity theory. Complexity theory allows for the development of a systemic view on the systems' development on the one hand, while integrating aspects of coevolution with aspects of decision making on the other. Coevolution is an element of process within the complexity theoretical framework and the result of various patterns that drive the mutual adjustment of systems and agents within systems. The first sub-question of this research topic is discussed in Chapters 2 and 3, and can be framed as follows:

What is complexity theory, what is coevolution, what are its main aspects and how is this approach positioned with respect to related (systemic) theories in general?

With complexity theory as the ontological point of departure, the next step is to deal with the issue of epistemology. Complexity science carries a positivist epistemology since it is rooted in natural science. Although positivism remains the common point of departure in the study of physical systems, it has, however, been criticised in the realm of the social sciences. An interpretative perspective fits better with the less-knowable social reality, where a stringent fact-value dichotomy no longer applies. Upon designing a set of indicators for the analysis of coevolution between a physical and policy system, it should be taken into account that these indicators are qualitative representations of coevolution. The second sub-question is addressed Chapters 2 and 3, and can be framed as follows:

What is the epistemological position that best fits the analysis of complex adaptive systems and the coevolution between these systems, how can coevolution be conceptualised in order to analyse empirical cases and how is such a conceptualisation related to the qualitative understanding of coevolution?

As discussed in the first two sections of this chapter, it is important to understand coevolution empirically and at the level of concrete, daily decision making. Two empirical case studies have therefore been conducted in order to fulfil this need. The first case study concerns the German Unterelbe estuary and tidal river running between the North Sea and Hamburg. The case study follows the decision making process in the period from 1996 to 2007, during which the port authorities attempted to deepen the Unterelbe. During this time, the authorities deepened the Unterelbe once and had to deal with the consequences of that deepening when planning for a new deepening operation. The second case is the Westerschelde estuary that is located between the North Sea on Dutch territory and the Belgian port of Antwerpen. This case study spans the period of time between 1993 and 2007 and follows the deepening operation of the Westerschelde and subsequent attempts to develop a different approach to the management and development of the estuary. Both cases are examples of estuaries that have been heavily modified to suit anthropomorphic needs (cf. Corlay, 1993) and as such, are very useful when studying the coevolution between a physical system and policy system. The case studies will assist in answering the

third sub-question, which can be framed as follows:

How do physical systems and policy systems coevolve in empirical cases, what regimes are deployed by the actors in the policy system in order to deal with this coevolution and what are the subsequent responses from the physical system?

Two chapters each are devoted to the case studies. The first chapter presents the case chronologically, discussing how it developed and how policy-makers and other actors experienced the situation. This allows for an understanding of the erratic nature of coevolution. The second chapter shows how and why the cases developed in terms of the conceptual model presented in Chapter 3. The Unterelbe case is covered in Chapters 4 and 5 while Chapters 6 and 7 chronicle the Westerschelde case.

A comparison of the findings from these two cases allows for greater depth and meaning. While a search for deterministic laws would be futile due to the complex causation in these cases, patterns can be found in the chain of actions and responses between the two systems. This is the subject of Chapter 8. On one side of the coin are the events in the physical system, the responses of the policy-makers and the subsequent responses from the physical system. This chain exists because of mutual interaction, out of which grows mutual influence. On the other side of the coin is the internal process of change, or lack thereof, in the way the policy-makers deal with the process of coevolution, i.e. how they give shape to their regime. For example, these actors must find a way to respond to the uncertainties they face or the difficulties of dealing with contradictory goals. Both types of processes, between systems and within the policy system, may develop certain patterns. When considered alongside the empirical observations regarding the favourable or unfavourable results stemming from the chain of responses, discernable patterns of coevolution can be observed. These patterns can be classified into different types of coevolution. The fourth sub-question addressed in Chapter 8 is as follows:

What characterises the coevolution between physical systems and systems of actors in both empirical cases, which patterns of responses are deemed favourable and which are not and what types of coevolution can be discerned?

This last sub-question completes the discussion. Although the research in this book is presented as a coherent narrative, this can be broken down into

three parts that are all essential for a complete understanding. The theoretical argument has been introduced in this chapter and will be further discussed in Chapters 2 and 3. The empirical cases and the analyses of these cases are presented in Chapters 4 to 7. The final portion of the research, in which the gentle art of coevolution is discussed, is presented in Chapters 8 and 9.

Chapter 2: Complexity Theory

2.1 A systemic approach

Chapter 1 established the fact that the development of estuaries and tidal rivers is more complex than it may seem at first glance. The physical system may respond to changes unpredictably and even have adverse effects, which is troublesome because the development and implementation of plans for a physical system requires stability. The first step in tackling this issue is to adopt a theoretical framework with which such an erratic relationship between the action and the unintended or adverse effect can be understood. Following up from the observations in Chapter 1, such a theoretical framework should take three things into account.

First, isolating the object of research from its environment decreases its explanatory power. Physical change is driven by many developments, which can include the decisions made by actors. Unintended changes may occur as a result of an incorrect decision but could also be caused by a physical development elsewhere or by a combination of these factors. The relationship between decisions, causes and effects is multi-faceted and therefore requires a systemic approach for analysis with the understanding that isolating the object of research from its context is unhelpful, as this context is necessary for a complete understanding of the complex relationship.

Secondly, such a systemic framework must take into account that there is mutual interaction between the diverse systems as well as between the diverse elements within the systems. The causal relationship between these components can be one-sided but is more often circular. With circular causation, the interaction between the physical system and the policy system is mutual, i.e. the physical system responds to the changes made by the policy-makers and in turn creates a situation to which the policy-makers are compelled to respond. Whether this response is deliberate and whether it results in adaptation is discussed later in this chapter.

Third, the complexity of causation does not stem only from the multiple causes and effects but also from erratic change. This means that the relationship between cause and effect could be altered through the occurrence of events or could lead to different developmental pathways if repeated elsewhere in

time and/or location. The outcome of an intended change may therefore be disproportional or adverse to the intent. This also holds true for unintended change or change that takes place outside the actors' influence. Although it is possible to understand complex non-linear change theoretically, in practice causality is probabilistic. Any change made to the physical system may or may not lead to the desired outcome and if repeated, could produce different results.

Therefore, there are three provisions for a starting point of a theoretical framework that is suitable for understanding the messy realities of managing and developing estuaries: it should be of a systemic disposition, it should regard relationships as mutual interactions and it should take into account that the nature of change may be erratic. By combining these provisions and adding the fact that systems and elements within systems can be of a diverse nature rather than homogeneous entities, all the basic components are now in place to build a theory on. These components describe the basics of complex adaptive systems (Flood & Jackson, 1991; Gell-Mann, 1995; Hartvigsen, Kinzig, & Peterson, 1998; Levin, 1998) and this is the point of departure for the theoretical framework developed in this chapter. Complex adaptive systems are at the core of the approach called complexity science or complexity theory.

This approach is introduced in the next section (Section 2.2.1) and further developed with regard to its elements of structure (Section 2.2.2), the issue of agency and boundary judgements (Section 2.2.3), its elements of process (Section 2.2.4) and the issue of simplistic and complex complexity (Section 2.2.5). The argument is then temporarily sidestepped to discuss complex causation and the ways to investigate it in Section 2.3 while Section 2.4 features a review of complexity theory with regard to theory development, theory transfer and the question of whether complexity theory can enhance ideas of social change. Chapter 3 then continues the argument by refining the concepts discussed in this chapter to a model of coevolutionary policy processes.

2.2.1 Introducing complexity theory

It is by no means a new idea that developments can be explained through a systemic approach. Ideas about the nature and workings of phenomena as systems date back to the 17th century (François, 1999). Since that time, multiple variants of systemic theories have been developed and many of these are still evolving. One

of these systemic approaches is complexity theory. The use of the term 'theory' is, in fact, a subject of debate as complexity theory draws upon many fields for its core concepts, including diverse theories such as evolutionary biology, game theory, cybernetics and catastrophe theory (Goldstein, 1999). Therefore, the term 'complexity science' has been proposed as a more appropriate term to use when discussing this group of theories. However, the term 'complexity theory' is used here in order to conform to the developed nomenclature.

Due to its varied background, complexity theory has not developed in a linear fashion; however, it is beyond the scope of this research to draw up a conclusive history of the emergence of this collection of theories. At the heart of these approaches is the fundamental understanding that simple systems, for example those consisting of a small number of elements or a limited set of behavioural rules, can lead to complex emergent structures and processes. The Newtonian worldview, which essentially assumes that the mechanisms behind developments are mechanical, i.e. that causality is fixed and that developments are stable, time-reversible and replicable, has long dominated science. Some developments, however, have been found to behave time-irreversibly, even if the origins of these developments were of a simplistic disposition (Prigogine & Stengers, 1984). Moreover, the simplistic nature of these origins does not explain the outcome. Thus, the Newtonian worldview can be replaced partly by a thermodynamic worldview which acknowledges that systems are interconnected and that the properties of systems' cannot always be traced back to the properties of their constituent elements (Byrne, 1998).

While these explanations for system developments appear throughout the literature on complexity, there seems to be less consensus on what complexity actually means (Rescher, 1998) and what it is that sets it apart from the predictability of mechanical order and the complete randomness of chaos. There are, as Byrne notes, several accounts in which some common aspects exist while other aspects are not shared. The fact that in common conversation, the words 'chaos' and 'complexity' are often used interchangeably and 'order' is seen as the opposite of these words does not help clarify these notions.

The adjective 'complex' is usually used when one encounters something that is difficult to comprehend, such as a ten-page application form for a dredging permit. However difficult it is to deal with such things, they represent order as their mutual relations are fixed and the outcomes are predictable. Such difficult but ordered things will be referred to as 'complicated' in this book. 'Chaos' is often mentioned in daily parlance if something is complicated and people do not

like it. Something is called 'chaotic' when the complicated thing is perceived as being negative, such as a major traffic jam downtown. However negative a traffic jam may be, 'chaos' itself does not have this negative connotation. As a scientific term, chaos is not the absence of order but rather, randomness as determined by its constituent components that are stable in terms of their composition and disposition (Gleick, 1987). The concept of chaos, however, will not resurface in the remainder of this book.

Complexity, then, is neither complicatedness nor chaos. Both order and chaos emerge from the same type of systems described above, i.e. systems that are of a stable nature. Complexity is sometimes defined as the boundary phase between order and chaos where stability and randomness are entangled in a tense state (Waldrop, 1992). However elegant this definition is, it is difficult to handle in empirical research as it requires one to be able to determine the state of systems as being orderly, chaotic or complex. This research departs from a more practical choice, namely that complexity is experienced by agents as the erratic properties described earlier, but it differs from chaotic systems in that complex systems are open instead of being limited by boundaries. Thus the composition and nature of the constituent parts are cellular and dynamic instead of being static. Rather than explaining erratic change as a result of enclosed systems, which is a simplistic premise, it is understood that such changes stem from systems that are themselves dynamic with regard to composition and disposition, thus closing the theoretical loop between erratic dynamics and complex adaptive systems described in the previous section.

Rescher (1998) argues that the notion of 'complexity' is itself complex as systems have multiple and often intersecting modes of complexity. A principal distinction can be drawn between epistemological, ontological and functional complexity, with each category having several subcategories of its own (Rescher, 1998). This categorisation helps to position investigations on complexity with regard to other investigations. The research in this book attempts to build the empirical cases from both epistemological and ontological complexity, i.e. it is argued that complexity theory requires complexity-informed investigation. This requires the structural use of the corresponding notions (Section 2.2) and a consequent approach towards research (Section 2.3).

Because of its diverse background, complexity theory consists of a myriad of notions, some of which have similar meanings under different headers. Moreover, much of the vocabulary of complexity theory is rooted in natural science which carries with it notions that have common ground in science

but have an exotic appearance in the social sciences. In order to structure this diversity into a coherent framework, a division is made into elements of structure and elements of process, with the latter describing the activities within structures without the condition that structures can exist without activities (Cilliers, 1998). A discussion of these two dimensions of complexity is the subject of the following sections.

2.2.2 Elements of structure

The previous section has shown that erratic dynamics and complex adaptive systems are closely linked concepts. The complex adaptive system lies at the heart of complexity. Gell-Mann takes the word complexity to mean the connections between the simple and the interlinked together, which implies that multiple connections that form a network are not separate from the notion of complexity (1995). In order to understand where non-linearity comes from, the basic features of such a network or complex adaptive system must be understood.

Theoretically speaking, a complex adaptive system is a system consisting of diverse components that are connected and interacting with each other (Marion, 1999). This diversity is in terms of form, capabilities and consequent behaviour (Holland, 1995). These diverse components influence one another through interactions and their diversity can elicit a large variety of responses. They are given different names in the literature on complexity theory depending on how they are operationalised for specific theoretical or empirical domains. For now, it is important to note that these components are assigned the capabilities to process information that enables them to be active in the network and thus to act as agents of information.

There is an obvious difference between human agency and physical agency; while the latter lacks the reflexive capacity to act strategically on information, the former can plan, forecast, anticipate and act deliberately. While this distinction is important for an analysis of complex dynamics, these differences do not render outdated the idea that agents of different dispositions are connected. This is a radical point of departure equal to the one assumed in actor-network theory, namely that humans are connected in heterogeneous networks of interactions in which all objects are indeed heterogeneous but not different to the degree that they should be treated as different categories. Networks or systems are interactions between components or agents and the meaning of

these components or agents stems from the interactions (cf. Latour, 2003; Law, 1996, 1997). This means that there is no hierarchy between physical systems and social systems. The (often assumed) anthropocentric and one-sided relationship between the two, which places policy-makers and engineers in control of the physical system, has to be abandoned for a multi-faceted pattern of interactions in which all agents are engaged in a complex pattern of actions and responses. More precisely, the physical system is as much an agent in a policy process as are the human agents, thus rendering the anthropocentric perspective obsolete.

In this new perspective, both horizontal and vertical connections between agents exist. The vertical connections stem from the idea that what constitutes a system at one level may constitute an agent in a larger system, hence the concept of meta-agents that are aggregations of the behaviour of individual agents to the nature of the system (Holland, 1995) or the concept of nested systems, the more commonly used term in the vocabulary of complexity theory. While infinite connections can theoretically be made, in practise there is a limit to the number of connections that can be maintained by the agents. According to Kauffmann, each set of agents interacts with a subset of the total number of other sets of agents. This makes up the network-like properties of complex adaptive systems (Kauffman, 1993).

Maguire and McKelvey radicalise the conception of agents further by adding that agents act in a locality, i.e. they are not omnipresent nor can they deal with all available connections. Agents can become unconnected or new connections can be established over time (Maguire & McKelvey, 1999), although these may not necessarily be deliberate actions. Consequently, the complex adaptive system as the basic structure is a network of interactions between agents in which the connections do not extend to all agents and in which these connections can be of a temporal nature. The complex adaptive system becomes dynamic through the ongoing actions and responses from agents.

An important condition for the existence of these dynamics is that agents are required to have the capacity to process information. According to Gell-Mann, the basic information that surges through the network includes information about the system, its environment and the interactions between the two that allows agents to draw up an image of the system and the environment and from that, to predict the future in order to act accordingly (Gell-Mann, 1995; Parker & Stacey, 1994). The quest for sense-making is ongoing and Maguire and McKelvey therefore characterise the behaviour of an agent as a constant exploration of the possibilities and a constant struggle to adapt to the

ever-changing circumstances. This is why adaptive agents are named as such – to emphasise the fact that these agents adapt themselves to the changing environment. Since these agents are the constituent components of systems, this ability to adapt is transferred to the nature of the system, hence the term complex adaptive system.

2.2.3 Agency and boundary judgements

The perspective on agency described here departs from human agency as it assumes that agents have the ability not only to receive information but also to act accordingly, i.e. they have a reflexive capacity. Such an assumption may trigger a debate on whether non-human agency has similar characteristics and, if not, whether it is able to respond to incentives. Agents that are able to respond actively to information are adaptive agents while agents that respond passively are merely adopting information. However, this book does not partake in this debate. Based on the empirical accounts presented in the upcoming chapters, the foundation of the arguments in this book is that physical systems are complex adaptive systems whose constituent components can respond to incentives that can lead to non-linear dynamics. Whether the physical system's response is deliberate or not is not important to the analysis.

There is one important assumption about the existence of complex adaptive systems described here that is often made but less often reconsidered, namely the assumption that such systems exist as entities in reality. In many accounts on complexity that are based in the sciences such as physics and chemistry, especially those from the Santa Fe Institute, systems are assumed to exist outside the perception of the observer. This is sometimes reinforced through vagueness about whether a physical system or a social system is being described (Rosenhead, 1998).

In this way, complex adaptive systems have much in common with the systems theory that was developed in the 1970s. Although there are many differences between these two approaches that are discussed later in this chapter, some authors argue that a system can and must be defined incontestably. One of the deficits of first generation systems theory was this goal and complexity theory should not inherent this deficit in order to avoid this dead-end street. With the further development of systems theory, that point has evolved into the idea that systems' boundaries must be set dialogically with agents that have partial

knowledge about the boundaries of systems (Midgley, Munlo, & Brown, 1998; Ulrich, 2005). The argument is that it is necessary to determine the boundaries of a system through continuous debate but also to understand that a dominant view of what the systems' boundaries are could suppress minority views that are equally important to the definition of the boundaries, i.e. the boundary critique. This approach acknowledges that system boundaries are relative and depend on the agents' perception while nevertheless assuming that systems do exist.

Cilliers states that underlying this assumption is the idea that for a system to be recognisable as such, it must have boundaries that set it apart from other systems or its environment. This requires an observer to be able to determine a boundary in any case. However, as he points out and as argued in the first section of this chapter, the disposition of a complex adaptive system is an open one and thus, the decision of what is and is not included in the system remains debatable (Cilliers, 2001). Rather than attempt to define a system's boundaries, it is more realistic to focus on the debate around the system's boundaries than on the boundaries themselves.

Behind the argument in favour of an observer's boundary judgement lies a desire to intervene in order to improve the state of the system. The goal of this research, however, is to analyse how decision making over physical systems can be understood as coevolution, which includes the way agents view and shape their systems. This implies that how the act of defining the system relates to decision making in coevolution must be understood instead of simply attempting to arrive at a second-order boundary judgement. Thus, the idea of complex adaptive systems described in Section 2.2.2 is not abandoned but it is understood that the agents' perception of what defines the system is decisive in determining what is included in the system, as it is from this perception that agents act accordingly. This perception extends to the physical system as well. In theory, the physical system is infinite but human agents make decisions about what they regard as part of the system that they have to make a decision on. Again, this emphasises the importance of agents' perceptions in an analysis of decision making in coevolving systems.

From this point of view, it is also clear that the elements of structure cannot be separated from the elements of process as the structure and process exist through each other, as pointed out by Cilliers (ibid.). The elements of process are the subject of the next section.

2.2.4 Elements of process

Complex adaptive systems exist because of interactions and these interactions contribute to the capriciousness of systems' development. Thus, capriciousness is a property of process. There are a number of elements that contribute to this property which are presented here. Breaking up this capriciousness or erratic nature into distinctive components may be construed as reductionism, but this is not the case. All the elements discussed here are recognised as parts of the overall complexity and are known to occur simultaneously.

To start with the idea that interactions are of pivotal importance for complex non-linear developments, it is necessary to understand the nature of interactions in terms of feedback. Because agents are connected to one another, each action leads to a response from these agents, which in turn starts another stream of actions, with each response constituting a feedback loop. In other words, feedback is the return of a portion of the output of a process or system to certain input. Complexity theory discerns between two types of feedback: positive and negative feedback (Parker & Stacey, 1994).

Negative feedback consists of loops that have a dampening and stabilising effect (Marion, 1999; Parker & Stacey, 1994). Diehl and Sterman attach a self-correcting quality to negative feedback loops during decision making processes, in which the gap between the current situation and the intended situation is closed (Diehl & Sterman, 1995). However, such a quality depends on human agency as it requires the definition of a desired state and the execution of an intentional action to acquire that state. With reference to the discussion on agency in Section 2.2.3, negative feedback is understood here as existing and stemming from both intended and unintended actions and stemming from human agency and non-human agency, the latter being outside the direct range of control of human agents. Negative feedback is therefore stabilising even if human agents want it otherwise.

Positive feedback, on the other hand, consists of loops that oscillate progressively and lies at the heart of the complexity thesis that small events can lead to major consequences (Prigogine & Stengers, 1984). While negative feedback reinforces the status quo, positive feedback drives change in an amplifying, destabilising way. Again, this is independent from the type of agency as positive feedback loops can be intentional, for example a small intervention leading to major success, unintentional or even accidental and in the case of non-human action and response, outside the direct control of human agents.

To add to the complexity, negative and positive feedback loops can occur simultaneously, sequentially and on different timescales (Diehl & Sterman, 1995), all in interconnected patterns.

The use of the substantives 'negative' and 'positive' may result in an unintended interpretation of the terms as adjectives. This is the case in some accounts on the management of complexity. Such a connotation does not do justice to the meaning of the notions of negative or positive feedback. While stabilising situations may indicate inertia, there are certain situations that can benefit from stability. As Parker and Stacey argue, positive feedback can be both virtuous and vicious circles (1994). In order to avoid any further confusion while acknowledging that a negative or positive outcome is agent-bound, the terms favourable and unfavourable are used throughout the book to indicate agents' assessments of a given situation.

Patterns of feedback loops are not well-structured in practice. A change may or may not be received by agents and may or may not provoke responses that in turn can lead to adoption or adaptation. In addition, responses do not necessarily occur on the same proportion as the original action. The consequent ever-changing patterns of feedback between agents and unpredictable outcomes are the essence of non-linearity.

The accumulation of negative and positive feedback loops can increase the pressure on the complex adaptive system to such an extent that the current stable state of the system is challenged. While a change from one state to another may be gradual, the concept of punctuated equilibrium can be used to explain the erratic changes observed in both physical systems (Scheffer, Carpenter, Foley, Folke, & Walker, 2001) and social systems (Baumgartner & Jones, 1993). Change resulting from pressure is characterised by periods of acceleration alternating with periods of stability. The reversal into periods of fast change is not caused by a particular event at that point in time, although events can function as the final trigger, but is the result of a build-up of system pressure to the degree that the system's resilience can no longer cope with the pressure and gives way to a new state.

Punctuated equilibrium means that the state of the system can remain seemingly stable because a gradual increase in pressure does not lead to gradual change but rather, to more radical change once the threshold has been reached. However, because the state remains seemingly stable, human agents cannot forecast punctuated equilibrium and the location of the threshold in time and space remains unknown until the moment it is passed (Walker & Meyers, 2004).

If punctuated equilibrium is regarded as a property of systems and the interaction between systems, as is the case in this study, the complexity of the causation of change is further increased as agency is confronted with change in both the system it is a part of and other systems, such as in the case of physical systems interacting with social systems (Muradian, 2001). Punctuated equilibrium is therefore something that can only be known through reconstruction after the fact (Gunderson, 2001). Adding to the complexity of such changes is the concept of hysteresis, which is used to describe the phenomenon where once a change has taken place, restoration of the previous state of the system requires considerably more energy than was required to topple the system over the threshold into its new stable state (Hughes, Bellwood, Folke, Steneck, & Wilson, 2005; Scheffer et al., 2001).

While punctuated equilibrium and hysteresis can explain the occurrence of sudden change, path-dependency and lock-in explain why changes are not sudden and sometimes even altogether absent. Path-dependency is the term used to describe the pattern in which changes are incremental and defined by the previous state of the system in the sense that history matters (Greener, 2002; Pierson, 2000). Lock-in is the process of increasing inflexibility and fixation in a certain situation because the amount of energy required to leave the situation exceeds the benefits of preserving that situation (Arthur, 1994; David, 1985). Initially, a particular choice may lead to increasing returns: the more agents choose it, the higher the returns, i.e. a positive feedback loop is created. After a certain number of adoptions, a new option may present itself. However, because the old choice has been adopted so many times before, the energy required to shift towards the new option is considered to be too high compared to the benefits of remaining in the current situation. Hence, agents and systems are locked-in to a situation that, in the end, may be unfavourable for them compared to a (hypothetical) different situation (Pierson, 2000)

In sum, processes that build complexity are driven by negative and positive feedback loops and are characterised by both erratic change (punctuated equilibrium and hysteresis) and increasing stability (path-dependency and lock-in) that can occur simultaneously. These notions can be discerned theoretically but empirically, there are two constraints. Firstly, processes are not neatly separated but interlocked and interfering. Secondly, the time scale of the observations has an impact on the interpretation of the process. While a certain development may appear to be stable or locked-in if observed over a given period of time, it may simply constitute a temporal stable state between two periods of rapid change

if the observation period is extended at both ends of the series. As with the argument presented in Section 2.2.3, these constraints impair both the agents in a system as well as the observer. Longitudinal studies may help to partially overcome this problem, which is discussed in Section 2.3, but should still take into account the agents' perceptions and experience of a particular situation and the way the agents respond to this assessment.

2.2.5 Simplistic versus complex complexity

The constituents of complexity become apparent when the elements of structure and process are considered together rather than separately and when it is understood that there are considerable limitations on how this complexity can be understood empirically. All the elements together build the complexity of non-linearity that agents are confronted with and often forced to respond to. Responses in turn aggregate into pressures that influence the stable state of the system. The stability of systems is therefore temporal at best (Mulder & Bergh, 1999). The argument here is that the complexity of social reality can only be understood as a whole, despite the inherent complicatedness. Byrne (2005) argues for a distinction between simplistic and complex complexity in order to clarify the relationship between complexity and social reality.

Simplistic complexity is essentially complexity within closed systems, with the emergence of structures and processes depending entirely on the (fixed) variables within the system. Such systems display complex behaviours but are deemed simplistic because the roots of this complexity always remain within the closed system. This means that the dynamics are confined by the variables that define the system. Many of the archetypes of complexity theory that are often referred to, such as the computational simulations by Reynolds or Langton (Smith & Stevens, 1996), are examples of simplistic complexity. While simplistic complexity is functional in demonstrating the principles of non-linear development, it does not resemble social reality as its roots are fixed and bound.

In social reality, the number and nature of the variables defining an emerging structure or process is not fixed but rather, changeable. Complex adaptive systems are considered to be open and constantly exchanging energy with other systems and with such systems, the constituent variables do not define its borders (Byrne, 2005). What constitutes and limits a system is relative to the agents' and observer's locality, which complies with the argument on agency and

boundary judgements (see Section 2.2.3) and as such, is connected ad infinitum to other representations of systems. Therefore, complexity arises not only from the constituent elements of a system but also from the fact that this constitution is dynamic in itself, i.e. that it is constantly changing. The initial idea behind complexity theory that a limited system or set of rules can create complexity that cannot be explained by breaking this complexity down into separate components is therefore amended with the notion that, in reality, the origins of complexity are discursive to the extent that it is not possible to discern the afore-mentioned simple elements.

Thus, the stable state of complex adaptive systems is challenged by the pressures from the constituent elements discussed in the previous sections and from the interactions between systems because of their cellular boundaries. The current stable state of a system and the future possible stable states at which it may arrive through the pressures it is subject to can be described in terms of attractors and attractor basins, and the influence of pressures on that stable state can be described in terms of selection pressures. This provides an outline of the idea of coevolution between systems that challenge each other's states and that are also challenged from within, challenges that amount to selection pressures.

The argument thus far is that complexity theory provides a coherent framework for an explanation of the erratic nature of interactions between complex adaptive systems because it discerns and names the components of such interactions in terms of systems and processes, allowing for an understanding of complexity not through reductionism but through the inclusion of all the elements involved. It is distinguishable from earlier attempts at systemic theories as it regards processes as thermodynamic rather than mechanical and systems as open and dependant on the agents' judgement rather than closed and existing a priori. This is the point of departure for a model of coevolutionary policy processes with which the management and development of estuaries and tidal rivers can be analysed. The presentation of this model is the subject of Chapter 3.

In light of the focus of this book, the choice has been made to omit a discussion on the state of the system in terms of chaos and order and the bifurcation between these states. It is accepted here that agents experience continuous complexity and that an outsider's judgement of the chaotic state of a system does not contribute to answering the questions posed in Chapter 1. Instead, a tangential issue is discussed in order to address two closely-related subjects. The amendments of complexity theory to systems theory mentioned

above are rooted in sometimes implicit epistemological assumptions that affect the method of research. This is discussed more explicitly in Section 2.3. In addition, while complexity theory presents a coherent framework for research, it borrows heavily from other fields as mentioned earlier and therefore requires a critical review in order to establish its value. This is discussed in Section 2.4.

2.3.1 Investigating complex complexity

As has earlier been argued, complex adaptive systems do not exist independently from agents' interpretation and representation. This is disputable as early attempts at formulating the mechanisms of complexity assumed that systems existed independent from interpretation. The fact-value dichotomy that underlies such an assumption has been thoroughly undermined (Fischer, 1998) and has given rise to a number of epistemological approaches in which causality, generalisation and therefore predictability have been replaced with a focus on discourses, interpretations and, in postmodern accounts, a complete rejection of the idea of causality. Some researchers have argued that postmodernism requires science to withdraw into storytelling (in the context of public administration, see e.g. Frissen, 1999), which has given it a reputation for being nihilistic (Cilliers, 2005).

At first glance, complexity has an ambiguous epistemology. On the one hand, it has inherited its positivism from the physical sciences it has emerged from, but on the other hand this positivist stance has been criticised and amended (cf. Byrne, 2002; 2005), a debate that was touched on a few times in the previous sections. Complex causality is always subject to interpretation and consequently debatable as every interpretation carries with it normative judgements, which makes a strong case for negotiated subjectivism (Byrne, 2003; Haynes, 2001; Uprichard & Byrne, 2006) or critical realism (Guba & Lincoln, 1989). Although this introduces the convergence of fact and value into the analysis of complex causation and acknowledges the locality of knowledge, it does not accept the postmodern stance because it assumes that explanation is possible, as long it is understood that such an explanation is local in time and place (Byrne 2005). Although temporal, cause and effect relations do exist and can be known. The ontological point of departure is therefore complex realism (Reed & Harvey, 1992; Byrne, 2002). In order to understand this it is necessary to refer to the distinction between simple complexity and complex complexity (cf. Byrne, Buijs

& Eshuis 2008).

As argued earlier, simplistic complexity takes simple rules creating complexity at its core. The work of Axelrod (1984) and Holland (1995) are examples of such an approach with their explicit references to the hidden order that is understood to underlie complexity. Investigating such types of complexity justify a positivist approach as reductionism and singular explanation may assist in finding the simple, orderly patterns of rules from which this complexity supposedly arises. The proviso of this approach is that these rules are discernable independently from the agents' interpretation.

With complex complexity, it is understood that systems' boundaries do not exist a priori but that they are defined by partial boundary judgements made by agents and that systems and contingency are therefore not clearly separable. In other words, complex complexity is not confined to systems' demarcations but intersects all system representations by agents. The observer is as much part of the complexity as the system or agents that are observed. Cilliers states that this implies that there are multiple interpretations of what complex adaptive systems are and how they behave (2005). Rather than reverting to reductionism with the aim of narrowing down to the essential core driving complexity, one should attempt to understand complex causation as a whole, something that is even advocated in simplistic accounts on complexity, while acknowledging that this understanding is local in time and space and agent-bound, with the latter including the observer. Amidst this complexity, causality can still be determined in terms of change and response (cf. Hammersley, 2008).

Complexity theory as complex realism is positioned as the synthesis of positivism with the antithesis of postmodernism because while it accepts the impossibility of complete understanding of complexity, it accepts that given all limitations, an inter-subjective account can reveal some of this complexity (Byrne, 2003; Morçöl, 2001). Cilliers (2005) calls for modesty on behalf of the observer because of the constraints of understanding complexity. He argues that limited knowledge is obtainable, neither claiming that all complexity can be understood nor that anything goes, as advocated in postmodernism. He argues that the observer must be modest in his claims and that this modesty is not a weakness but a responsibility.

2.3.2 Longitudinal investigation and agents' representation

Investigations into the complexity of coevolving complex adaptive systems from this perspective have to deal with two major issues: the fact that coevolution is essentially a process and can only be understood longitudinally and the fact that complexity and agents' representation of complexity are similar things. These issues have practical consequences for empirical research.

As discussed earlier, complexity is very much a matter of development over time, requiring continuous longitudinal research. While there are many cases of longitudinal research that consist of points in time, this book argues that such snapshots are not the right mode for longitudinal research into complexity. Periods of relative stability can be punctuated with periods of relatively swift change in which events follow each other up more rapidly than before or afterwards. The risk of taking snapshots at (fixed) intervals is that the oscillating nature of complex change will go unnoticed and that these alternating periods are missed, which in turn could mean that an observed state of the systems cannot be explained because its preceding period remains unobserved. This leaves continuous observation as the more appropriate mode for research.

Such a continuous longitudinal approach should be very detailed as the non-linear emergence of structures and processes cannot be traced back to its roots mechanically. The nature of complexity makes it inevitable that it is reconstructed afterwards and in order to find these roots, a high resolution of past developments should be obtained. This minimises the risk of overlooking certain developments that appear in the context of cases that prove to be determinants of further developments. The obvious drawback is that in retrospect not all data collected is meaningful. However, the observer is hindered by the same lack of predictive power as the agent being observed and what is of explanatory importance cannot always be known in advance.

Central to complexity informed data collection is agents' representation and achieving inter-subjective understanding of the empirical cases. Qualitative interviews allow respondents to provide a full and detailed account of their experience of the complexity and their subsequent responses and it enables the researcher to understand the social construction of boundaries. This in turn allows for the reconstruction of how boundary judgements converge, diverge or intersect and how this influences the process of coevolution between systems.

While understanding social systems in terms of agents' representations is a well-accepted practice in the social sciences, this is less so with regard to the

study of physical systems. Investigating and understanding physical systems was the traditional domain of the natural sciences but this does not automatically mean that the same epistemology and methods should be used in the analysis of coevolving social and physical systems. In anticipation of the conceptual model to be discussed in Chapter 3, it is argued here that the process of decision making by human agents is pivotal in the analysis of coevolution between social and physical systems, as these agents investigate the physical system and derive directions for management from the research results. In doing this, the agents interpret (most often quantitative) data and act according to their interpretations. This reintroduces quantitative data into the qualitative analysis of coevolution as it shows how (perceptions of) physical developments lead to adoption or adaptation socially. Of importance is the observation by Williams (2007) that social and physical objects are not clearly separated because the physical world is also interpreted. However, that physical world is not a pure social construct because there it also exists without actors' interpretation. Triangulation, then, can help to comply with the demand of intersubjectivity. This means that, firstly, at the operational level of this research the sample should extend to the plausible full variety of accounts rather than seek reconfirmation of a recurring account while ignoring outliers. Secondly, it means that accounts have to be compared to alternative sources such as policy documents and newspaper articles.

The continuous longitudinal empirical approach with its high resolution in order to meet the demands of complexity informed research is labour-intensive and therefore the number of cases is restricted. Combined with the notion that explanations are local, these limits to the number of cases in turn constrain the possibilities for comparative research. Comparison is often aimed at finding the crucial variable that explains differences and similarities in cases. Following the discussion on simplistic and complex complexity, such a search is beside the point. It is acknowledged that every case has its unique trajectory and comparison should be used to highlight the particularities of each case rather than finding a common denominator that points at the supposed simple rule that governs the cases. The two cases studied in this book are therefore treated as unique cases, whose uniqueness can be made more explicit through comparison.

These considerations conclude the discussion on the elements and nature of complexity and the investigation of complexity. If the management and development of physical systems is understood as a systemic interaction in which there is no hierarchy between agents and if the surprises that come with such management and development are understood as a trace of non-linearity,

complexity theory is the appropriate point of departure for this analysis. The rise of complexity theory, however, has not been without critical review and the arguments put forward are worth considering before turning to the subject of coevolution in the next chapter.

2.4.1 Reviewing complexity theory

Complexity theory is essentially a collection of theories that has yet to reach the end of its development cycle. In developing a proper framework for this theory, a critical review of its constituents and its added value would be useful. Its diverse background adds to the need for understanding its position in science along with the need to understand the nature of the theory, the latter having already been discussed in the previous sections. Articles with titles such as 'Complexity theory in organisational science: seizing the promise or becoming a fad?'(McKelvey, 1999) and 'Complexity and management: fad or radical challenge to systems thinking?' (Stacey, Griffin, & Shaw, 2000) indicate that complexity theory is subject to continuous assessment. This assessment is conducted here from the perspective of social science in terms of three main intersecting arguments: the matter of using concepts and findings from natural science in the context of social science, the matter of creating metaphors instead of explanations and the matter of novelty.

2.4.2 Using concepts and findings from natural science?

Due to its roots in the natural sciences, complexity theory utilises natural scientific jargon and epistemology and there are a number of instances where findings from natural science are declared to resemble social developments without much consideration. Major criticisms concerning the indiscriminate transplantation of concepts from one realm of science to the other has been voiced by Sokal and Bricmont (1999). They challenge a number of assumptions that are made in complexity theory (Haynes, 2003), most importantly the use of the term 'non-linearity' and the consequences of non-linearity for understanding social reality. Since this concept touches on the heart of complexity theory, their critique is worth considering.

Sokal and Bricmont argue that contamination of the concept of non-linearity occurs when people speak of linearity or non-linearity as a way of thinking. This interpretation appears to have become ingrained within the literature on complexity theory, but according to Sokal and Bricmont it does not have much in common with the original idea of non-linearity. They observe that non-linearity is often positioned as the opposite of linear thought, which has the characteristics of the mechanical workings and reductionism often associated with physical science. From this perspective, non-linear thought is assumed to be the opposite, namely thermodynamic, holistic and relying on subjective perception. This is more than just a discussion over semantics, they argue, because this interpretation considers non-linearity to be opposed to Newtonian mechanics, an oft-cited point of departure for many books about complexity. Non-linearity, however, fits well into a Newtonian worldview and the concepts actually reconfirm this worldview rather than break away from it (Sokal & Bricmont, 1999).

Underlying this critique is the ideal of conceptual purity. This book does not argue that Sokal and Bricmont are incorrect in their critique, which tends to be the case in other accounts, but rather argues that conceptual purity cannot always be maintained in a theory under development. Restrictive use of concepts could cut off the potential of added explanatory power and may in turn, frustrate further theoretical development. Williams (2000, in Haynes 2003) posits a thesis that while purity itself is a good thing, it should not serve to restrict further development within the realm of the social sciences. It is this development that has lead to perceived contamination.

As was argued earlier, complex complexity does not exist without the human agents' perception of this complexity. It may seem coarse but human agents are reflexive, contrary to non-human agents, and if they classify their experiences of complexity, such as unpredictability and erratic responses to actions, under the banner of non-linearity it makes sense to use the concept with that connotation, even if it does not cover its original meaning. The use of the supposedly contaminated version is a way of avoiding confusion. In the process of developing a social theory this could lead to conceptual pluralism if it turns out that a certain concept does not adequately describe a certain phenomenon. As long this is a transparent process there is not much reason to oppose it. However, the critics are correct in asserting that there are a number of publications where this transparency has not been maintained, which has indeed led to vagueness on the meaning of particular concepts.

Haynes (2003) regards the criticism from Sokal and Bricmont as an expression of a fundamental debate concerning the appearance of social science, as it has long been treated as a copy of physical science. This means that similar ideas, concepts and methods are to be used when investigating social phenomena, even when this proves to be troublesome due to the nature of social reality. Both Byrne (1998) and Haynes argue that complexity theory for the social sciences can adopt concepts from the physical sciences but that this process cannot just be pure replication as the meaning of a concept evolves when confronted with social reality. This applies to the epistemology as well, as discussed in section 2.3.1. This evolution should be allowed to take place.

2.4.3 Creating metaphors?

Chettiparamb proposes an alternative way of looking at theory transfer and theory evolution by understanding it in terms of metaphors. From this perspective, metaphors are understood as the vehicles for transplantation from one field of science to another. It is accepted that the properties of the target domain do not necessarily correspond to the properties of the source and thus, that the metaphor has a dynamic meaning because of this difference. Metaphors may be used to develop analogies between the two domains and can work to enrich both, as the transformation of the metaphor during the confrontation with the target domain can help to enhance understanding in the source domain (Chettiparamb, 2006). This approach replaces the one-sided perspective that informs conceptual purity by focusing instead on the interaction between domains.

An extensive survey of the literature conducted by Maguire and McKelvey points out that the use of complexity theory to interpret social events often relies on metaphors. Maguire and McKelvey note that these metaphors are constructed without much mapping of the source and the alterations that occur during transplantation and therefore provide a very superficial understanding of the subject, thus leading to the criticisms voiced by Sokal and others. While Chettiparamb argues that there is a role for metaphors in shaping a theory in an alien domain, other authors believe that the careless application of metaphors ultimately harms the development of complexity theory. Metaphors can be used to persuade an audience to look at something in a different way but if a closer look reveals nothing but more metaphors, initial enthusiasm may turn into cynicism.

In order for a theory to gain authority, it should be able to pass the level of the metaphor for it to reach explanatory power (Mitleton-Kelly, 2003; Rosenhead, 1998). Rosenhead concludes that much of the initial work on complexity theory and social science barely passes that level and that the empirical foundations are either of anecdotal character or derived from physical science without much consideration, which further erodes the use of metaphors as a method of theory development. He also points out that some of the oft-quoted researchers from the natural science domain such as Kauffmann and Krugman do not state that they have evidence for every argument they make. However, reference to these works as solid proof of assertion has occurred in the literature. This weakens the case for complexity theory in the social sciences.

Although the criticisms regarding the thoughtless application of metaphors is targeted at the early attempts at theoretical development in the social sciences and more elaborate accounts have been published since, and although the complexity project in the social sciences is still in its infancy, it is a clear indication that the transfer of concepts from other domains to this domain requires concept mapping, either when used as a transfer by means of metaphors or when used as an explanation for certain events beyond the level of metaphors. This research aims towards the second option, which requires clear operationalisation of the specific concepts to a specific subject, i.e. operationalisation of the complex adaptive systems and the mechanisms of coevolution between those systems. This will be the subject of Chapter 3.

2.4.4 Introducing something new?

Murray states that complexity theory in the social sciences has three potential impacts: as a mathematical model, as a metaphor and as an explanatory narrative (Murray, 2003). The decision not to use the first and the ambition to move beyond the second option raises the question of whether complexity theory as an explanatory modus can introduce novelty and result in a better understanding of social events than existing approaches and frameworks. A number of authors have heralded complexity theory as the new science and as a paradigm shift (cf. Waldrop, 1992), but the optimism of some of these advocates would be deceiving if an attempt to move beyond the metaphors and operationalisation reveals that concepts could have a meaning similar to existing ones. The discussion in this chapter has shown that, at least superficially, complexity theory appears

to be similar to systems theory and the specific points regarding the hierarchy of systems is informed by actor-network theory. The next chapter also features concepts from public administration and ecology. The question must then be asked: do the basic properties of complexity theory discussed in this chapter have anything to add to what is already known?

As a systemic theory there are many apparent similarities with systems theory. These two theories use similar vocabulary, including terms such as emergence, dynamics, non-linearity, adaptation and systems' hierarchy (Phelan, 1998). However, systems theory is rooted in the idea that systems can be disentangled whereas complexity theory states that taking a system apart removes its unique features, thereby rendering any investigation of these features meaningless. Systems theory or hard systems thinking is in every way what is defined as 'complicated' in the beginning of this chapter. It promised to find the control parameter but failed (Otter, 2000). Soft systems methodology (Checkland, 1981; Flood, 1999) provided an alternative to that failed attempt with the introduction of the learning human agent in systems instead of treating systems as disentangled from these agents (Flood, 1999). That introduction heralded the idea of boundary judgements as earlier discussed. The focus shifted from the question of how to achieve something to what should be achieved (Otter, 2000).

This inclusion of the human dimension in systemic approaches is an important refinement of systemic thinking and has been imported into this research. However, systems theory is still driven by the assumption that systems tend towards an optimal equilibrium and although it is recognised that this equilibrium may be temporal or fluctuating, the underlying assumption is that systems can achieve and maintain optimised stable states in the long run (Haynes, 2003). With this assumption comes the ambition to undertake incentives to achieve this optimal equilibrium. Regardless of the perceived complexity, this is still assumed to be possible and desirable (Midgley et al., 1998). However, this is disputable as there are many accounts of the continuous instability of (social) systems. The idea of stable equilibriums does not have any basis in social reality. The stability of a system is a matter of perception and this points at the existence of subjective multiple, temporarily different equilibria at any given time. Consequently, there is no optimal equilibrium but rather a collection of possible states that a system may develop for a certain period of time (Bergh & Gowdy, 2000). This idea is further developed in Chapter 3.

Complexity theory, on the other hand, centres on the idea that systems

do not tend towards an optimal equilibrium in the long run because there is no a priori distinction between systems. This makes it impossible to determine a stable system that fits in with its environment. Instead, in keeping with the discussion on the elements of complexity, it is accepted that cases are in a constant state of complexity as defined earlier and that there is no dichotomy between stability and change, i.e. they can occur simultaneously. This is the fundamental difference that sets complexity theory apart from many other (systemic) theories with regard to both description and prescription. In this way, it radicalises existing notions and challenges the assumptions of stability and dynamics on which these concepts are build.

In articulating these premises, complexity theory draws from a basin of shared ideas with other theoretical approaches, such as path-dependency, hysteresis and feedback. The ideas on the hierarchy between systems is informed by actor-network theory while the conceptual model in Chapter 3 bears traces of theories from evolutionary biology and public administration. This may give the impression that complexity theory is merely a replica of these theories. The point, however, is that these concepts are combined to form a coherent framework from which complexity can be explained, while they were simply treated as singular explanations in their source contexts. Although the value of these singular explanations is not contested, it is understood here that, contrary to how they are often applied, these concepts are not mutually exclusive and therefore, any attempt to capture complexity must use a combination of these ideas.

Given these findings, the notion that complexity is new or perhaps even revolutionary is not supported in this book. If anything, it is an evolution of other theories. As it has evolved, it has acquired two major advantages: the radicalisation of concepts and their underlying assumptions and the combination of concepts that were previously considered as separate explanations.

2.4.5 Being modest

The rise of complexity theory and its introduction to the realm of the social sciences automatically brings up questions about the nature of complexity and the theories used to describe it. The three (intersecting) types of critiques discussed above should be taken into account. As has been argued before, the complexity project is still under development and while this should not prevent

experimentation, it is necessary to understand that such a development requires a considerate approach in terms of the transfer of concepts, particularly when one aims to transcend the level of metaphors, as is the aim in this book. Extolling the merits of complexity theory in the first part of this book may have been, in a way, premature. It is left to the readers' assessment whether this attempt to address the critiques of this theory has been successful.

The primary condition of this research is therefore to extend the call for modesty voiced by Cilliers (2005) beyond the explanatory dimension and to apply it to the theory as a whole. Complexity theory has the potential to enhance our understanding of (social) dynamics through combination and radicalisation provided the process of theory transfer and theory evolution is mapped accurately (Mathews, White, & Long, 2004). It should not be discarded just because it challenges the status quo in terms of theoretical approaches or their underlying assumptions. Nevertheless, this book adopts a complexity theoretical perspective in an attempt to reveal some truths about interacting physical and social systems without excluding the explanatory power of alternative approaches. The premise that explanations are local in time and space applies throughout.

2.5 Conclusions

The main argument in this chapter is that the observation that the management and development of physical systems leads to unforeseen and sometimes unwanted effects should be understood as a systemic matter, i.e. a matter of interacting systems in which the multiple interactions lead to the effects. The ensuing complexity can be understood in different ways and here, to its full extent, i.e. that complexity concerns both ontology and epistemology and that it extends to the investigation of social events.

Complexity theory may provide a basis for explanation of this point, but it is important to note that the development of this theory and its subsequent transfer into the realm of the social sciences has brought up the question of whether this transfer is possible. Strictly speaking, such a transfer may alter the original meaning of a concept during the transfer process, although this is not considered problematic from the point of view of metaphors. However, the careless use of metaphors can create its own set of problems. The goal of this book is therefore to move beyond the metaphor. This requires two steps. First, one should move from ontological and epistemological complexity towards

a conceptual model of interacting systems and second, one should apply the potential explanatory power of such a model to empirical cases. The first step is the subject of Chapter 3 while the empirical cases are presented in the Chapters 4 to 7.

Chapter 3: Coevolution and Decision Making

3.1 Systems' interaction and coevolution

The argument so far is that understanding the complexity of systems' interaction requires a systemic approach that is founded on complexity theory. Complexity's main elements and disposition were presented in Chapter 2 and the requirements for investigating complexity were formulated there as well. From the observations made in Chapter 1, it is clear that decision making is of great importance in shaping the interaction between physical and social systems. Decision making and complexity theory are brought together in this chapter through an understanding of policy processes as coevolutionary processes between complex adaptive systems that are driven by reciprocal selection and mutual adjustment.

The elements of structures and processes discussed in Chapter 2 concern the state of the system and the changes to that state. The state of systems can be considered an attractor in an attractor basin comprising all possible future states of a system. A coevolutionary approach to policy processes centres on the process of reciprocal selection and mutual adjustment within the attractor basin. A conceptual model of coevolutionary policy processes that allows for empirical investigation is presented in this chapter.

Cilliers (2001) argues that a model of complexity is always imperfect because models require simplification and abstraction and, within complexity theory, this could mean that what is retrospectively seen as important has been inadvertently left out because it was unforeseen. In addition, Byrne (2005) argues that research conducted through a conceptual model is inevitably constrained by the structure of empirical observation and a limited set of variables but that this is not insurmountable if it is kept in mind that the variables do not represent the full complexity but rather the tangible traces of it.

Bearing this proviso in mind, the conceptual model is built through three steps. Section 3.2 introduces the concept of coevolution and its mechanisms with regard to intentional and blind reciprocal selection (Section 3.2.2), selection patterns, adoption and adaptation (Section 3.2.3), strange attractors and the attractor basin (Section 3.2.4) and the directional dimension of coevolution (Section 3.2.5). The concepts of coevolution are then used to build a conceptual model that is presented in Sections 3.3.1 through 3.3.5. Section 3.3.6 discusses

the question of whether coevolution is a sequential process or not. The two main empirical cases and the way they were investigated are introduced in the final section of this chapter (Section 3.4).

3.2.1 Introducing coevolution

The concept of coevolution is rooted in evolutionary biology and was coined by Ehrlich and Raven (1964), who observed that groups of organisms evolved through reciprocal selective interaction (McKelvey, 2002; Norgaard, 1984; Odum, 1971). The reason d'être for coevolution as a type of evolution lies in the reciprocal nature of selection. It has been observed that the evolution of an organism can depend on the evolution of another related organism. While mutation can be explained by observing selection pressures on an organism from the environment, coevolution explains that this mutation in turn affects the environment of that organism. The explanatory power of coevolution for change is therefore situated in the pattern of mutual influence that can arise between organisms or, in the context of this research, in complex adaptive systems. While Odum (1971) suggests that coevolution can explain the occurrence of biodiversity, this research focuses on the disposition of the interaction between systems as an explanation for the erratic nature of development as presented in Chapter 1.

Although it is rooted in biology, the coevolutionary principle has emerged in other domains as well, although not always under the same heading (Sanderson, 1990). Every theory that regards change as a mutual process between elements arguably subscribes to the coevolutionary principle. From that perspective, Sanderson argues that much theorising in sociology and anthropology has an implicit or explicit evolutionist or evolutionary character, something which also rings true for many theories in the domain of public administration, such as Lindblom's 'muddling through' and Kingdon's policy streams .

The distinction between evolutionist and evolutionary change is functional in demarcating theories about long-term (societal) change in general and change as a result of mutual interaction and selection as argued earlier. Moreover, for a theory to have an evolutionary character, it should assume a directional tendency to change, whether by progression or regression, as well as explanatory mechanisms that drive this change, bearing in mind that these mechanisms are local rather than presumed universal (Sanderson, 1990). The

latter demand converges with the epistemological point of departure formulated in Chapter 2. While many theories can be evolutionist, not every theory within this category has an evolutionary character. The approach to coevolution in this book can be classified as an evolutionary theory as it focuses on the patterns of reciprocal selection and attempts to understand change in systems as a (complex) directional consequence of those patterns. However, it is not the purpose of this book to fully replicate all (co)evolutionary patterns as some patterns are understood differently and not every pattern explains social and economic change (Ayres, 2004).

Originally, the concept of coevolution was restricted to the biological domain while the social scientific discourse was concerned exclusively with socio-cultural evolution. However, Sanderson states that there are a growing number of accounts that regard socio-cultural change as a result of coevolution between a biological system with genetic mechanisms and a cultural system with non-genetic mechanisms. This introduces the idea that, broadly speaking, biological and social systems can be considered to be intertwined in a coevolutionary relationship in which there is reciprocal selection between these seemingly incompatible systems.

An explicit attempt to abandon the development of a physical or social system as a parallel or analogue one and to replace it with a coevolutionary perspective can be attributed to Norgaard (1984; 1994). His work aims to refine the coevolutionary argument discussed by Sanderson as one that is based on social systems in a homeostatic equilibrium. Norgaard argues that while this approach has its merits, it is not applicable in highly complex societies. He believes that coevolutionary development has been occurring for millennia as people attempt to use physical systems to their benefit, examples of which include the deepening operations and land reclamation described in Chapter 1. In doing this people engage in a pattern of feedback loops. In order to deal with the ensuing feedback from the physical system and aim for optimisation of the use of that system, they are pushed to create increasingly individualized task specifications and more complex institutional and cultural contingencies. Thus, while ecosystems respond to anthropomorphic changes, social systems respond to the ensuing changes from the physical system, which the physical system then responds to with yet another set of changes. Over time, the complexity of this pattern renders it nearly impossible to attribute any particular development to a specific feedback loop as the two systems have become completely intertwined. This is the idea of complex causation. These feedback loops can be considered to

be selection pressures as they can have a determining impact on future possibilities for the systems.

This, then, is the coevolutionary argument about social and physical complex adaptive systems in a nutshell. Norgaard initially focused on economic systems because it allowed him to address the pool of resources that can be utilised for progress. He incorporates the ability of human agents to select and manage the selection pressures that feedback loops exert on systems deliberately and to decide on the pool of resources. This is similar to the approach from evolutionary economics in which the focus shifts from the representational agent that is central to neoclassical analysis to an erratic population and how the decisions of this particular population influence the state of the systems (Bergh & Gowdy, 2000). Evolutionary economics therefore incorporates the complexity of the systems from which choices regarding selections and selection pressures are made into its analysis (Foster & Hölz, 2004).

It is through this focus that the biological understanding of coevolution coincides with complex adaptive systems and human and intentional agency as discussed in Chapter 2. While the core of coevolution, namely reciprocal selection, concerns content (i.e. what is selected and what are the consequences to the state of the system), the coevolutionary approach adopted by Norgaard, among others, introduces the elements of structure (complex adaptive systems and agency) and elements of process (positive and negative feedback following deliberate selection, punctuated change, hysteresis, path-dependency and lock-in) discussed in Chapter 2 to the analysis of the issue presented in Chapter 1. Thus, coevolution is complexity-informed. Of critical importance here is the ability of human agency to act deliberately in its interactions with physical systems.

While this makes it tempting to venture into a debate on Darwinian versus Lamarckian evolution (cf. Hodgson & Knudsen, 2006) this book does not delve into this debate. It is assumed here that the ability of human agents to make deliberate decisions is central to the coevolutionary argument framed in this book because deliberate decisions are an important part of policy processes. Consequently and conforming to the nomenclature of public administration, a distinction between agents and actors can be made, the latter category having reflexive but bound capacities. The ways in which actors in the policy-making realm process information in order to deal with the selection pressures on them must be analysed to achieve an understanding of policy processes from a coevolutionary perspective. Actors as policy-makers are considered to be the

formal organisations that make up the aggregated behaviour of individual actors (Sanderson, 1990) (see also the discussion on nested systems in Chapter 2), which is expressed in terms of policy action systems (see the further discussion later in this chapter).

The approaches described in the introduction to this chapter acknowledge the importance of reflexivity and deliberate decision making in shaping the pattern of interaction with a physical system. However, while these approaches concern macro patterns of decision making over fairly long time spans and across large populations of agents, they are less helpful in explaining the day-to-day decision making within the patterns of interactions with physical systems. This is the goal of this research, but requires an understanding of the concrete patterns that drive coevolution. As discussed in this section, an investigation of coevolution between complex adaptive systems in which a number of agents are able to deliberately forecast, plan, anticipate and respond should take the following elements into account: reciprocal selection and selection pressures as forms of feedback, selection patterns by human agency and consequent adjustment and, finally, the attractor basin and the trajectory through this basin.

3.2.2 Perceptible and blind reciprocal selection

At the heart of coevolutionary processes lies the concept of reciprocal selection. The concepts of 'feedback' and 'selection pressure' appear to be closely related but the difference between them is not purely semantic. Originally, Norgaard (1984) stated that coevolution occurs when at least one feedback loop between systems changes. In his later work, he added that a change in feedback loops does not necessarily lead to a change in the state of systems as negative feedback loops can reconfirm the system's state, effectively not driving coevolution. Coevolution therefore thrives on positive feedback loops (Norgaard, 1994) as they provoke adaptation and thus, a change in the state of systems. Feedback therefore becomes selection pressure as a response to an incentive leading to change. This poses two questions: what is being selected and how is it selected?

The answer to the first question is basically that the future state of a complex adaptive system is being selected. The adaptation to a certain incentive means a change in the systems' states but, following the processes of path-dependency and lock-in, this in turn means that certain future trajectories or sequences of systems' states become possible while others are relegated outside

the range of what is feasible. This process applies to both physical and social systems. With regard to physical systems, it means that choices made by human agents lead to changes within the physical system that rule out other possible directions for development. For example, the decision to straighten the course of a river and to utilise reclaimed land denies the river the possibility to meander. Conversely, a physical change such as the persisting increase in the sea level pushes human agents into a reactive role as they face an unfavourable situation to which they have to respond regardless of their earlier intentions. Reciprocal selection therefore means that the future state of systems is mutually determined by selection pressures from the systems.

The question of how this future state is selected is also important here. Aldrich and Ruef (1999) note that there are two ways of creating variety in organisations: intentionally and blindly. This is helpful for the research in this book but there are two provisos that must be taken into account. They start from an organisational perspective that allows them to make a distinction between internal selections, or selections from within the organisation, and external selections, or selection from the environment thrust upon the organisation. Consequently, there are two types of variation, i.e. intentional variation and blind variation. Intentional variation is driven by active attempts by agents to find solutions while blind variation occurs through events independent from agents' behaviour (Aldrich & Ruef, 1999). Generating variety is regarded as an attempt to create alternatives to addressing current problems. Such alternatives are then selected or are being selected. Since the perspective here is centred on coevolution, the creation of variety and selecting variety is considered to be a part of the same feedback loop; variation and selection are intertwined in a complex way (Foster & Hölz, 2004).

This framework therefore assumes that there is no neat separation between variation created by agents and actors and variation that is not. The latter type of variation cannot be externalised from the selections made by agents because, although some actions can be without consequences, it is quite possible for agents' actions to lead to change and further variation in the future with the complex causation obscuring the relationship between the two. This ostensible absence of clear causation may give the impression that, while intended selection is perceptible, certain variation cannot be related and is, therefore, blind. The argument here is that complex causation could indeed create that impression but that variation in the future can still be triggered by current selection, even when this variation is unintended, unobserved and unexpected. In other words,

selection and variation are part of the same feedback loop that affects a complex adaptive system (Hrebiniak & Joyce, 1985). Consequently, there are two basic types of reciprocal selection: perceptible and blind, each exerting its own selection pressures on the systems.

Perceptible selection, then, is a result of choices made by actors. They assess the current situation, define a desired state of the system and draw up a solution to change the current situation into the desired situation. For example, borrowing from the cases discussed in the following chapters, the port authorities aim to receive larger ships, they deem the current depth insufficient to achieve this aim and consequently make a plan for the deepening of the navigation channel that they execute. In other words, these actors attempt to define the future stable state of the physical system and act accordingly, which exerts a selection pressure on the physical system to change. This creates a renewed situation from which the actors can continue to work, i.e. it determines the variation available to actors at a later stage.

However, the cause of this selection pressure is not necessarily clear. Although a clear and intended change in the other system could occur, it is also possible that, given the complexity of the environment, a certain action may lead to no changes or unintended changes. The timeframe of these changes might be erratic, with results sometimes appearing immediately while there may be long delays in others cases. Due to the limited information capacity of actors, the consequence of a particular action may appear to be detached from it (see also the discussion in the Chapter 2). Because this consequent action also results in changes to a situation and determines the variation available at a later stage, this is considered to be blind selection, i.e. variation that is seemingly detached from the act of selecting but that, in fact, is not. Its source is obscured by complex causation and changes in time sequences but the causality is nevertheless present. For example, changes to the sand transport of an estuary can be attributed to several decisions made by the policy system, but its exact causation is almost impossible to determine. However, it still pressures the policy system to act even though its cause is obscure and might, in fact, be a result of the actions of the same policy system.

The erratic nature of blind selection can be explained by the elements of process discussed in Chapter 2. Selection pressures constitute feedback loops that can be positive or negative and can lead to the occurrence of change, punctuated equilibrium, hysteresis, path-dependency and lock-in effects, all of which render the result different in time and place from the initial intention, sometimes even

altering the systems beyond recognition. However, these results determine a situation and this defines the degree of freedom available to actors in the policy system in shaping the physical system. Selection can therefore be blind because of the disposition of processes in complexity while still being reciprocal because of the mutual influence of systems to determine their future states.

Not every selection pressure sets off a change in the future state of a system and it can take multiple selection pressures that mount system pressure for a change to take place (Bruijn, 2004). While blind selection exists because of complexity, there are also instances where blind selection occurs through chance events. Chance events are discrete events that come together by chance and whose results influence the systems' state (Sibeon, 1999). These events do have an impact although they are effectively detached from actors' influence instead of being (complex) connected to them. For example, a cargo ship that runs aground in an estuary because of the captain's incompetence could stall a policy process on the development of the estuary. Such events are genuinely outside policy actors' operating radius and are chance events that can generate selection pressures.

The nature of perceptible and blind reciprocal selection as elements of coevolution raises the ostensible complexity and inherent uncertainty experienced by actors (Rammel, Hinterberger, & Bechtold, 2004). In order to structure and give meaning that inform actors how to respond to these selection pressures, they apply selection patterns. These patterns are as much part of coevolution as perceptible and blind selection.

3.2.3 Selection patterns, adoption and adaptation

A circular relationship between perceptible and blind reciprocal selection and agents' and actors' responses exists. The stance of agents and actors and the consequent selection pressures that are exerted alter their stance in response to the selection pressures. These feedback loops basically consist of information for agents and actors, upon which they act accordingly (Foster & Hölz, 2004), by comparing the new information they receive with an existing pool of information that allows them to assess the nature of the new information. There are then two basic types of responses to this new information: adoption and adaptation. Adoption occurs when information is absorbed but not acted on. This includes the rejection of information. Adaptation occurs when information is not only absorbed but also leads to changes in response to this information (Dopfer,

2005; Tappi, 2004). It should be noted that these two basic options are not synonymous with the passive or active processing of information as agents or actors can actively decide not to alter their internal structure when confronted with new information.

As argued in Chapter 2, this distinction is important as it is understood that although physical systems respond passively to information, they are still able to respond through adaptation of the systems' properties. Human agents or actors, however, have a reflexive capacity that allows them to respond actively to information. They act as intermediaries, processing selection pressures from the societal environment in which they are operating into concrete measures for the physical system (e.g. deepening of the navigation channel in response to demands from shipping companies) and respond to selection pressures from the physical system (e.g. dredging in response to sediment accumulation). Two types of selection patterns help actors to structure selection pressures and to decide between adoption and adaptation: boundary judgements and diversity of information.

Regarding boundary judgements, it should be pointed out that these are important responses in the confrontation to selection pressures from an erratic environment and diffuse information (Churchman, 1979; Flood, 1999; Hrebiniak & Joyce, 1985). Boundary judgements define the area of action in terms of elements that are included in the decision making and those that are not. In other words, the limits of the complex adaptive system are set by boundary judgements. As Flood (1999) points out, such boundaries are local in time and space and are subject to change if the actors defining the boundaries decide to do so. In the case of policy making this involves the cooperation or competition between actors. Through Simon's (1991) research it is understood that actors' capacity to process information is limited and that representations through boundary settings can help to enhance this capacity. Cooperation, e.g. inter-organisational cooperation or stakeholder involvement, enables actors to enlarge the pool of information available to them with which they can judge the most appropriate response (Gerrits & Edelenbos, 2004). At the same time, however, boundary judgements also demarcate which information is not taken into consideration, as actors find it difficult to cope with the multiplicity and complexity of information (Teisman, 2005). Boundary judgements made by policy actors therefore simultaneously define the policy system from the societal environment, i.e. those that are accepted to participate in the decision making, and the physical system that this policy system attempts to manage and

develop.

There is, then, a relationship between the boundary judgements and the diversity of the information available against which selection pressures can be assessed, as the inclusion of more actors in the policy system has the potential to introduce more diversity into the policy system. This enables actors to cope with these selection pressures, but there are limits imposed by their capacity and willingness to process information and by the defined boundaries. Actors are therefore likely to explore a limited degree of diversity or variety, i.e. the variety that exists locally and that falls within the set boundaries (Bergh, 2004). There is an incentive for actors to actively pursue further variation of information in order to develop a better picture of the situation and to act upon it (Dopfer, 2005). However, according to Richardson, it is impossible to fully determine the state of unlimited complex systems and reductionism is unavoidable. Instinctively, actors can preserve the information that lasts and discard information that is unique because repetition is a sign of stability and may point at something important. The inherent risk is that information that is initially considered to be white noise or waste and not taken into account may later prove to be vital (Richardson, 2007). Actors are therefore under pressure to locate the thresholds between reductionism that remains informative and holism that is manageable in their search for information.

It is now clear that boundary judgements define which actors connect with each other and which actors are accepted into the decision making process whereas variation through research and through definition of the scope of the decision making process defines which information is considered in the assessment and which is not. Both boundary judgements and variation have their limitations as the information processing capacity of actors is finite. Actors are, nevertheless, kept informed about the situation and whether they should adopt or adapt.

Both adoption and adaptation can occur as a result of the assessment of the information describing the situation (Dopfer, 2005). While such information may lead to changes in the management and development of the physical system, it is not a natural law that information always leads to adaptation as actors may decide that maintaining the current situation is the best response to the selection pressures it is subject to or that the information is irrelevant (Ashmos, Duchon, & McDaniel, 2000; Weick, 1979).

There is a circular feedback pattern between selection pressures, selection patterns and adoption or adaptation. Actors respond to selection pressures by

establishing what is important through selection and by adopting or adapting. The very act of doing this exerts selection pressures on the physical system. March and Shapira (1987, in Aldrich 1999) state that actors are often convinced that all selection is intentional and clearly visible. However, both Aldrich and March (1994) conclude that most selection is actually blind and that, given the complex causation between selection pressures and responses, the success of the response depends as much on chance as it does on intentional and perceptible action. However, it must be emphasized once again that what is considered chance may, in the end, be the policy systems' own action obscured by complex causation. As discussed before, there are limits to what actors can understand. Therefore, the complex causation might not be fully understood, thus rendering outcomes blind. This research can help to explain the process of blind selection and to unveil some of the complexity actors are faced with when managing and developing physical systems.

3.2.4 Strange attractors and attractor basins

The difficulty of the discussion in the previous sections is that it may suggest a unilateral relationship or even a hierarchy between all elements when, in fact, the argument is essentially circular with all elements influencing each other mutually. The concepts attractors and attractor basins helps to explain the connections between perceptible and blind reciprocal selection, selection patterns and adoption and adaptation as they are functional in summarising the process of coevolution.

Essentially, attractors and the attractor basin are concepts that allow for an understanding of the resilience and stability of systems. Attractors are the situations in which systems find a temporal equilibrium. They represent the current stable state of the system. An attractor is marked by its relative stability which indicates that it has certain resilience against perturbation and therefore does not always change whenever pressure is exerted on it (Gleick, 1987; Marion, 1999). With reference to the discussion on punctuated equilibrium in Chapter 2, it follows that shifts in the stable state of systems only occur when enough system pressure is built up. This is why complex systems can appear to have a certain level of stability.

The simplest type of attractor is a fixed point attractor, which constitutes a single stable state that keeps a system in that situation regardless of the pressure

it is subject to (Otter, 2000). However, Byrne states that fixed point attractors do not provide accurate representations of the complexity of the systems under investigation in social science as systems' states change over time as a result of system pressure and successive states may be different from the initial ones (Byrne, 1998). Otter mentions the periodic attractor, also known as the torus attractor, as a representation of the changing states of systems. The periodic attractor describes the alternation of systems between a limited number of states. Periodic attractors may occur in the systems under investigation but it is likely that over time, systems continue to change from one state to another without continuously returning to the same limited set of attractors. Strange attractors describe such a succession of temporarily stable system states in which the repetition of stable states may occur but not ad infinitum. There are two important denominations in this description: the use of the plural form and the emphasis on the succession of states. The first points to the existence of multiple (strange) attractors in a given space whereas the second indicates a progression through time. Both can be understood through the concept of attractor basin.

The number of possible future states of a system is represented by a group of attractors. As discussed in Chapter 2, a system does not have a single determined future but rather, there are a number of possible futures that represent a possible next state of the system. This group of attractors describing all possible future states of a system form a phase space (Gleick, 1987), a state space (Kauffman, 1993) or an attractor basin (Arthur & Durlauf, 1997; Martin & Sunley, 2006). The system moves between the (strange) attractors in the attractor basin because of the feedback loops and consequent system pressures they are subjected to. Historically, a system follows a trajectory through the attractor basin as it moves from one strange attractor to another. These changes display the characteristics of complex processes discussed in Chapter 2, i.e. the system can be locked-in in a certain stable state and changes between these states are punctuated. Since change is driven by coevolution, the trajectory through the attractor basin basically shows the evolution of a system.

A system can only be in one stable state at a time and the other attractors in the attractor basin are, therefore, future stable states, i.e. the states that are possible but not real at the moment of observation. This difference between the current state and the possible future states is important in an analysis of coevolutionary processes. Systems do not switch between states at random. Some states are more likely to be achieved than others, something in which path-dependency is explanatory. Functional in this analysis are the selection

pressures. As argued in Section 3.2.2, the stable state of a system determines its own possible future states and those of the other states. In other words, the current stable state of the system renders some attractors in the attractor basin of other systems more likely and others less likely. Because this process is reciprocal, the states of systems depend, at least in part, on the states of other systems.

The trajectory through the attractor basin is therefore determined by perceptible and blind selection. Actors can actively decide about the future state of a physical system but at the same time, this (future) state determines the possibilities for the policy system, i.e. not everything is possible given a certain situation. In deciding on the future state of the physical system, i.e. when managing and developing that system, policy actors attempt to make an assessment of the current situation, the desired situation and the measures required to achieve that situation. As noted by Richardson (2007), it is impossible to see and assess the attractors comprising the attractor basin; reductionism is thus applied through the use of the selection patterns discussed above. This means that when actors make assessments for policy-making, they must base their goals, plans and strategies – the projected attractor basin – on a compromised image of what the possible future states are. This projected attractor basin is then taken as the point of departure to exert selection pressures on the physical system as described in Sections 3.2.2 and 3.2.3.

The process of coevolution can now be depicted in *figure 1*. This figure shows a hypothetical attractor basin which consists of four main discriminating attractors w, *x, y,* or *z*, with each attractor having an infinite subset of small variations i^{1-n}. Note that the number of attractors is defined by the observer and not based on second order judgements.

At any given moment in time, the system is positioned at a certain temporarily stable state of equilibrium. It can remain in this attractor because of existing feedback loops that reconfirm the situation. It may take considerable system pressure, illustrated here by the arrows, before the system changes to another attractor. If enough system pressure is exerted on the system, it may move to another attractor in a punctuated fashion. The role of decision making processes is important here in deciding the future state of the systems. Assume that the physical system is located in *w*. Upon assessing this situation based on their own desires, the policy actors decide to apply pressure in an attempt to move the physical system into a new stable state, *z*. However, because of the limited information capacity of the actors, they may overlook the existence of attractor *x*. The solid lines indicate the projected attractor basin (*wyz*) that

observes which system pressure keeps the system in *w* but at the same time overlooks the existence of attractor *x*. Because perceptible selection is paired with blind selection, the physical system may move to a new but unforeseen attractor *x* instead of moving to *z* because blind selection accumulates more system pressure than does perceptible selection, something which was overlooked due to the limited information processing capacity of actors.

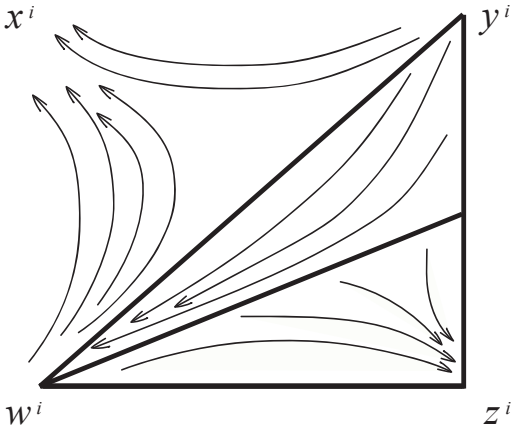


***Figure 1**: A theoretical attractor basin consisting of four attractors of which w-y-z is included in the projected attractor basin as defined by the policy action system.*

This process describes the unilateral evolution of a physical system under selection pressure. Coevolutionary processes are driven by reciprocal selection, which means that a process such as the one described above is mirrored. In other words: every stable state of one system determines, at least in part, the attractor basin available to the other system. The freedom to move from one attractor to another is therefore compromised by the actual situation. And discussed in the previous sections, actors have difficulties deciding over intentional and perceptible selection as their information on the attractor basin is limited and because selection is at least partially blind. Each cycle of reciprocal selections marks a change from one attractor to another.

3.2.5 The matter of direction

Sanderson (1990) suggests that one of the premises for a theory to have a (co)evolutionary character is that it should have a directional dimension, because the adjective 'evolutionary' becomes an arbitrary denominator without that dimension. The directional dimension is the succession of a system's stable states as visualised by the trajectory through the attractor basin discussed in the previous section. According to Kerr (2002), confusion over this directional dimension has resulted in diverging interpretations of the disposition of coevolution. It is important for policy actors to understand the direction of coevolution as policies are developed in order to improve an unfavourable situation, i.e. to shift between attractors. A survey of the literature suggests that the directionality of coevolution is explained in a number of ways that are occasionally normatively-informed. There are four diverging, sometimes intersecting and sometimes contradictory views on coevolution: coevolution as progression, coevolution as equal distribution, conditional coevolution and multidirectional coevolution.

The directional demand concerns a succession of states but not necessarily progression to a better or more favourable state. Still, such interpretations exist and coevolution from this perspective is regarded as a non-linear route to progress or improvement (Kerr, 2002). These interpretations are, perhaps, informed by the Darwinian thesis of the survival of the fittest, i.e. that evolution leads to a continuously improving fit with the environment. However, both Kerr and Sanderson argue that there is no fixed relationship between evolutionary change and progress. What constitutes an improved state is based on agents' judgements and what is seen as a progression by one actor may be regarded as a regression by another. As the environment continues to evolve as well, another central component of the coevolutionary argument, the supposed better fit is lost because the conditions of that fit have changed. A second-order judgement that systems' states have undergone an intrinsic improvement is therefore untenable.

According to Norgaard, such perceptions on improvement are rooted in a materialist ontology. He argues that this point of departure obstructs a thorough understanding of the processes of coevolution and that much of the issues with physical systems are actually caused by this (Norgaard, 1994, 1995). Coevolution, he states, is inherently incompatible with the idea of progress as the latter relies on exploitation, which implies that progression comes at the cost of a regression of resources elsewhere. From his perspective, coevolution substitutes perceived progression and it is centred on the idea that materialist improvement

is part of the problem. He believes that social systems have become disconnected from physical systems and that it is reconnection that provides a way out of the problems with physical systems.

This way of thinking seems to inspire accounts in which coevolution is regarded as an equal distribution of the burden between social and physical systems. The interaction leading to coevolution between these two types of systems is therefore seen as a desirably balanced one between the two (cf. Ruijgrok, 2000). This implies a normative approach to coevolution, i.e. that developments should not exploit resources if it is impossible to replenish these resources. Such a goal is praiseworthy but should not necessarily be labelled as coevolution. Proposing the requirement of non-interference in the connected development of systems rules out the possibility of interference during coevolution and it is exactly reciprocal selection that could cause such interference. Since reciprocal selection lies at the heart of coevolution, it is contradictory to this normative explanation.

This approach also revolves around the idea that coevolution is something that actors can create by lifting this interference. The concept of conditional coevolution, i.e. coevolution that can only exist when actors develop the right circumstances, appears to have gained ground in accounts on complexity from the fields of management science. Two recurring themes in this perspective are mutual influence and cooperation for the benefit of all concerned. Conditional coevolution is rooted in the idea that hierarchical relations between organisations or within organisations should be replaced by relationships that are more network-like. Cooperation between actors should then help to establish coevolution, which means that the participants engage in a mutually favourable interaction. Once again coevolution is given an exclusively positive connotation. However, as argued before, reciprocal selections take place regardless of the intentions of actors and regardless of whether the outcome is favourable to all concerned. Hence, coevolution is not something positive that only exists because of management incentives.

Although coevolution is considered to be an empirical phenomenon in this research, a classification of the directional dimension in order to assess the impact of selection pressures is useful for both analysis (this book) and management and policy making (actors in the case studies). Such a classification should bear in mind that coevolution can take place regardless of whether actors want it or not, that coevolution does not necessarily move in the direction of progression and that assessment of the nature of coevolution relies on actors' valuation and interpretation. The work of Odum (1971) provides the basis for

such a classification as his analysis of two-species population interactions allows the outcomes of patterns of interactions per system to be subdivided. There are two conditions to the use of this classification in naming the direction of coevolution. First, it draws a distinction based on the relative size of each species or system. However, this research understands that the boundaries of systems are constructed and that it is unrealistic to determine whether the physical system is smaller or bigger than the social system. The second condition is that not every interaction leads to a change in the systems. This means that there are cases where interaction occurs but coevolution does not. This is so in cases of neutralism when, regardless of the interaction, neither system is affected. However, the types of empirical problems that are investigated in this book all imply interaction in which one or both systems were affected by the consequences of the interactions. In other words, cases where interaction but no coevolution occurs were not observed.

Bearing these provisions in mind, Odums' classification allows for a distinction to be made between three types of directions that coevolution can take. Interferential coevolution occurs when the systems involved draw from the same resources but in the act of doing so, compromise the systems concerned, in other words when the interaction does not lead to favourable results for any system. In cases where there is an asymmetrical distribution of favourable results, i.e. when one system is perceived to reach an improved stable state while compromising the resources and state of the other system, this type of coevolution is called parasitism. Finally, when both systems reach a more favourable state it is called symbiotic coevolution. This classification relies on actors' judgement that allows for an understanding that the direction of coevolution differs per actor and does not necessarily have a univocally positive connotation, hence the term multidirectional coevolution.

3.3.1 Conceptualising coevolution

To sum up what has been discussed so far in this chapter, coevolution is the process of multidirectional changes in the systems' state through both perceptible and blind reciprocal selection. Actors are able to apply selection patterns deliberately and to adopt or adapt in response to the results. Coevolution becomes visible as the succession of systems' states from one strange attractor to another. The next step is to relate these ideas to the empirical puzzles presented in Chapter

1. A conceptual model is helpful in understanding the relationship between coevolution and the role of decision making in this coevolution.

Coevolution is conceptualised in this research as a form of interaction that occurs between two systems: the physical system and the policy system. Physical systems, such as estuaries or tidal rivers, can be regarded as complex adaptive systems (Blott, Pye, Wal, & Neal, 2006; Hartvigsen et al., 1998; Levin, 1998; Macleod, Scholefield, & Haygarth, 2007; Pahl-Wostl, 2007; Surian & Rinaldi, 2003). While such systems were understood to be continuously stable in the past, they are now more often regarded as being temporarily and dynamically stable (Lankford & Beale, 2007) and shifting between stable states or attractors. Physical systems consist of multiple interrelated and intertwined elements and changes made to one or more of these elements for certain purposes, such as to suit economic needs, can set off a chain of responses from other elements that lead to erratic outcomes. For the same reasons but with the addition of reflexivity, societal systems can also be considered as complex adaptive systems.

At first glance, the demarcations between an entire societal system and a policy system are porous. Within the societal system there are actors who are able to make decisions on the physical system, e.g. when waterway and shipping administrations or port authorities are delegated to the management and development of this physical system. Because of this, they act as an intermediary between physical pressures and societal pressures that are converted into concrete measures concerning the physical system. It is easy to see that the (complex) dynamics of the decision making processes that take place within the policy system have an impact on the process of coevolution.

Part of these dynamics concern local boundary judgements to demarcate between actors who are and are not allowed to have a say in this decision making process. For this reason and based on respondents' boundary judgements, a distinction is made between the policy action system and the societal environment. The denominator 'action' indicates that it is this part of the societal system that can actively decide over the physical system. Coevolution in this research therefore concerns the cycle of reciprocal selection between the systems as mediated by the policy action system. Each change in the systems' state can be regarded as a full cycle of reciprocal selection. This cycle goes through a number of steps that are discussed in the following sections.

3.3.2 Initial selection pressures

The start of a case study is arbitrary as there is no real beginning to any case, since the situation at any given time is born out of earlier situations (cf. Mitleton-Kelly, 2007). Nevertheless, a case study does have to start somewhere. During this phase, it is not possible to determine in detail how the actual state has emerged but it is possible to determine the selection pressures the policy action system is being subjected to. There are two types of selection pressures: those exerted from the physical system and from the societal environment. The physical system is in a particular condition that requires action from the policy action system, e.g. when changes in the average water level have to be addressed in order to cope with this increase.

At the same time, there are also pressures from the societal environment to change something within the state of the physical system. For example, shipping companies can request a deeper navigation channel as illustrated in Chapter 1, environmental pressure groups can demand the restoration of the natural state of the system and concerned citizens can ask for higher and stronger dykes to protect their land against the possibility of flooding.

Both types of pressures are selection pressures as they present the policy action system with a situation in which not everything is possible. The current physical state does not allow for limitless tinkering, as some changes would clearly result in unfavourable effects. Similarly, the societal environment does not accept every type of decision. Resources allocated to the decision makers are limited, so the societal situation constrains the possibilities available to the policy action system.

3.3.3 Selection patterns: boundary judgements and variation

Taken together, all selection pressures present a complex puzzle to the policy action system. It has to make decisions regarding the physical system but some demands, wishes and practical possibilities are not compatible. Moreover, it is important to assess the state of the physical system as this determines what is possible. The complex adaptive nature of estuaries and tidal rivers means that any anthropomorphic change could have major consequences or no consequences at all and any major unfavourable changes are to be avoided. Naturally, the policy action system wants to develop an idea of what a certain change will result in.

In order to structure the information from the selection pressures it is subject to and to develop an assessment it can act upon, the policy action system applies two selection patterns, namely boundary judgements and diversity of information – as discussed in Section 3.2.3. Each of these two patterns can be subdivided in two more subtypes. Within the selection patterns of boundary judgements, the policy action system can decide on its connections and its composition. Within the selection patterns of diversity of information, the policy action system can decide on the research it requires and the scope of the project it intends to initiate.

Regarding connections, the policy action system can decide to connect with actors from the societal environment in order to communicate its plans or to draw upon the resources of these actors, such as their knowledge or funds, in order enhance the decision making on the physical system. It can also decide to go one step further to widen the boundaries demarcating the policy action system by including certain actors from the societal environment within the system, i.e. by altering the composition of the policy action system. In other words, these actors may be granted a say in the decision making, for example through advisory boards or through co-decision (Arvai & Gregory, 2003; Ast, 1998; Mostert, 2003).

Diversity of information is determined through research and the scope of the project. It has already been argued that research is necessary for understanding the potential impacts of a certain policy measure or operation (Cimorelli & Stahl, 2005). By ordering research, the policy action system also determines what is and is not being researched. With this it defines part of the diversity of information, as do the outcomes of the research. The other part is determined by the scope of the project, i.e. what is regarded as belonging to the project and what is left unconsidered. Together, research and scope account for the diversity that is created.

All four selection mechanisms are non-hierarchically related and dependent on one another (cf. Hisschemöller, Tol, & Vellinga, 2001; Jasanoff, 1987). Connections and composition both determine the system's boundaries while research and scope determine the diversity of information. The boundary judgements are also functional in determining research and scope while diversity is functional in determining which actors are granted access to the decision making process and which are not. The application and shape of these selection mechanisms help to deal with the selection pressures the policy action system is subjected to.

3.3.4 The projected attractor basin

As has been argued before, it is beyond the policy action system's information processing capacity to observe and understand all possible future attractors. The selection patterns therefore determine which part of the attractor basin is actually observed, i.e. the projected attractor basin. This projected attractor basin is the point of reference from which the policy action system determines the required policy measures. It is used to assess the current situation and the steps required to achieve the desired situation given the selection pressures the policy action system is subjected to.

Shaping the projected attractor basin is an important step because, given the complexity of the physical system, it is possible for a particular change to have disproportional and unfavourable results, i.e. it leads to a shift from one attractor to an unforeseen and unfavoured one. Bearing in mind the nature of the elements of processes, such a change can be persistent through the occurrence of hysteresis and lock-in, which could be very problematic if it presents an unfavourable situation. Shaping the projected attractor basin is therefore a relatively uncertain act for policy actors because of the inherent capriciousness of the systems. The projected attractor basin is the basis from which the policy action system derives its indications for action.

3.3.5 Consequences of selection and action

Having determined the projected attractor basin with an assessment of the situation and the measures that are deemed suitable to achieve the stated goals, the policy action system then executes the measures it has developed. In other words, it implements the policy, which exerts selection pressures on the physical system as it attempts to determine the future stable state. This could be the deepening of an estuary, the dredging of channels, the replenishment of shoals and sandbars or the reconstruction of dykes. In the case of estuaries and tidal rivers, such measures are often combined in a package consisting of main measures and complementary or supporting measures.

The selection patterns that are cast can have a two-fold impact. They affect the physical system because of the physical changes, but indirectly also affect the societal environment because of these physical changes. They can satisfy the actors who had wished for the physical change while it can lead to

protests from those who had opposed the physical change. The policy action system is therefore not only fed with feedback from the physical system but also from the societal environment.

As analysed in the work of Pressman and Wildavsky in 1973, the implementation of policy measures in order to achieve a goal in an erratic environment is often more complex than it is assumed to be (Parsons, 1995). A given incentive does not necessarily lead to the desired change, or it may lead to the desired change while also generating unwanted side effects given the complex nature of the physical system, as discussed earlier. The societal environment can display a similarly capricious response to the physical changes. Given the occurrence of punctuated equilibrium and lock-in, the results of the incentives from the policy action system can appear at a different locality than expected, which further complicates the whole operation.

Regardless, the physical system and (consequently) the societal environment respond to the incentives from the policy action system. This response determines the attractor basin available to the latter as the new situation, i.e. the new stable states of the systems, limits the attractor basin because path-dependency renders certain future trajectories through the attractor basin impossible. For example, a channel in an estuary may have reached its maximum depth before collapsing or societal resistance has grown to the degree that further modifications have become unfeasible. Coming full circle, the policy action system then faces this new situation through a myriad of feedback loops. It has to assess the new situation and to compare its desires with the practical possibilities. Upon conducting this assessment, it decides whether to change or not, i.e. it decides between adaptation and adoption. The selection patterns of boundary judgements (connections, composition) and diversity of information (research and scope) are applied in order to structure the information faced by the policy action system. The circular process of mutual selection then begins anew.

3.3.6 (Not) A sequential process

The conceptual model presented in the previous sections suggests a sequential process. Since the work of Cohen, March and Olsen (1978), Kingdon (1982), Hogwood (1987) and March (1994) among others, it is understood that empirically, decision making is seldom a well-structured, sequential process but more often an apparently messy process in which problems, solutions

and policy-entrepreneurs meet in a capricious, sometimes accidental, fashion. Parsons' suggestion (1995) that these models of decision making are at least superficially evolutionist-informed further indicates that decision making should not be treated as a sequential process when understood from a (co) evolutionary perspective. Nevertheless, complex (policy) processes evolve over time (see the discussion in Chapter 2), which implies that there are sequences of events out of which new events unfold. Decisions can demarcate policy rounds and a continuous, sometimes infinite, string of decisions builds the trajectory of the policy process through time and shapes the outcome (Teisman, 2000).

The conceptual model presented here therefore is a hybrid perspective that acknowledges that decision making does not take place in fixed sequential steps but that, at the same time, it has a longitudinal character consisting of consecutive events. The cycle of reciprocal selection is not considered to be a sequential process but a simultaneous process that consists of continuous feedback loops between the elements. The sequential presentation in this book is necessary in order to structure the empirical data for this research but should not lead to a sequential interpretation of events. Demarcations in time in the process of reciprocal selection are formed by perceived systems' shifts from one attractor to another as a result of the reciprocal selections. Such a shift, which carries with it the complex nature of change discussed earlier, can occur in the physical system, the policy action system or both. The sequence of systems' shifts through the attractor basin constitutes coevolution between physical systems and policy action systems.

3.4 Two case studies

Case studies are the appropriate means to investigate the empirical puzzles presented in Chapter 1 as this allows understanding events as a property of relations with their contingency (cf. Emirbayer, 1997). The empirical mainstay of this research therefore consists of two case studies: the Unterelbe estuary and tidal river in Germany and the Westerschelde estuary in Belgium and the Netherlands. The Unterelbe case covers the period between 1996 and 2007 and follows the attempts of the policy action system to prepare a deepening operation in order to facilitate the movement of bigger ships, how it decides to deal with physical changes following that operation while at the same time preparing for another deepening. The Westerschelde case runs from 1993 as the policy action system

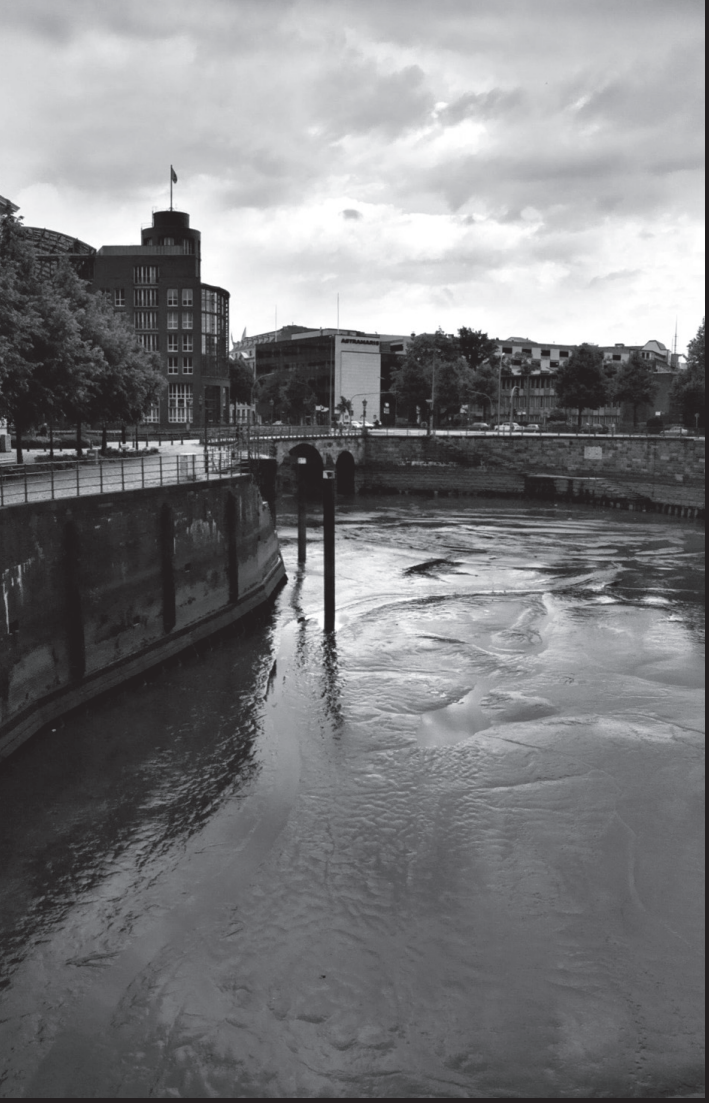
prepares a deepening of the estuary to 2007, when a new deepening operation is prepared while actors attempt to understand what happened physically after the earlier deepening.

Data was collected through interviews and document analysis. Document analysis covered over 350 newspaper articles, policy documents and scientific publications published about these cases. Newspaper articles from each case were triangulated using multiple sources. A full list of all articles and documents is included in the appendices of this book. Some of the main terms and abbreviations are kept in the original German or Dutch in order to preserve the character of the word in its context. A list of abbreviations and their translation is included in the appendix to this book. Forty-nine respondents were interviewed during semi-structured in-depth interviews that typically lasted about 90 minutes. These interviews were recorded and then transcribed. Upon request, three of the respondents took the opportunity to review the transcripts and to correct factual errors. Several respondents did not allow excerpts from the transcripts to be reproduced in this book. Consequently, no quotations were used except for the ones that were already published in the public domain (e.g. interviews in newspapers, texts from policy documents).

Using the documents, a chronological series of events was reconstructed for each case. This provides the backbone for the case studies. The personal accounts of the respondents were then used to give meaning to the events and to retrieve events that had remained outside the public domain. These accounts were merged to form a single hybrid account of each case, presented in this book. Inevitably, there have been instances where personal accounts of respondents diverged. This is indicated in the case descriptions. Once the case descriptions were finalised they were send to a number of experts involved in the cases for a peer review. Interpretations and analysis are the author's responsibility and the reviewers can not be held responsible for possible errors.

The cases are presented twice. Each case is presented chronologically first and in terms of coevolution afterwards. The first account is a representation of how the case developed and how it was experienced by the actors involved. The second account shows which reciprocal selections took place and how the situation as presented in the first account developed based on this. This two-fold presentation stems from the discussion in the previous section on the (non-)sequential nature of processes and is necessary in order to understand both systems' changes because of reciprocal selections and the erratic, complex nature of these changes. Systems' changes are explained in the second account while

the first account explains the latter. All theorising aside, the problems presented in the first chapter are empirical ones. The cases are presented in the following chapters.



Unterelbe

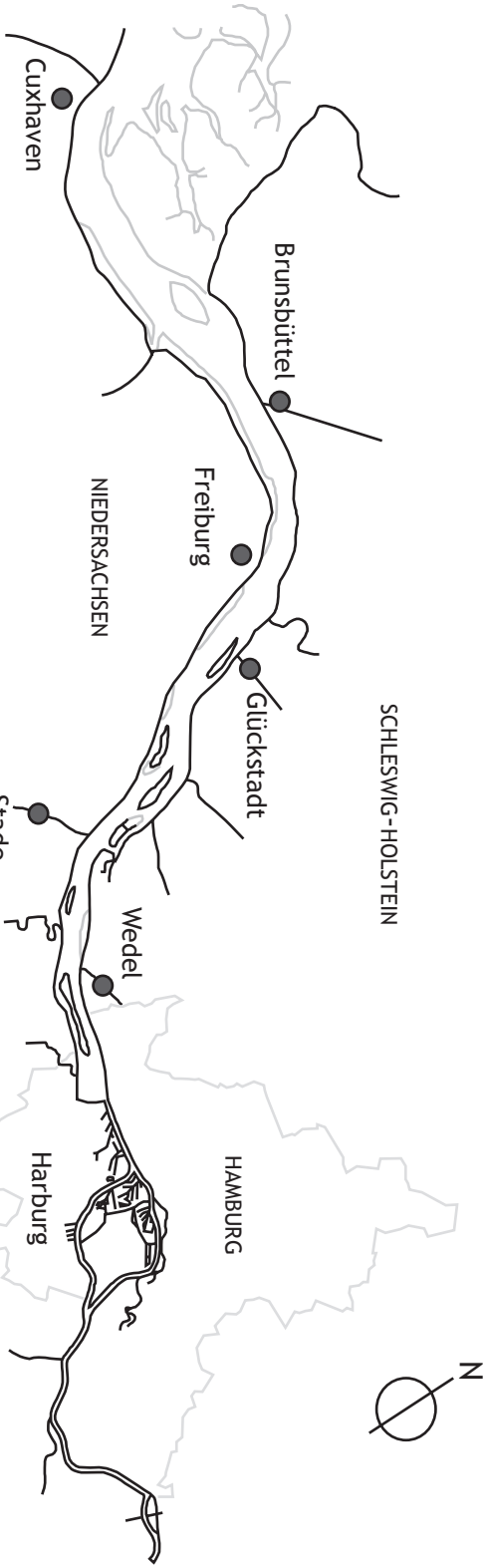


Figure 2: *Map of the Unterelbe and Elbe estuary, based on* WSD*-Nord, 2005*

Previous pages:
The changes in the tidal range (see page 67 for explanation) are visible in the channels of Hamburg. During ebb, the very low water level exposes the river bed;
View from the St.-Nikolai Kirche to the west, showing the city of Hamburg (foreground), the Unterelbe and the port (background).

Chapter 4: Modifying the Unterelbe between 1996 and 2007

4.1 Introduction

The Landungsbrücke at the bank of the Elbe river is just a few minutes walking distance from the central district of St. Pauli in Hamburg. Its location allows for a broad overview of the entire Unterelbe case. The redeveloped Hafencity, with its monumental storehouses once meant for cargo transfer and now home to Hamburg's nouveau riche, is located at the old docklands in the east. The Hafencity is also the site where the offices of the Hamburg Port Authorities and the main container operator, Hamburger Hafen und Logistik AG, are located. The quaysides extend high above the water level in order to withstand the tidal changes. The south riverbanks right in front of the Landungsbrücke display a dense forest of cranes and containers and the famous shipyard of Blohm+Voss. Ships such as the Queen Mary II dock here for refurbishment and repair. To the west lies the seemingly endless port while the north banks hold grand mansions between the trees and the Elbe beaches.

The Elbe is an important lifeline for Hamburg and indeed for the entire northwestern region of Germany, as it provides maritime access to one of Europe's largest ports and as such facilitates logistics, industries and jobs. The spacious offices of the Hamburg Port Authorities in the Hafencity bear witness to the port's potential and delivery of economic growth. The high quaysides, however, serve as a constant reminder that the Elbe abides by its own rules that are notoriously difficult to manage. The port thrives because of its open connection to the North Sea but this also means that it faces the brunt of the consequences from the over-utilisation of the Elbe.

The buzz of activity surrounding the shipyards and container terminals is a sign of a port fully alive, but their proximity to the city and the few as yet unutilised areas are a sign of the tension between further economic development and transitions to alternative ways of generating prosperity. The view of the north banks further to the west serve as a reminder that the Elbe is a natural, ecologically significant system that is highly valued by the people who live there – some of whom also enjoy the profits generated by the port.

The portion of the Elbe northwest from the city of Hamburg is a heavily modified river. Through the centuries, it has become fixed between dykes

and groynes, its flood plains have become confined behind these dykes and its tributaries have been closed off. The main consequences of these modifications are that the river's geometry has become fixed and funnel-shaped and its dissipative capacity has diminished. The main reasons why this stretch of the river has been modified are for flood control, port accessibility and the acquisition of new land for agricultural and urban purposes.

The port authorities of Hamburg continue to pursue modifications of the river in order to allow for larger cargo ships to call at the port. These modifications involve deepening the navigation channel in the river from time to time. This case study begins in 1996, when the port authorities were preparing for a deepening of the Unterelbe. The study follows the changes in the physical system and ends in 2006, when the policy action system attempted to deal with the changes in the physical system while simultaneously preparing for another deepening operation.

4.2.1 The physical system

The Elbe is one of the main rivers in Germany. Its sources are located in the Krkonoše mountain range in the Czech Republic. From these mountains, the river descends through the north of Germany and arrives at Hamburg 620 kilometres (km) later. From Hamburg, the river continues running towards the northwest before flowing into the North Sea after 730 km (Maring & Gerrits 2005). This last section, the stretch of river between 620 km and 730 km, is the focus of this case study. It is called the Lower Elbe or Unterelbe, and consists of two parts: an estuary between the river and the sea and a tidal river between the estuary and the city of Hamburg. Both parts are subject to tidal changes and are characterised by multidirectional flows, i.e. the water and with it, the sediment, travels up and down between the North Sea coast and Hamburg. The distinction between the tidal river and the estuary is an analytical one; empirically, they share the same issues and the dynamics are very similar. The two parts are treated as one physical system in this thesis: namely, the Unterelbe.

The region through which the Unterelbe flows is filled with marshland, flood plains, holms and a large number of islands situated just beyond the coastline. Over the centuries, this region has been permanently threatened by tides, sea currents and peak discharges from the Elbe River. The Unterelbe has multiple channels and tributaries and continues to have an estuary. Originally, this resulted

in a highly dynamic river basin. However, the development of permanent human settlements required a reduction in the risk of flooding and thus, dykes were constructed. A brief discussion of five types of anthropomorphic modifications is required in order to understand the current state of the Unterelbe.

First, there is the progressive construction of dykes. Dykes have been built in the Unterelbe in order to protect the land as well as to reclaim land from the marshlands for agriculture. Over time, the dykes were built increasingly close to the riverbanks. The quest for increased safety meant that people required a second line of defence, thus another line of dykes was built even closer to the river. The construction of the dykes means that the overall geometry of the river basin has become fixed and locked in and the total surface area of the flood plains has decreased. Altering this situation would be costly as the realignment of dykes is expensive and means that land must be converted back into flood plains.

Secondly, over time, the land behind the dykes has been converted into agricultural areas or used for the construction of buildings for living and working in. This means that the areas that were once part of the flood plains have increasingly become unsuitable for their original function, namely the absorption of excess water. Even if the dykes were to be relocated, these areas would still require conversion back into flood plains.

The third type of modification is the closing-off of tributaries. The main reason for this development is that the shorter the dykes are, the lower the cost of building and maintaining them. During times of increased risk, short dykes are also easier to monitor. Rather than following the contours of the land and river basin, people have opted for short dykes and decided to bridge tributaries with dykes or, in some cases, with a lock. As a result, many tributaries have been separated from the main Unterelbe. Although shorter dykes are indeed easier to maintain, this policy has at the same time diminished the capacity to absorb excess water from the Unterelbe in the tributaries.

The fourth human-induced modification is the change in morphology of the river, i.e. the changes to the riverbed itself. From the beginning of the 20th century to 1999, the Unterelbe has been deepened from approximately 8 metres to 14.50 metres in order to facilitate the sailing of larger ships. Coupled with the natural dynamics of the system, this has had consequences for the tidal energy and the sediment transport through the body of water. It has lead to a further widening of the estuary and lower absorption of tidal energy than in the past, causing more of this tidal energy to penetrate closer to Hamburg. The altered tidal activity also means that more sediments are transported through the

estuary. A positive feedback loop has emerged in which the silting up of flood plains has resulted in less room for tidal dynamics, which in turn has led to the upstream transportation of sediments that has ultimately reinforced the process of silting up. It is not just the geometry of the Unterelbe that has caused this phenomenon; the construction of a production site for Airbus airplanes in a lake at the borders of Hamburg, the Mühlenberger Loch, which is connected to the Unterelbe has also reduced the amount of room for tidal dynamics. Together, this has led to an increase in the tidal range at Hamburg.

The fifth anthropomorphic modification to the Unterelbe is the contamination of the water and sediments. The Elbe has for a long time served as a convenient place to dispose of toxic waste, especially during the time when most of the river was behind the Iron Curtain. Since the fall of the communist regimes, the quality of the water and sediments has improved considerably because of new regulations, closure of (old) plants and the installation of wastewater treatment plants along the river. However, the Unterelbe continues to suffer some pollution, for example from anti-fouling paint that is grinded away in Hamburg's shipyards and disposed of in the river. Although point contamination is now more or less under control, diffuse contamination continues to be a problem.

The five manmade modifications of the Unterelbe mentioned above have altered the Unterelbe since the region began to function as a base for human settlements. The physical system that exists at the start of this case study can be characterised as a tidal system that has considerably less room than in the past, with a fixed and relatively narrow geometry, with increasingly focused tidal dynamics, an upstream transportation of sediments and a poor but improving quality of water while the sediment quality seems to remain on an insufficient level, mainly due to contaminant loads from upstream.

4.2.2 The policy action system and the societal environment

Germany is made up of federal states and the Unterelbe crosses three of them. The north banks of the Unterelbe fall under the territory of Schleswig-Holstein while the south banks belong to Niedersachsen. In Hamburg, the river is situated within the borders of the Free and Hanseatic City of Hamburg, the Delegationstrecke where the City of Hamburg takes responsibility for the river. The Unterelbe outside the borders of Hamburg is a federal waterway, and therefore comes under the authority of the federal government. The borders

with Niedersachsen and Schleswig-Holstein are located west from the Neßsand Island, near Rissen and close to the Airbus site at Finkenwerder. If Hamburg authorities wish to do something with the Unterelbe outside its Delegationstrecke, authorisation is required from the federal government, through the Wasser- und Schiffahrtsdirektion Nord (Waterway and Shipping Direction Nord - WSD-Nord), as well as from the states of Niedersachsen and Schleswig-Holstein.

Within the city limits, Hamburg has sole authority over the river. The city of Hamburg and the Hamburg Port Authority (HPA) are very closely linked, the latter being a part of the municipal Department for Economy and Labour (Behörde für Wirtshaft und Arbeit - BWA) until 2005. It was called the Amt für Strom und Hafenbau before it became the HPA. The division between the city's government, Senate, HPA and BWA is a managerial one; in practice they often want the same thing done in the same way. The Handelskammer (Chamber of Commerce) is also closely linked to these entities. Much of the wealth in Hamburg has been created by the port in the past and it is the duty of the Handelskammer to keep the momentum going, thus making it a strong supporter of the further economic utilisation of the Unterelbe. For similar reasons, Hamburg Hafen und Logistik AG (HHLA), the main operator of the terminals, is constantly urging policy-makers to extend the port. These actors form the stable core of the policy action system in Hamburg: a system kept together by the desire and routines to expand the port and broaden the Unterelbe in order to facilitate the growth of the port and its activities.

The federal states of Niedersachsen and Schleswig-Holstein are not always in agreement with the desire the utilise the Unterelbe for economic growth. At times, they oppose the deepening of the Unterelbe out of concern for the safety of the dykes and the possibility of suspended contamination. However, they do acknowledge the impact of Hamburg's economy on the region and therefore allow the continuation of the river's deepening. Throughout the course of the period studied in this chapter, the states of Niedersachsen and Schleswig-Holstein agree and disagree with Hamburg at different times and for various reasons. They are sometimes very critical of the attempts to deepen the Unterelbe, while agreeing with it at other times.

There are two research institutes that play a role in the policies that guide the management and development of the Unterelbe. The first is the Bundesanstalt für Wasserbau (Federal Waterways and Engineering Research Institute - BAW), a federal research institute that delivers the information necessary for sound decision making. The BAW works mainly with computational models. The

second research institute is ARGE-Elbe (Arbeitsgemeinshaft für die Reinhaltung der Elbe - Association for Maintaining the Ecology of the Elbe), an inter-federal cooperative entity aimed primarily at monitoring and reporting the ecological state of the Elbe river basin from the Czech border to the North Sea with regard to water quality. Its goal is to produce a cleaner river. Formally, it has no decision making power but the fact that it is a cooperative initiative between the federal states along the river and the fact that it reports extensively on the state of the river give it some influence on decision making. Both BAW and Arge-Elbe are independent organisations and both share information with the policy action system as well as with the actors in the social sphere.

One important group of social actors in the debate and policy decision-making around the Unterelbe are the non-governmental organisations (NGOs). These organisations often have a long history of critically following the management and development of the Unterelbe and other natural assets in the region, and are often opposed to the ideas of the policy action system. For instance, Rettet die Elbe (Save the Elbe) is a 30 year old organisation of concerned citizens that questions the continuous economic utilisation of the Unterelbe in general. It does not focus exclusively on the environment or nature but rather aims to cover all subjects regarding the Unterelbe. BUND Hamburg (Bund für Umwelt und Naturschutz Deutschland - Association for the Protection of Environment and Nature), NABU (Naturschutzbund - Association for Environmental Protection) and WWF Hamburg are some other NGOs that have been around for many years. These groups are focused more exclusively on the environmental aspects of the region and the Unterelbe. The groups mentioned here – there are others that play a minor role – are not considered to be a part of the policy action system, as they do not share the policy-makers' objective to continue using the Unterelbe for further economic development. For this reason, the actors within the policy action system often have no desire to engage with these NGOs. At the beginning of the case study's time frame, there is a clear division between the policy action system on the one hand, which includes the City of Hamburg, its departments and HPA, and the social actors on the other. The case study begins in January 1996 when there is an intensifying call for a further deepening of the Unterelbe.

4.3.1 January 1996 – June 1996

Setting the scene - desire to deepen. Before 1996, the most recent deepening operation, which saw the Unterelbe deepened to 13.50 metres, was completed

in 1980. Ever aware of the competition between the different ports along the North Sea coast, the City of Hamburg is eager to plan a new deepening operation. By the end of 1995 and the beginning of 1996, the call for further deepening begins to take shape as concrete plans. A new deepening operation is strongly promoted by the senator of the Behörde für Wirtschaft und Arbeit (BWA), Erhard Rittershaus, who states in a meeting of the Senate of Hamburg in January that the low depth of the navigation channel has prevented hundreds of ships from calling at Hamburg. The Senate, shocked by the statistics, demands more detailed information from the Senators' department, only to find out that there is not a single case of ships being unable to reach the port. The Schiffsmeldedienstes Hamburg, which collects data on all ships calling at the Hamburg port, reconfirms this. The Senator is forced to admit that his statement is, in fact, untrue but claims that what he had actually meant to indicate was that theoretically speaking, there are 120 ships a year that are unable to enter or leave Hamburg fully loaded.

The Senator also indicates that two shipping companies, Maersk and Evergreen, have threatened to leave Hamburg if the Elbe is not deepened. It is later revealed that Maersk's reasons for wanting to leave were not related to the deepening of the Unterelbe but rather because its choice of Dutch pilots Kotug had stirred anger among German navigators and led to the deliberate obstruction of the unloading of Maersk ships and damages of 200.000 euros. Evergreen wanted to leave because of the high costs of calling at Hamburg's port. Even with such unclear facts and figures being presented, a new deepening operation is planned to begin as soon as possible. At this point, it becomes clear that this new deepening operation is very likely to be implemented as its strongest promoters, the HPA, BWA and its Senator, are all a part of the same governing and decision making system, namely the Free Hanseatic City of Hamburg.

4.3.2 June 1996 – July 1996

Laying the foundations - presenting the preliminary plans - sediment management. In June 1996, the policy action system announces that research by the BAW illustrates the feasibility of a further deepening operation. The effects on vegetation and animal life, however, are as yet unknown, as the results of the Environmental Impact Assessment (EIA) carried out by the Behörde für Stadtentwicklung und Umwelt (BSU) are delayed until the end of 1996. The deepening immediately

gets the nod nevertheless.

The total dredging volume is estimated to be between 25 and 30 million cubic metres. Of the total dredging volume, approximately 2 million cubic metres appear to be strongly contaminated and require remediation in a treatment plant. Until then, material from maintenance dredging comes up to approximately 15 million cubic metres per year, so it appears that the new deepening operation will result in a small increase (an additional 3-5 million cubic metres annually) in material from maintenance dredging. The total cost of the operation, without maintenance dredging, is estimated at 200 million DM and is to be distributed between the City of Hamburg (10%) and the federal government (90%). The planning for the deepening operation begins in Spring 1996, despite the lack of an EIA and with no knowledge about the potential consequences on the Unterelbe's ecology.

When Senator Rittershaus presents the preliminary plans in June 1996, he states that "Die wirtschaftlich dringend erforderliche Vertiefung der Elbe hat keine gravierenden Folgen für Natur und Umwelt" ("The deepening is necessary in order to promote the economy and will not have negative effects on nature and the environment." - LG). The Senator and his officials from the BWA and the Port Authorities assume that there will be no negative environmental effects and are willing to take the risk to go ahead with the deepening operation without an EIA. At the same meeting, Georg-Wilhelm Keil, president of the Wasser- und Schiffahrtsdirektion Nord (WSD-Nord), reconfirms that the deepening will not have a negative effect on the natural dynamics of the Unterelbe and will not increase the risk of flooding.

Although claims are made that a new deepening operation is feasible, problems begin to appear in the planning stage when it becomes known that there will be more dredged material than can be coped with. In April 1996, there appear to be insufficient sites to dispose of the dredged material. Remediation would be very costly and in some cases is not well developed. Although the neighbouring federal state of Schleswig-Holstein is currently in the process of constructing a disposal site, it is reluctant to offer it to Hamburg, asserting that the city should solve its own problems.

Hamburg, however, does not have the capacity to store its own dredged material. Its confined sites Francop and Feldhofe are estimated to have reached their maximum storage capacity till 2006 and will already be further stretched by another 2.5 million cubic metres of contaminated sediments that will be removed from the harbour basin and Unterelbe during maintenance operations. The city

will not have the capacity to deal with the dredged material from the planned deepening operation and from the maintenance dredging works that will later be conducted. Both operations are expected to generate more dredged material per operation than is currently the case, thereby adding even more pressure on the policy action system to act.

Several possible measures are considered. First, the City of Hamburg decides to rename the sediments as 'Elbeschlick' , in order to stress the point that the sediments are not a problem that Hamburg should have to deal with alone, but rather a problem for the whole region including the federal states of Niedersachsen and Schleswig-Holstein. In 1984, both federal states had promised Hamburg that they would reserve 200.000 cubic metres of space for the disposal of contaminated sediments, but since that time no additional capacity has been offered. Another solution had been offered in the summer of 1995: to store the sediments in the abandoned salt mines of Dow Chemicals at the site of Stade. This option was found to be unfavourable because of the high cost and the damage it would do to the environment. A third option is to dispose of the sediments in the Unterelbe and expect them to flow back to the North Sea during low tide. This is the option that is selected because it appears to be the most cost-effective.

4.3.3 July 1996 – May 1997

Responses from societal actors. The City of Hamburg, its departments and the shipping companies are happy with the decision to deepen the river and satisfied with the various possible solutions for managing the dredged material. However, this is not the case for everyone else. Recreational users of the Unterelbe fear that bigger ships will cause larger stern waves and that the deepening will increase the velocity of the currents, thus putting recreational shipping on the Unterelbe at risk. Environmental pressure groups such as BUND Hamburg strongly oppose the deepening as they fear the effects this will have on tidal changes, current velocity and the resuspension of contaminated sediments. The government of Schleswig-Holstein acknowledges the perceived need to deepen the river but opts not to support the deepening because of the risks it may pose to the environment with regard to resuspended contaminated sediments and safety. Later, Rainder Steenblock, the Minister for the Environment from Schleswig-Holstein, decides to designate an island at Glückstadt as a protected nature area even though

Hamburg intends to store dredged material there.

4.3.4 June 1997 – October 1998

The Environmental Impact Assessment - Planfeststellungsverfahren - preparatory dredging – societal protests. Senator Rittershaus presents the results of the Environmental Impact Assessment on June 18, 1997. The general assessment is that the consequences of the deepening will be minimal. The assessment is extensive, covering several different areas including topography, hydrology, morphology and the development of the riverbanks and flat water areas. An estimated 92 hectares of biotopes are expected to disappear because of the deepening operation. WSF-Nord is compelled to prove whether the results from the deepening exceed the prognosis. If so, compensation must be provided.

Rittershaus presents the potential negative consequences as a minor problem because the City of Hamburg intends to invest 10 million DM into the construction of flood plains and the realignment of dykes. The volume of dredged material is estimated at 30 million cubic metres, of which 27.5 million cubic metres will be dispersed in the Unterelbe where it is supposed to be taken to the mouth of the estuary by the fresh water discharge from the Elbe. The remaining volume of dredged material will be stored.

The presentation of the EIA signifies the formal beginning of the planning process, which is called 'Planfeststellungsverfahren' in German. Technically, a sound planning process is necessary for the issuance of a permit, granted by the policy action system, which is required to start the dredging operation. However, at this same meeting, it is announced that the HPA will begin deepening before the permit is issued. Jörg Osterwald, Baudirektor of WSD-Nord, states that this initial operation will remove the first 30 centimetres of the riverbed. The argument put forward is that this should not be regarded as the deepening operation itself but rather as a preparatory operation to facilitate a good deepening process; hence, no official permit is required.

The planning process begins on July 29, one month after the presentation of the EIA and the expression of intent to start dredging immediately. The first stage of the planning process lasts for three months, during which BWA assesses the plans of the Wasser- und Schifffahrtsamt Hamburg. The plans will be published after this period and the stakeholders including residents, municipalities, fishers and environmental pressure groups will then be allowed to voice their opinions

on the plans.

The environmental pressure groups are the most vocal in their objection to the deepening. Förderkreis Rettet die Elbe, Naturschutzbund Hamburg, Landesnaturschutzverband Schleswig-Holstein, WWF, the Landesverband Bürgerinitiativen Umweltschutz and the federal departments of the Bund für Umwelt- und Naturschutz (BUND) Hamburg, Schleswig-Holstein and Niedersachsen all protest against the plans. They fear that the deepening will further damage the ecological state of the Unterelbe, and also fear that the risk of flooding will increase. The BWA, however, brushes aside these protests and promises that all damages will be compensated. The pressure groups are infuriated. They state publicly that while they do not oppose the deepening as such, they demand a strategy that will complement the natural ecological developments of the river: "Wir brauchen eine Strategie, die mit der Natur arbeitet und nicht gegen sie" ("We need a strategy to work with nature, not against nature." - LG).

The formal objections from the stakeholders are processed in hearings held in the second week of December. Approximately 650 objections are heard by the Amt für Strom- und Hafenbau. Stakeholders complain that these hearings are meaningless because the decision to deepen the river has already been made, as evidenced by the fact that dredging is scheduled to begin in the next few days. They also argue that the office assessing the objections is not independent as it is a part of the same organisation preparing the deepening. On Monday, December 15 1997, there is a procession of cutters along the Unterelbe as fishermen protest against the deepening. Despite these protests and formal objections to the deepening operation, the HPA orders the dredging works to start on Wednesday.

The dredging works are halted on January 1, 1998. Four fishermen had filed their objections to the Oberverwaltungsgericht and the judges have decided that the dredging works are illegal, and ordered a stop to the operation. The judges rule that dredging can only commence again after the planning procedure has been finalised, as all objections to the operation are based on the current state of the estuary which the dredging operations will alter.

At this point, the City of Hamburg offers 1 million DM to the fishermen as compensation for damages, but they decline the offer. In February 1998, another offer is made, this time of up to 7 million DM. This offer is accepted by the fishermen, who agree to withdraw their complaints once the first payment is made. An agreement between the fishermen and the BWA is signed in which the Behörde promises to reinvigorate the fishery sector through investments and to minimise any hindrance to fishing caused by the deepening operation.

Just opposite of St. Pauli the port of Hamburg shows its industrial face. This is the Elbe Dock 17 at the shipbuilding and engineering works Blohm + Voss.

Although the objections from the fishermen have been dealt with, the complaints from the neighbouring countries and the environmental pressure groups remain. Complaints coming from neighbouring countries are brushed aside, with the Behörde arguing that the Länder are required to comply with the decision because of the principle of cooperative neighbourliness. Complaints from the environmental pressure groups are also brushed aside. BWA decides that these groups are illegitimate parties and therefore the City of Hamburg is under no obligation to respond to them. The complaints remain unaddressed. The preparatory dredging operations resume on March 10, 1998 after the Oberverwaltungsgericht has lifted the ban.

4.3.5 October 1998 – December 1999

Restarting the preparatory deepening operation - defending the necessity of the deepening - European Commission warning – deepening. Although the deepening operation is now becoming more and more of a reality, it remains controversial. Förderkreis Rettet die Elbe releases a statement in which it questions the data used to rationalise the arguments for the operation. Bernd Meyer of BWA sidesteps the issue by arguing that the important thing is that a deeper Unterelbe can be used to increase the attractiveness of the port of Hamburg to shipping companies. Research from Dieter Läpple of the Technische Universität Hamburg (TUHH) shows that the port generates approximately 62.500 jobs. While this is a considerably large number, it is less than half of that stated by the HPA, who claim that there are 140.000 people working at the port. This number comprises all the workers who are directly or indirectly dependant on the port. Läpple's data accounts for 8 percent of Hamburg's labour force.

The environmental pressure groups, after having been brushed off by the local authorities, turn to the European Commission with their complaint. The European Commission decides that the City of Hamburg has violated the EIA procedures and the Habitat Directive and issues a formal warning in November 1998. The Commission threatens to issue a fine of multiple millions of DM and to file a complaint to the European Court if the warning remains unheeded. Hamburg continues to maintain that the preparatory deepening operation is not really a deepening operation and therefore not subject to the EIA, even though it will lower the riverbed by approximately 35 centimetres.

The preparations for the actual deepening continue. The Hamburg Senate formally agrees to the deepening in January 1999. It then takes another few weeks to reach an agreement with the states of Niedersachsen and Schleswig-Holstein. The Länder agrees and the formal planning procedure is finalised on March 5, 1999. The dredging operations are now intensified.

A sober ceremony marks the end of the deepening operations in the Unterelbe nine months later on December 14, 1998. Ships with a draught of up to 12.80 metres are now able to call at the port without being dependent on the tide. The mayor of Hamburg, Ortwin Runde, states that he feels this deepening will be sufficient for years to come. The real costs of the entire deepening operation have exceeded the planned budget by 60 million DM, having risen to 260 million DM in total. No reason is given for this. One-sixth of the costs are allocated towards the construction of compensation measures at several sites

around the Elbe.

4.4.1 December 1999 – April 2002

Debating a modified Unterelbe – Wilhelmshaven – a new deepening? – struggling to compensate. The Unterelbe suffers from oxygen depletion in the summer of 2000. Often, the oxygen level drops below the minimum limit of 3 milligrams per litre, causing fish to die or influencing their senses so that they are unable to find their birth grounds. According to the ARGE-Elbe research institute, the depletion of oxygen has been at least partly caused by the deepening of the Unterelbe - the relationship between the depth and the surface of the river has had a negative impact on the capacity of the water to absorb oxygen. The environmental pressure groups continue to speak out against the recent deepening and other modifications to the Unterelbe.

However, the port authorities and their associated actors are already thinking about another deepening operation. The chairman of the association of German ports, Peter Dietrich, who works with Hamburg Hafen und Logistik AG (HHLA), has argued that another deepening is necessary. Meanwhile, UNESCO is preparing to include the Unterelbe in its list of world heritage sites.

This time, a different issue brings up the possibility of a new dredging operation. On March 30, 2001, Niedersachsen, Bremen and Hamburg agree to develop a new deep-sea port at Wilhelmshaven. The purpose of this new port, which is to be located almost directly along the coast of the North Sea, is to create additional capacity for the turnover of goods, especially for those ships that are too large to travel on the Unterelbe or the Weser. Mayor Ortwin Runde approves the deal on behalf of the City of Hamburg. This causes an uproar among the Hamburg Senate, as they would have preferred for the deep-sea port to be located at Cuxhaven, directly at the Elbe's estuary. They fear that the construction of such a port at Wilhelmshaven will draw ships away from Hamburg. In response, the mayor of Bremen defends the decision to build the new port: "Die ersten Schiffe, die nicht mehr nach Hamburg und Bremerhaven kommen können, sind bereits bestellt, nämlich bei den Asiaten - ich weiß das. Wenn wir dieses Problem aussitzen, dann sind wir weg." ("The first ships that can't call at Hamburg and Bremerhaven have been ordered already in Asia. I know that. If we don't act now we will lose ground." - LG). Newspapers Die Tageszeitung and the Hamburger Abendblatt begin to speculate about a new deepening of the Unterelbe.

In spite of the Hamburg Senate's criticisms, Mayor Ortwin Runde pursues discussions with Niedersachsen and Schleswig-Holstein and manages to reach an initial agreement with them to deepen the Unterelbe again. His reasoning is that while awaiting the construction of the new deep-sea port, a deeper Unterelbe should be able to accommodate the larger ships of the future. The GAL, the green coalition in the Hamburg Senate, is furious about this decision but the ruling SPD (Social Democratic Party) has already decided that a new deepening is unavoidable. This provokes fierce opposition from a number of social actors. BUND argues that it is unnecessary to deepen the Unterelbe for ships that are not even on the drawing board yet. The Internationale Kommission zum Schutz der Elbe (IKSE) believes that a new deepening will violate the Habitat Directive. Many accuse the Senator and the port authorities of contravening their earlier statements that the recent deepening would suffice for a long period of time.

Elections held in the summer of 2001 herald a change in the Senate, with the Christian Democratic Party (CDU) heading the BWA and appointing Gunnar Uldall as its Senator. Gunnar Uldall has been strongly against the agreement to build the deep-sea port at Wilhelmshaven and one of his first measures as Senator is to announce that Hamburg will not take up its 20 percent share in the project. Instead, he aims to deepen the Elbe as soon as possible in order to secure a potential market share of the new port at Wilhelmshaven. He appoints a civil working group to investigate the possibility of conducting a new deepening operation. Later he also announces that the Länder have agreed to a new deepening. Niedersachsen and Schleswig-Holstein assert that they have not granted permission. Social actors continue to oppose any new deepening.

On the surface, the policy action system seems confident that a new deepening is feasible and strives for quick decision making on it. However, the actors within the system are struggling with the compensation measures from the previous deepening. It has become clear that these compensation measures are, in fact, very difficult to implement. Although people in the HPA and BWA have made suggestions on how to realise aquatic compensation, such as through the regeneration of the secondary channels, putting these ideas into practice proves to be more complicated than expected. Compensation measures are therefore focused on the terrestrial dimension but this poses another range of problems. The terrestrial compensation predominantly involves 'extensiverungs Maßnahmen', which are measures to diminish land use. However, there are few spots along the banks of the Unterelbe where room can be found for such compensation. Many

flood plains have disappeared over the years due to the construction of dykes and the rise of the water level. Most of the land behind the dykes is already in use and most of the areas that are not have gradually developed into habitat for birds, thus ironically obstructing ecological compensation there as well.

Away from the public eye, the search for terrestrial compensation results in heated discussions between the three federal states over which state gets how much compensation in which areas. Then the City of Hamburg argues that some of the observed physical changes to the Unterelbe cannot be attributed to the deepening operation anyway and should not be taken into account when debating compensation. In other words, compensation does not need to be as intensive as planned before because it should only be required to address the unfavourable changes that have clearly been caused by the deepening.

This discussion finally results in fragmented physical compensation areas that are mostly not aquatic and in terrestrial compensation measures that are mostly implemented at quite a distance from the Unterelbe in other locations throughout the states. This is not illegal; however, some people in the policy action system feel that the actual compensation does little to alleviate the effects of the deepening. Despite good intentions, the compensation is deemed to be only a small success among all actors.

4.4.2 April 2002 – February 2003

Announcing a new deepening - societal protests - Elbe flood - presenting the preliminary plans - Federal response. Senator Gunnar Uldall calls a press conference on April 4, 2002, in which he announces that the City of Hamburg will deepen the Unterelbe by 1 to 1.5 metres, less than three years after the previous deepening operation has been completed. He emphasises that attention will be paid to the risk of flooding and to the environment: "die Umwelt soll "nicht unverhältnismäßig belastet" ("The strain on the environment should not be out of proportion." - LG). However, he invites the environmental pressure groups to a meeting in which they can discuss the new deepening with him.

The meeting takes place but does not satisfy any of the concerned parties. The environmental pressure groups make it known to the senator that they oppose a deepening but, if it is unavoidable, that the senator should wait for the outcomes of the monitoring project as there is too little information available at this point about the effects of the latest deepening. The senator in

turn emphasises that Hamburg wants to be able to receive ships of any size independent from the tide – something that is currently impossible.
Protests are heard not just from the environmental pressure groups but also from the neighbouring Länder and municipalities. The council of Elbmarsch in Niedersachsen adopts a motion in which it asks the federal government to act against the deepening. The municipality of Pinnenberg prepares a Protestnote. Besides the fear of an increased risk of flooding, several municipalities agree that the compensation measures for the previous deepening have not been properly implemented. The City of Hamburg's decision to pull out of the deep-sea port project causes the government of Niedersachsen to pull its support of a further deepening of the Unterelbe in a tit-for-tat move.

The summer of 2002 is marked by heavy rainfall. The Elbe cannot cope with this sudden excess of water, leading to the breaching of dykes, which not only causes severe damage from flooding but also transports contaminants through the Elbe. The normal discharge of the Elbe during the summer is 300 cubic metres per second but this August, it peaks at 5.500 cubic metres per second.

Beyond the physical damage, this calamity is another spark in the debate over the deepening. The GAL calls for the senator to think about safety instead of employment. BUND states that it does not believe a new deepening can be carried out without any consequences on the environment, calling for the relocation of dykes and the creation of flood plains as compensation measures for the earlier changes to the estuary. Schleswig-Holstein once again demands that Hamburg must first provide evidence that a deepening will not increase the risk of flooding. Hamburg responds that this is not necessary as the effect will be small.

Senator Uldall continues to develop his plans in spite of these protests. In October he tells the newspaper Hamburger Abendblatt that the civil working group has released a preliminary research report. One of the main conclusions – besides the conclusion that a deepening is feasible – is that it will not increase the risk of flooding. Hans-Gerhard Kniess of the WSD-Nord, which is part of the working group, supports this claim by stating that the previous deepening has not caused any changes other than the ones expected. There were, indeed, changes to the tidal range but the working group concludes that this was due to reasons other than the deepening of the Unterelbe. Consequently, Uldall orders the start of a cost-benefit analysis and plans the next steps. He expects the Planfeststellungsverfahren to be finalised by the end of 2006 and thinks that the dredging works can commence in early 2007.

However, within the policy action system and away from the public eye, preliminary results from the monitoring of the earlier deepening lead to more cautious conclusions. Indeed, the outcomes so far are in line with the predictions that had been made by the EIA but these conclusions were drawn early and some experts think too early. In addition, it appears that the erosion of the riverbanks is larger than expected. Meanwhile, the Unterelbe continues to undergo further physical changes. These are presented to the public as changes caused not by the deepening but rather, as a result of natural developments and should therefore not provide a reason to halt any further deepening.

In actual fact, researchers within the policy action system are struggling to disentangle the complex causal relationships within the Unterelbe and are finding it very difficult to separate natural developments from anthropomorphic developments. Besides the past changes made to the geometry of the basin and the construction of the Airbus site in the Mühlenberger Loch described in Section 4.2.1, other anthropomorphic developments include the filling up of harbour basins as well as the deepening operation.

The first two operations considerably reduced the total surface area of the river in and around Hamburg, which in turn decreased the river's capacity to dissipate tidal energy, while the deepening has likely allowed for the tidal energy to meet less resistance on the way to Hamburg. The combined result is an increase in the tidal range – the difference between the water level during periods of ebb and periods of high water. Measurements at St. Pauli in the heart of Hamburg reveal that during periods of ebb, the water level is lower than ever, to the extent that the riverbed is exposed in the channels in the city centre. The water level during periods of high water, on the other hand, is higher than ever and this increases the risk of flooding the quaysides. The tidal range has been increasing for about a century but this has been accelerated ever since large-scale anthropomorphic changes such as deepening operations and the construction of dykes from 1.80 metres in 1850 to 3.60 metres in 2004 have begun to be made. At this point in time, the policy action system begins to realise that very real problems and risks will emerge if this trend continues. However, it continues to maintain in public that there is no connection between these problems and the deepening.

The announcements proclaiming that a new deepening is feasible raise another series of protests from the neighbouring Länder. Landeskreis Stade argues that the tidal range has changed because of the deepening, contrary to what BWA and WSD-Nord are saying. The municipality of Hornerburger expresses the same

opinion and wonders why the preliminary research has not observed what people living along the dykes say to observe every day. Small ports such as Freiburg complain that the previous deepening has caused an accumulation of sediments in their ports, consequently raising the costs for maintenance dredging. Many actors are of the opinion that discussions over a new deepening operation should wait until the monitoring programme has delivered its results in 2009 – 10 years after the previous deepening operation was conducted.

Those who oppose the deepening are supported by the new German federal government consisting of the SPD and the Grüne. A coalition agreement has been drafted in which it is explicitly stated that a new deepening is out of the question: "Die Ausbaumassnahmen und in ihren Auswirkungen vergleichbare Unterhaltungsmassnahmen auf der Elbe werden nicht fortgesetzt." ("New operations, and maintenance operations that have a similar impact on the Elbe, are to be discontinued." - LG). BWA's press officer asserts that this formal block from the federal government only applies to new projects and argues that since the next deepening is already up and running, the decision does not apply to it. This is met with approval from the shipping companies and terminal operators, and with disapproval from environmental pressure groups and local authorities outside Hamburg.

4.4.3 February 2003 – May 2004

Debates about the deepening - Federal disapproval - preliminary research outcomes - further planning of the deepening. This period is marked with relatively few events except for the continuous exchange of views. BAW and HPA start to organise meetings in the region to provide information about the next deepening. During one such meeting, Gerd Flugge from BAW states that the fear of flooding is subjective and not based on facts. He appreciates that peoples' fear of flooding may be based on past disasters but argues that there is no reason to worry as current safety levels are much higher than they have ever been.

BAW does, however, acknowledge that the tidal range has increased considerably and that problems with the sediments transport may arise due to the increased tidal velocity. The new dredging works are not expected to require considerable reallocation of sediments but the tidal currents in the Unterelbe may cross this point of departure. This development is expected to be preventable through the construction of artificial shoals in the mouth of the

estuary which may help to slow down the currents. BAW argues that all these developments are rooted in the modifications of the Unterelbe made during the 1970s and that the recent deepening has not played any role in causing these physical changes to the river. Instead, the new deepening should be used to counter any unfavourable developments.

While the City of Hamburg is preparing for a new deepening operation, the federal government does not appear to support these plans. When the federal Minister of Transport releases the Bundesverkehrswegeplan (Federal Plan for Infrastructure), it makes no reference to the plans for deepening the Unterelbe. The federal government states in a commentary that planning for a new deepening can only begin after the monitoring process has been finalised. The BWA's press officer Christian Saadhoff states that the deepening has nothing to do with this plan and that people should not worry that the deepening will not go ahead.

Throughout the rest of the year, the Senate, HPA, BWA, HHLA, and others make statements justifying the need for a deeper Unterelbe as the turnover in the port grows considerably. Local authorities from neighbouring states as well as environmental pressure groups such as NABU and BUND continue to oppose the deepening.

Two more research reports are released during the spring of 2004 and this is when the concrete plans for the new deepening are presented. A cost-benefit analysis indicates that a deepening would bring in more revenue than the costs it would incur, but specific numbers are not published. The deepening is estimated to cost 350 million euros, of which one-third will be paid by the City of Hamburg and two-thirds will be paid by the federal government. The junior minister of the federal Ministry of Transport indicates that the federal government will grant this budget before the summer of 2004. There are no indications as to what has caused the change in the federal point of view.

There is also more information on the physical dimensions of the new operation. The Bundestanstalt für Wasserbau und Gewässergüte does not believe that a deepening would lead to ecological or hydrological problems. Jörg Oellerich from HPA suggests using some of the dredged material to build shoals in the mouth of the estuary in order to slow down the velocity of the currents and to decrease the tidal range. Ideas are also put forward to use dredged material to restore the beaches along the Elbe.

The Wasser- und Schiffahrtsamt Hamburg (WSA), which has been monitoring the effects of the most recent deepening operation, confirms that there have been no unfavourable effects other than those that had been predicted to

occur. The monitoring programme involves observing nine measure points along the Unterelbe and is expected to run for 15 years after the previous deepening. The WSA agrees that the tidal range has increased since 1843 during which time the Unterelbe has first been deepened from 4 metres to the current14.50 metres. However, they argue that the changes in the tidal range are not exclusively related to the deepening but also to the progressive dykening and closing of the river's branches. After the last deepening, the tidal range was predicted to increase by 12 centimetres but so far the increase has only been by 8 centimetres. The results of both research projects are released but the research underpinning these findings is not published.

During this time, Senator Gunnar Uldall presents the time frame for the project: after formal agreement has been obtained from the federal government in the next few months, it will take another year to complete more detailed studies and to develop an EIA. The Planfeststellungsverfahren is scheduled to start in January 2006, while the deepening is planned to begin in 2007 and be completed by 2009. In an interview with the Hamburger Abendblatt, the senator once again expresses his desire for the planning to begin as soon as possible.

As with the earlier situation, the environmental pressure groups vehemently oppose this planned deepening. The difference is that these groups are now formally entitled to file a complaint during the Planfeststellungsverfahren. They argue that a new deepening is not necessary because there are no existing ships that would require this depth (Rettet die Elbe) and fear further detoriation of the flood plains and more oxygen depletion (BUND). They point out that an 8 centimetre change in the tidal range may not seem like much but that even a change of 1 centimetre can cause considerable ecological changes. They also point out to the rest of the public that the compensation measures from the last deepening operation have been poorly executed due to difficulties with the acquisition of land.

The Niedersachsen and Schleswig-Holstein local authorities oppose the deepening because they fear an increased risk of flooding and the possible sedimentation of the Unterelbe's secondary channels. The small towns and ports along the Elbe such as Stade, Wedel and Freiburg fear the deepening will lead to sedimentation of the ports, which will reduce opportunities for recreational shipping. They propose the establishment of a fund from which maintenance dredging can be paid for. Mr. Oellerich denies that there is a link between the deepening and the sedimentation of the ports.

4.4.4 May 2004 – October 2004

EU Habitat Directive – Wilhelmshaven – moderation – sudden sediment accumulation. Despite the City of Hamburg's eagerness, the deepening does not take place overnight. Niedersachsen and Schleswig-Holstein submit an application to the European Commission to include the banks of the Unterelbe in the EU Habitat Directive. This submission may delay the deepening as any change to such an area must be accompanied by several compensation measures. At the same time, this move allows the two neighbouring federal states to refrain from submitting the Weser and Ems to the European Commission, which will make it easier for them to build the deep-sea port at Wilhelmshaven. Senator Gunnar Uldall opposes this move but is forced to accept it. The Handelskammer of Hamburg in turn writes a letter to its mayor, Ole von Buest, complaining that this should not have happened. The Senate of Hamburg, however, admits that it does not have any choice but to accept the situation: "Wir hätten es sowieso nicht mehr verhindern können. Unser Widerstand hätte aber zu Verärgerungen in Brüssel geführt" ("We could not stop this anyway. Our resistance has provoked irritation in Brussels." - LG). In other words, the Senate realises that it is being watched by the European Commission for its failure to comply with the directives for sound decision making on the most recent deepening operation. As such, it cannot afford to block this move by the two states.

Mayor Ole von Beust sends a letter to Prime Minister Gerard Schröder to ask for a special treatment in deepening the Elbe while Senator Gunnar Uldall lobbies the European Commission to exempt the port of Hamburg from the Habitat Directive. He presents an old treaty from 1922 in which the German Reich had promised to help to keep the Unterelbe accessible. He claims that this treaty does not allow the federal government to submit the Unterelbe to the Habitat Directive. However, the federal government replies that the treaty does not compel them to deepen the Unterelbe but rather, obliges them to assist in the deepening, which is something quite different from what Hamburg is demanding.

Although this judicial strategy does not work, the combination of various strategies finally compel the federal government in Berlin to decide to accept the submitted areas under the condition that the allotment of the Elbe banks as Habitat areas does not hinder the deepening operation. The environmental pressure groups are mildly optimistic as this would require a new deepening operation to pass the Habitat test. HHLA and the Handelskammer believe

that a deepening has now become impossible and warn of negative economic consequences. In practice, however, there is still room to have the Unterelbe deepened.

Having passed this hurdle, Hamburg moves on to take up the next one. Ole von Beust decides to support the deep-sea port as a 'central front port' in exchange for support for the deepening from Niedersachsen and Schleswig-Holstein. This decision is formalised in a document signed by the Senatskanzlei and the governments of Niedersachsen and Bremen that says: "Die Projekte stehen nicht in Konkurrenz zueinander, sondern sind Bestandteile einer gemeinsamen Politik." ("The projects are not competing but are part of a common policy." - LG). Von Beust realises that Niedersachsen and Bremen will move forward with the construction of the new deep-sea port with or without the support of Hamburg, so he decides that it is more useful to support it in exchange for their support of the deepening. The document also outlines the main principles for the deepening operation. It states that the safety of the dykes should not be compromised and that the ecology should not be destroyed. It also states that current research indicates there will be no effect on the high water level.

The Wasser- und Schifffahrtsamt Hamburg also states once again that the effects of the previous deepening were lower than expected, which should make another deepening possible. Uldall is confident that the EIA can be finalised in 2005.

The document signed between Hamburg, Bremen and Niedersachsen, however, is a formal decision and it does not remove suspicions among social actors about Hamburg's true motives. Moreover, there are many more actors who are not part of the agreement and who are less likely to agree easily to the deepening. The next step is to get these actors to support the deepening as well. To this end, a mediation process is established at the request of Niedersachsen and Schleswig-Holstein. The Senate of Hamburg appoints Heinrich Reincke, former director of ARGE-Elbe, as the moderator in this process. His task is to negotiate a deal between 30 municipalities and 10 districts in Niedersachsen and Schleswig-Holstein. He is also asked to speak with other stakeholders, including locals, and is given 18 months to accomplish his task. Reincke's appointment is a strategic move to build a bridge between the policy action system and the stakeholders. As the former head of ARGE-Elbe, he has a good reputation and appears independent from the policy action system and its desire to deepen the Unterelbe. Besides his knowledge of the Elbe, he speaks the dialect of the region and is able to relate to the people. The policy action system hopes that this will

help to speed up the decision making process. It reasons that if the stakeholders can reveal weaknesses in the plan before the Planfeststellungsverfahren, the plan can then be modified and strengthened, thus decreasing the chances of it being rejected during the Planfeststellungsverfahren itself.

While the policy action system is working on securing a further deepening, it is suddenly faced with a major unfavourable physical change in the Unterelbe. Dredgers find that the amount of material dredged during maintenance operations this year is considerably higher than during previous years (*figure 3*). Soundings confirm their observations, i.e. that the amount of sediments accumulating in the harbour basin has suddenly increased from 4.5 million cubic metres in 2003 to 9 million cubic metres this year. This comes as a major surprise to the actors in the policy action system. In the EIA that was drawn up before the deepening, BWA had predicted a small increase in dredged material after the operation but did not foresee this large of an increase. This now poses major problems for the policy action system. The first of these problems are escalating costs arising from an urgent need to intensify dredging to remove the sediments which are now obstructing navigation in the ports. The second problem is the lack of space to dispose of the sediments. The City of Hamburg does not have clearance to store the sediments in Niedersachsen or Schleswig-Holstein and needs to find alternatives, so it chooses to go back to an earlier solution: to take the sediments to the border of the Delegationsstrecke, dump them into the Unterelbe, and hope that the tidal currents will then take the sediments to the North Sea.

It is not completely clear what has caused the increased sedimentation in the harbour basins. The accumulation of sediments began prior to the most recent deepening and maintenance dredging operations have always been necessary. However, some actors within the policy action system believe that the deepening operation has contributed to this development by altering the stable state of the Unterelbe in such a way as to disproportionately accelerate sediment accumulation. Other actors within the system maintain that there is no connection, but this may be because they fear that an association between this issue and the next deepening operation will delay the latter. Either way, the problem does need to be solved. The policy action system is now beginning to be divided between two sides: those who continue to push the deepening and view the current physical changes as a coincidence rather than a consequence of the deepening, and those who view the physical changes as a sign that the Unterelbe is already suffering from too much anthropomorphic strain.

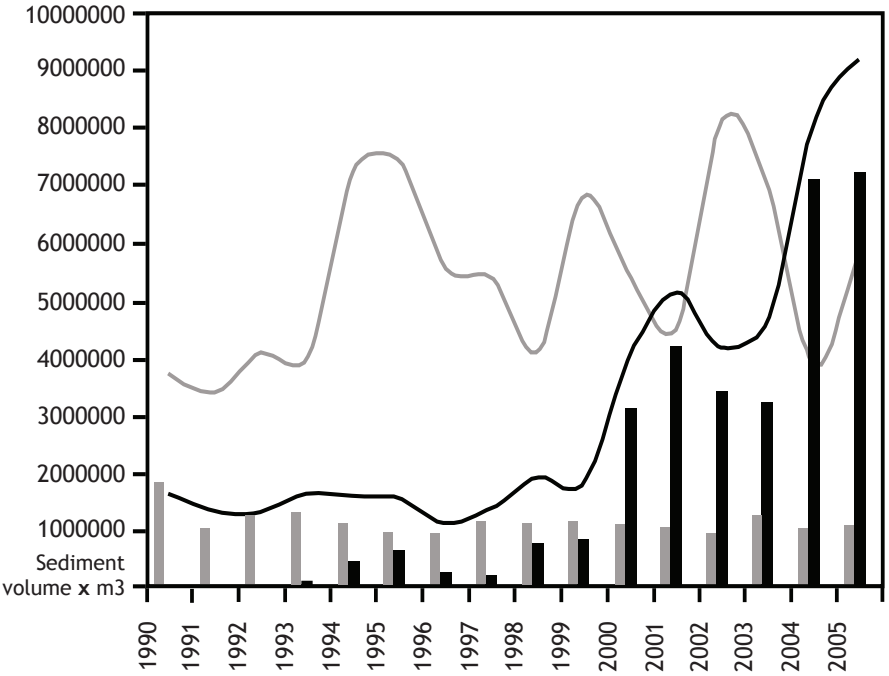


Figure 3: *Sediment accumulation in the Unterelbe between 1990 - 2005. The total volume of sediments is indicated by the black line. The total volume comprises sediments that are processed locally, e.g. storage, remediation (grey columns), and sediments that are dumped at the border of the Delegationsstrecke (black columns). The grey line indicates the fresh water discharge at Neu Darchau. Adapted from Bundesanstalt für Wasserbau, 2005.*

Although it is very complicated to assess how each individual measure has contributed to this physical change, there are a number of mechanisms that can explain the driving forces behind this sudden increase in sedimentation. Central to the policy action system's analysis is the tidal pumping effect. Sediments in an estuary or tidal river are constantly transported along the riverbed because of the alternating currents. When one current dominates, the pattern of sediment transport will follow accordingly. The research institutes have observed that the tidal currents in the Unterelbe have become flood dominant. This results in a

net upstream transportation of sediments during each tidal cycle. Sediments are transported from the mouth of the estuary towards Hamburg during periods of flooding, but are transported back across a smaller distance during periods of ebb. This effect is repeated during the next tidal cycle, thus effectively transporting sediments upstream.

According to the BAW, the tidal pumping effect has a direct relationship with the ever-increasing tidal range. Through the measures taken in the Unterelbe over time, the peaks of the tidal range have shifted from Cuxhaven near the mouth of the estuary around 1900 towards Hamburg more recently, resulting in an increased tidal range at St. Pauli. This means that the Unterelbe has a considerable exchange of tidal volume. The result is a flood-dominant sediment transportation process, i.e. the upstream tidal pumping effect.

This effect is reinforced because the balance between fresh water discharge from the Elbe upstream and the tidal energy from the North Sea in the Unterelbe has shifted in favour of the latter. Tidal energy meets fewer obstacles when flowing through the estuary and tidal river than in the past because of the degeneration of the dissipative structure of the river basin. Therefore, the tidal energy is more and more focussed towards the end of the Unterelbe, i.e. in the harbour basins and channels in Hamburg. The fresh water discharge from the Elbe, however, has not increased at the same rate and does not provide sufficient energy to transport the sediments back to the mouth of the estuary.

The accumulation of sediments because of the tidal pumping effect is worsened by the HPA's dumping strategy of transporting dredged material to the border of the Delegationsstrecke and dispersing it in the waters of the Unterelbe. Although the HPA hopes that the currents will take the sediments to the mouth of the estuary, the tidal pumping effect actually causes the sediments to be transported back into the harbour basin. This forces the HPA to dredge the material once again, disperse it into the water, wait for it to return and dredge it again. This 'cycle-dredging' in which the same material is dredged over and over again causes considerable frustration because of the high costs and the vicious, almost pointless character of the entire operation. This especially breeds embitterment as the dumping of dredged material in the Elbe was presented as the best solution a few years ago (see Section 4.3.2). The preliminary outcome is that the sediments accumulate in the harbour basin at a pace the policy action system has difficulty to cope with. The evidence that this development is related to the anthropomorphic changes, including all the deepening operations, puts the policy action system under much stress as it attempts to deal with this problem

while simultaneously attempting to obtain approval for a new deepening.

4.5.1 October 2004 – September 2005

Debating the new deepening - research and counter-research - announcing plans – the mediation process. The summer of 2004 has been well spent by the City of Hamburg as has managed to overcome a few hurdles. The months following this are relatively calm as no major events take place. The debate over the deepening of the Unterelbe, however, continues as many actors use this period to present their views on the operation and research from the policy action system is countered with alternative research from other actors.

BUND presents research that indicates how oxygen depletion has now emerged as a regular phenomenon every summer and connects this to the deepening of the Unterelbe. The government of Stade, one of the main districts at the south banks of the Unterelbe, expresses its worries about the safety of the dykes and demands the construction of higher dykes. They argue that with the flood plains having decreased by 75%, fewer margins are left to retain excess water. There are also worries about the increased velocity of the current, and that it would mean that there is less time to prepare for high water. The Stade government proposes the establishment of a fund to pay for extra measures to ensure dyke safety; this is similar to the maintenance fund proposed by the mayor of Freiburg to combat the sedimentation of the small ports. Many actors wonder why Hamburg does not wait for the results of the monitoring programme before proceeding but Hamburg is adamant that the results from 2000 show that there were no major changes, although the real developments appear hidden from the public.

Environmental pressure groups, including BUND and Rettet die Elbe, regularly criticise the motivation to deepen the Unterelbe. Because of political manoeuvring, people are now faced with both a deepening and the construction of a deep-sea port, which they argue is not only very expensive but also unnecessary as there are currently no ships that require this capacity. Even when ships of that size do call at Hamburg, they will not utilise the full depth of the navigation channel, as most ships call at more ports in Europe and never arrive at or leave Hamburg while fully loaded. Hamburg responds that such ships will, in fact, be built and that shipping companies will decide to call somewhere else if Hamburg does not offer them the opportunity to do so.

Hamburg releases another research report, this time by the Instituts für Seewirtschaft und Logistik (ISL), which shows that the deepening of the Elbe will help the environment rather than threaten it. The institute compared the effects of the deepening with a hypothetical situation where lorries are used to transport the expected number of containers in the future. The report concludes that the deepening will have less of an impact on the environment than if no further deepening was done as that would mean more lorries, more congestion and therefore more pollution. In other words, the deepening is environmentally friendlier than its alternative. Christian Saadhoff of the BWA states that this confirms the sound nature of the deepening: "Wir haben schon immer gesagt, daß wir so moderne Methoden anwenden, daß der Umwelt bei der Fahrrinnenanpassung nichts passieren kann" ("We have always said that we use modern techniques in order to preserve the environment during the deepening." - LG).

Environmental pressure groups attempt to obtain access to the cost-benefit analysis and the research, including a pilot study that, according to the policy action system, proves that a new deepening will not have the consequences they fear. However, HPA refuses to publish these documents and instead continues to say that there is no reason to worry. It does nothing to allay the fears of the pressure groups, who draw similarities with the previous deepening operation. The research conducted at that time was also not published and is perceived to have been inadequate as it did not predict some of the developments that have occurred to the Unterelbe post-deepening. The pressure groups also perceive the HPA's current spending of millions of euros to deal with the tidal pumping effect by dredging sediments from the harbour basin as proof of an inadequate cost-benefit analysis.

January 2005 brings news that the port of Hamburg has had yet another record turnover year in 2004. This prompts a renewed call for a deepening, with Uldall stating that the port of Hamburg's capacity will soon reach its limit. Jörg Oellerich announces that the deepening has increased the turnover from 6.8 to 13.4 percent annually.

The final cost estimation is published in February 2005 at 320 million euros, which is considerably higher than the cost of the previous deepening operation. The Handelskammer offers to pay 15 million euros in advance in order to speed up the process and have the Elbe deepened sooner. Uldall accepts the offer and attempts to convince the federal Ministry of Transport to allow the deepening to begin sooner in 2006 instead of 2008.

Meanwhile, the mediation process facilitated by Heinrich Reincke is

progressing. He has organised a series of meetings in the Unterelbe region and spoken with people in the two federal states, seven districts and more than 30 municipalities about their concerns over the safety of the dykes. They fear that an increasing current velocity will accelerate the erosion of the dykes' foundations, thus compromising safety and incurring further costs. These local authorities are responsible for the dykes and will have to bear the costs of any changes to the dykes such as reinforcement and realignment. Therefore, they want hydrological and morphological measures to be implemented in order to safeguard the robustness of the dykes, and they want money to pay for dyke maintenance.

The realignment of the dykes could provide a solution to the problem but this point is not easily accepted. Besides the issue of high costs, the local governments and people along the Elbe banks feel that realignment involves sacrificing safety. The most recently built dykes were constructed after the 1962 flood and positioned right next to the river. That meant that the flood plains became reclaimed land. As mentioned earlier on in this chapter, this layout allows for the building of shorter dykes, which are easier and cheaper to maintain, especially during emergencies. People who live along the Unterelbe are reluctant to return to the old system. In this way, perhaps the most sensible solution to the danger of erosion is also a very difficult one.

While experts in the policy action system see the deepening of the Unterelbe and the safety of the dykes as two separate issues, Reincke finds out that in the social realm, people tend to see these two issues as intertwined. He therefore decides that mediation should not just be about compensation and finding the weak points in the deepening operation plans, but that it should also be about further explanation of the facts of the deepening operation, such as explaining that the deepening will not increase the risk of flooding and that it is something different from the maintenance of the harbour basins.

The concerns of the recreational shipping associations are also addressed through mediation. They are unhappy that sediments are accumulating in their ports because of the cargo shipping traffic and the morphological changes. They believe that compensation is necessary to combat this silting up of their ports.

The most difficult actors for Reincke to speak with are the environmental pressure groups. There is deep mistrust among these groups of the policy action system, given its long history of modifying the Unterelbe. The actors in the policy action system, meanwhile, believe that these pressure groups are not going to accept anything the policy action system does. Reincke decides that since the environmental pressure groups will not agree to the deepening anyway, it

would be better for him to focus on explaining the deepening and compensation measures and discuss the deep-sea port. It puzzles the pressure groups that these plans are being developed in tandem with the deepening of the Unterelbe. As with other social actors, the pressure groups believe that the deepening is connected to other issues such as sedimentation of the secondary channels and the increased tidal range.

Reincke holds three meetings focussing on the effects of the last deepening, the hydrological aspects of the Unterelbe in its present state and the economic aspects of a deepened Unterelbe. He attempts to connect the environmental pressure groups to the deepening process, without expecting them to accept the deepening. Instead, he hopes to lay the foundations for a long-lasting dialogue, with the knowledge that even more modifications to the Unterelbe lie ahead in the future as part of the policy action system's intention to develop the Unterelbe in a more extended but also more comprehensive way, connecting economy with ecology and safety.

The pressure groups, however, are not impressed with the mediation sessions. They see them as information sessions where the policy action system attempts to explain once again what they already know and where they try to identify the weak spots in the planning. These groups would rather discuss other matters, such as the simultaneous development of the port at Wilhelmshaven and the deepening. However, they find that the scope of topics discussed in the sessions is strictly limited to the deepening operation, which frustrates them, as they want to widen the scope of the discussion. In addition, they view the policy action system's stated intention to develop the Unterelbe in a more comprehensive way as a veiled attempt at another deepening involving further development of the Unterelbe as an economic asset coupled with more compensation measures. The pressure groups are, in fact, not opposed to such an approach but do not understand why this concept is not being incorporated in the current deepening. In summary, then, the mediation process reaches out to many social actors, although the environmental pressure groups and policy action system remain on opposing sides.

The ideas about a more comprehensive and coherent long-term development of the Unterelbe stem from within the policy action system and are not made clear to the public at this point. A group of people from HPA and WSD-Nord are working on a long-term vision for more sustainable development of the estuary and tidal river that is meant to address the various problems that threaten the Unterelbe – the Tide-Elbe Konzept. It is significant that this plan

does not just aim for economic utilisation, which is what social actors have come to expect, but addresses environmental and safety issues as well. In its analysis of the current state of the physical system, it also takes into account the agricultural sector, tourism, flora, fauna and safety. The core of the analysis is that the current state of the Unterelbe and the way it is developing is unsatisfactory and is not sustainable for the future. The working group acknowledges that the main causes of this unsatisfactory development are the morphological and hydrological developments to the river and all their accompanying developments. It addresses the diminished dissipative capacity of the Unterelbe and states clearly that the current situation has arisen largely due to anthropomorphic changes.

The aim of the visionary proposal is to develop all functions of the Unterelbe in combination rather than developing one at the expense of another. This means that tidal energy needs to be absorbed by means of artificial islands, that the sedimentation process of the secondary channels and flat water zones needs to turn around, that a more sophisticated sediment management system needs to be developed and that this concept has to be implemented through cooperation with other stakeholders. In these ways, the proposal marks a clear shift away from the existing paradigm of the policy action system. However, it does not lead to a change in the short term. This working group and the project group working on the actual deepening are completely separate from each other; thus, the proposals for the pending deepening do not reflect any of the proposals made by the Tide-Elbe working group. The social actors are also largely unaware of the proposals until the end of 2006, when they are revealed to the public.

4.5.2 October 2005 – December 2006

Final proposals – societal protests – symposium. As more oxygen is depleted and more fish die in the summer and while social actors continue to warn of the effects of the deepening on the amount of oxygen in the Unterelbe, the HPA releases more details on the deepening to the public in October 2005. The river will be deepened by 14.50 metres. Jörg Oellerich states that the deepening is feasible in terms of its hydrological and environmental effects. The total dredging volume is estimated at 38 million cubic metres, most of which will be disseminated in the mouth of the estuary. The Planfeststellungsverfahren is scheduled to start some time in 2006. Senator Uldall takes this opportunity to call Niedersachsen and Schleswig-Holstein to pre-empt their resistance to the operation.

The announcement leads to social protests. The recreational shipping associations complain that the previous deepening has already caused considerable sedimentation of the small ports, for example up to 50 centimetres annually in Wedel. They also complain that the big ships cause a lot of damage, as the stern waves are too high for the small ships and yachts. The WWF publishes a report in which it states that the negative effects of the new deepening are expected to be much more severe than predicted by the HPA and its associated research institutes. The WWF notes that the modifications to the Elbe have led to a decrease in the amount of oxygen and to sedimentation of the secondary channels. It also points out that sediments have begun to accumulate much faster in the harbour basin following the previous deepening and notes that this was an unforeseen effect. The report therefore concludes that the capacity of the Unterelbe to absorb modifications has been stretched to its limit and that a new operation will do more harm than can be foreseen. Christian Saadhoff of the BWA states in response that the accumulation of sediments has nothing to do with the deepening and that the report is insignificant for the BWA. Saadhoff also denies any link between the sedimentation of the small ports and the modifications to the Unterelbe, but since even Heinrich Reincke thinks that there is a link, the City of Hamburg decides to contribute 5 million euros to the maintenance fund. Niedersachsen and Schleswig-Holstein will not contribute.

The news in June 2006 is that the federal Minister for Transport Wolfgang Tiefensee has informally agreed with the deepening. The funds for the deepening are seemingly secured. The news provokes another series of protests from environmental pressure groups. Besides the usual objections, they also question the idea of building islands in the mouth of the estuary as this contravenes the historical situation. Christian Saadhoff publicly announces that the construction of islands and the deepening are two separate projects and have no connection to each other.

The Länder also protest against the deepening, but they are more concerned about the safety of the dykes. Niedersachsen announces that it will not accept the deepening project until Hamburg clarifies what will happen to the tidal range and consequently to the safety of the dykes. The council of Stade observes that 12 metres of Elbe beach disappear annually because of the increased current velocity but has difficulty proving the relationship between the deepening and the disappearance of the beach. They nevertheless question whether Hamburg really has everything under control and believe that the last deepening had more negative consequences than expected. Torsten Heitsch

of the Deich- und Uferverbands in Otterndorf notes the disappearance of the shoals and sandbars throughout the years and warns that the Unterelbe has a diminished capacity to cope with excess water.

Jörg Osterwald (Wasser- und Schifffahrtsverwaltung) and Jörg Oellerich (HPA) admit that there have been unforeseen changes and that the Unterelbe has been altered by manmade operations. However, they tone down these criticisms by arguing that the river is a living thing that is not stable and that continues to change regardless of any human-induced change. They insist that this time the research has definitely shown that the risk of flooding will not increase.

The Planfeststellungsverfahren officially begins on September 12, 2006. As with the previous deepening operation, any objections to the plan submitted during the Planfeststellungsverfahren are judged by the same policy actors who have planned the deepening. Senator Uldall uses the opportunity to announce that Hamburg has unconditionally agreed to contribute to a fund meant to combat the negative effects of the deepening. This was a demand from Niedersachsen and Schleswig-Holstein that has been met. Environmental pressure groups prepare to submit their concerns but fear that they will be ignored because the policy action system will declare their concerns to be outside the scope of the project.

Following the formal start of the planning process, the Hamburger Abendblatt publishes an interview with the director of the BAW, Harro Heyer. He explains that according to the BAW's calculations, the deepening will not cause any major issues as long as additional measures are taken such as the sound dumping of sediments. However, he also stresses that the transportation of sediments through the estuary can be troublesome as a result of the deepening operation but also because of the construction of dykes, the disappearance of flood plains and the filling up of disused harbour basins. He foresees problems with the silting up of the secondary channels and emphasises that further development of the estuary should be framed in a more coherent development outline such as the Tidal Elbe Concept.

In November 2006, a symposium is organised in order to exchange ideas about the Unterelbe. Actors from the social sphere and policy action system are all allowed to present their views. The environmental pressure groups feel that they are restricted in what they can say because every time they try to widen the scope of the discussion, the discussion leader calls on them to stay on topic. They also believe that other experts are not willing to criticise the research presented by the policy action system as these experts depend on the same policy action system for work.

4.5.3 Final observations

Increasing opposition – demonstration – concessions – delay of the deepening. This case study officially ends in December 2006. However, the case has continued to develop. Opposition has continued to grow, culminating in a protest in March where people carry flaming torches between Cuxhaven and Hamburg to express their discomfort with the planned deepening. The main motivations that drive people to protest against the deepening are fear of the consequences on the safety of the dykes as well as ecological concerns. Meanwhile, an independent group of engineers in Hamburg has released a statement that the research results that support the decision to deepen were derived from incorrect methodology and are therefore not appropriate results to base a decision on.

Apart from a lack of support from local people, environmental pressure groups and fishermen, the policy action system has also seen declining support from official actors. Although Schleswig-Holstein maintains its support for the deepening, Niedersachsen has withdrawn its support in favour of the deep-sea port. The region Stade has presented a document with a number of errors that it claims Hamburg had made during the planning process. In the meantime, the City of Hamburg struggles to finance all its plans for port extension, including a costly deepening, and decides to float HHLA on the stock market in the near future in order to generate more funds.

The policy action system had originally intended to start a preparatory dredging operation by removing the first 30 centimetres from the riverbed, in a similar fashion as in the previous deepening. However, during the summer of 2007, it has had to abandon this plan as it realised that it would be perceived as a provocation and only lead to more opposition. In an attempt to calm down the opposition it decides to increase the funds for maintenance dredging of the small ports from 5 million to 10 million euros. It also negotiates with Niedersachsen about a deal in which Hamburg will pay the full cost of improving and maintaining the dykes along the Unterelbe. The case continues to develop and it is clear that Hamburg is not getting its desired deepening as quickly as it had wished for. If anything, public resistance has grown rather than diminished and the execution of the operation has been further delayed.

Chapter 5: Analysis of the Unterelbe case

5.1 Introduction

The chronology of the Unterelbe case presented in Chapter 4 shows how feedback loops are erratic rather than neatly synchronised, which increases the level of complexity faced by policy-makers. Behind this whimsical trajectory of systems' change through time lies a complex pattern of reciprocal selection. This pattern is analysed in this chapter by understanding the initial selection pressures, how the policy action system responds to this through selection patterns, how this shapes the projected attractor basin and how the physical system and societal environment respond to the consequent actions from the policy action system. This should shed light on the coevolutionary relationship between the changes in the physical system and societal environment and the (subsequent) response and partial loss of control by the policy action system.

5.2.1 Initial selection pressures *(January 1996 – December 1999)*

Operations to modify the Unterelbe in order to make it suitable for economic utilisation and to protect the people living behind the dykes date back to the beginning of the twentieth century. The policy action system is subjected to a number of pressures during the initial phase of the case study. Empirically, these pressures are responses to earlier incentives but as this case study starts in 1996, these pressures are regarded as the initial selection pressures.

The planning of a deepening gains momentum in the course of that year. The need to deepen stems from the pressure of international competition between ports and from the desires of the shipping companies within the port. In order to defend and increase the market share of Hamburg in the HH-range, the Unterelbe must be deep enough to enable currently operating ships to enter the port independent from the tide and to receive the extra large ships of the future during high tide. This pressures the City of Hamburg, HPA, BWA, HHLA and Handelskammer to plan a deepening operation. In doing so it stirs other, opposing, pressures as well.

While there is a rush to execute a deepening because the current depth of the Unterelbe is deemed to be insufficient, there are also a number of physical developments that require attention. First of all, there is the problem of handling dredged material. There is continuous sediment supplementation that requires HPA to carry out maintenance dredging operations. However, there is a lack of capacity to store or remediate the dredged material. With the capacity of the existing depots diminishing, there is therefore an urgent need to find alternative solutions.

In retrospect, the increasing tidal range is an issue at this stage as well. Ever since people started to modify and monitor the Unterelbe the tidal range has slowly but steadily been increasing. The increasing tidal range means a change in the relationship between ebb and flood in the tidal river and this may indicate an unfavourable change with regard to sediment transportation. However, at this stage, this is not perceived as such and the main concern is with the lack of capacity to store dredged material. Any increase in sediment accumulation is considered to be a threat.

Besides the pressure from economic competition and from the physical system, there is also societal pressure stemming from stakeholders who oppose the deepening. There are three groups of these stakeholders: environmental pressure groups who are concerned about the ecological state of the Unterelbe and the impact of the deepening on that state, fishermen who are concerned about the consequences of increased shipping on their fishing activities and citizens who are primarily concerned about the risk of flooding and the consequences of the deepening on the safety of the dykes.

The two federal states of Niedersachsen and Schleswig-Holstein take a more ambiguous stance. On the one hand, they agree with the argument that the region as a whole will benefit from the further development of the port of Hamburg. On the other hand, they oppose the deepening because they think that it compromises the safety of their dykes and fear that they will have to pay for environmental damage.

The pressures listed above have a selection capacity on the process of managing and developing the Unterelbe. They mark the bandwidth between what is feasible and what is impossible. These selection pressures are processed by the policy action system, which enables the actors to generate an image of what it can and cannot do and to understand the direction of the process it wants to steer.

5.2.2 Selection patterns *(January 1996 – December 1999)*

The policy action system has two distinct characteristics during the first phase of the case study. Firstly, it has a clear and urgent ambition, which is to deepen the Unterelbe. At this stage this ambition is widely shared among the actors within the policy action system and evidence of this appears on numerous occasions, for example, when the dredging works start before a permit is granted. Secondly, the policy action system maintains a clear distinction between those who are in favour of the deepening and those who are against it. The former are included as actors in the policy action system while the latter are excluded. In this way, the policy action system applies selection patterns in order to process the pressure it is being subjected to.

The policy action system can manage its response to pressures and its composition firstly through managing the *connections* between actors within the system on the one hand and the actors within the societal environment on the other. The architecture of the policy process during the planning stage reinforces this demarcation as there are no formal or informal arrangements to connect with opposing actors except for when there is a legal obligation to deal with opposition.

Initially, the policy action systems feels no need to do anything other than explain that the deepening is necessary and counter claims that a deepening will have negative impacts. During the planning process, the system is obliged to deal with the objections in more detail. Because the policy action system includes both the actors who plan the deepening and those who assess the objections, the complaints are mostly brushed aside. It is decided that the main opponents, the environmental pressure groups, do not have the right to complain and that the neighbouring states have an obligation to cooperate because of neighbourliness. The objections from the fishermen are also brushed aside during this same process and later, when the fishermen complain at the Oberverwaltungsgericht, money is offered in return for support because the Oberverwaltungsgericht proves to be willing to halt the dredging works.

With regard to the *composition* of the policy action system, the actors within the system appear to be inclined towards assimilating actors who are in favour of a deepening, while actors who oppose the deepening are kept at a distance. As a consequence of this and the way the connections are handled, the policy action system maintains a clear demarcation between people or organisations who agree with the argument that the Unterelbe has to be deepened and those

who have alternative ideas. Some politicians reinforce this through repeated statements in the press. They state that if actors do not support the plans, they are apparently against the further economic development of Hamburg.

The composition of the policy action system is kept stable during the period preceding the first deepening. The only actors who hold an ambiguous position are the neighbouring federal states of Niedersachsen and Schleswig-Holstein. However, actors usually remain either inside the policy action system, such as policy-makers from Hamburg, shipping and trading companies, or firmly outside the policy action system, such as fishermen, environmental pressure groups and concerned citizens.

In order to understand how a deepening can be carried out with minimal unfavourable results, *research* needs to be carried out. Research is also required because such large projects require an environmental impact assessment. HPA and BWA are quick to deliver the technical analysis behind the operation during the summer of 1996. It is assessed that a deepening is feasible and will not yield major unfavourable results. Despite the fact that an EIA is not available at the time, it is announced that the operation will not harm nature and the environment and it is decided that a deepening can be carried out.

The EIA is released a full year later and it confirms that the deepening will not have major unfavourable impacts. Although this is a slightly toned-down version of the statements made a year earlier, the unfavourable consequences are considered to be a minor issue by the policy action system and it reserves some resources for compensation. The EIA is extensive, covering many topics, and may therefore be seen as sound research.

The *scope* of the project is set and clearly not changeable. The primary aim is an efficient deepening of the navigation channel in the Unterelbe. Complementary measures are only considered when they are required to support the primary goal. A more comprehensive development of the Unterelbe or connections with other related projects and ideas are not considered as it is feared that such an enlargement of the scope will cause further delays to the planning. There are still some issues that need to be addressed, such as the upstream sediment transportation and the lack of storage and remediation capacity, but the policy-makers settle for the most obvious and efficient solution, i.e. disposal of the sediments back into the Unterelbe.

Another dimension of the scope of the project is the planning of the compensation measures. This is not considered at first but after the EIA is released, the Senator has to promise to allocate resources to compensate for

possible environmental damage. Concrete ideas about compensation for possible environmental damage such as the creation of flood plains and the realignment of dykes are not well-developed and the policy action system stresses that compensation will only take place if a causal relationship between the operation and the perceived damage can be established. If not, compensation measures will not be carried out. Therefore, there are no concrete plans at this stage to undertake compensation measures in anticipation of possible environmental damage.

There is a mutual relationship between the selection patterns described here and the nature of the policy action system. The choices made regarding connections, composition, research and scope stem from the nature of the system and these selections also determine the nature of the system. Through the selection patterns, certain selection pressures are diverted away while others are addressed and processed.

The way in which the policy action system handles connections results in the exclusion of alternative ideas. Although these ideas may question the goal of the deepening itself and may therefore threaten the quick execution of the operation, the underlying reasons for these protests may hold information that could have been of use for the policy action system in determining the attractor basin. The actors opposing the deepening did not forecast the increased tidal pumping effect and the sudden increase of sediment accumulation in the harbour basin, but the increasing tidal range and the observation that many shoals and sand bars were eroding led them to doubt the soundness of the entire operation.

However, the policy action system opts to maintain the dichotomy between those in favour and those against the deepening out of a fear that the operation will be delayed or even postponed. With the exclusive inclusion of supporters in the policy action system – witness the stable composition – the actors within the system have their ideas reinforced that they are following the right course in the management and development of the Unterelbe. The way in which they handle the planning creates further distrust among opposing actors and reinforces the dichotomy.

Sound research is necessary for the benefit of the policy action system. However, the fact that the decision to deepen was made before the EIA was completed and the fact that both the Senator and WSD-Nord stated that there would be no negative consequences evokes the idea that the outcomes of the EIA were largely determined by the desires of the policy action system rather than

the other way around, as is the purpose of EIAs. In this case with protagonists debating the deepening, the policy-makers cannot afford to present research that would indicate the opposite of what they desire. The affirming research in turn reconfirms to the actors within the policy action system that they are doing the right thing.

The narrow scope of the project determines the perspective of the policy action system. Anything that could lead to a widening of the scope and thus increase the chances of causing changes, delays or a postponement of the operation, not to mention increasing the chances of incurring higher costs, is left out of the project. For example, the issue of a lack of capacity to deposit dredged material is solved pragmatically. by dispersing it back into the Unterelbe where it is hoped that it will be transported to the North Sea. For the time being this short-term solution enables the swift execution of the deepening operation as it does not need to consider a long-term solution for this problem. Although this relieves the policy action system of immediate complementary operations other than the deepening, it does not remove the pressure but rather, adds to it, as the issue remains unaddressed.

In sum, the policy action system is trapped in a vicious cycle during this phase. The diversion of alternative events and ideas that may disrupt the dominant way of thinking reinforces the belief that the right thing is being done, which in turn reinforces the perceived righteousness of the act of deliberately diverting away selection pressures that may alter the system's dominant course. This means that these selection pressures no longer reach the policy action system, leading it to believe that it has made the correct decisions because there is no one to say that it has not. Consequently, the policy action system is affirmed and reaffirmed in its current actions. However, as the case illustrates, the pressures that may disturb the process have only been diverted away; they are not processed in any way nor have they dissolved by themselves.

The way the policy action system acts with regard to the selection patterns determines the nature of the system. All selection patterns point to a singular nature, i.e. convergence towards a concrete goal at the expense of diversity of information. Its urge develops a momentum but there are a number of risks. Physically, the main risk is that a new deepening operation provokes further changes to the tidal patterns in the Unterelbe and a further increase in upstream sediment transportation along with it. The risk is not perceived as such, although policy-makers are aware of the changes in the tidal range that may follow the deepening. However, the decision to deepen has already been

made and that is a point of no return for the policy action system. Although the process of assessing objections is still in full swing, policy-makers do not await the outcomes and begin deepening right away, calling it 'preparatory dredging'. All this indicates that the policy action system has decided that the benefits of a quick deepening outweigh any possible negative consequences.

The decision not to await the EIA and the outcomes of the public hearing means that there is a chance of being stopped by juridical authorities. This happens when the Oberverwaltungsgericht responds to the complaints of the fishermen. The policy action system removes this threat by offering funds to the fishermen. The complaint from the environmental pressure groups lodged with the European Commission bears the inherent risk that if the warning from the EC is not followed-up on, the policy action system faces a considerable fine. However, policy-makers are well aware of the fact that there is a long period of time between a formal warning and being sued for breaching the EU regulations and they speculate that they may be able to find a way around this in the meantime. Again, the advantages of a quick deepening operation are considered to be more valuable than waiting and completing the procedures with the chance of further delays.

5.2.3 The projected attractor basin *(January 1996 – December 1999)*

Through the selection pressures on the policy action system and the patterns of selection, the actors within the policy action system build a scenario for the desirable future state of the physical system. This consists of three parts, namely an image of the current state of the physical system, the desired state of that system and the measures that are required in order to achieve that state. In other words, it defines an image of the future attractor basin and from that projected basin it chooses a desired attractor of the physical system.

However, the policy action system is subjected to selection pressures and in order to deal with these it applies selection patterns. Together with the human limits on predictive capacity, these two factors compromise the view of the attractor basin. What actors see is what they have, consciously or unconsciously, selected from the attractor basin, or what has been forced upon them through selection pressures. The attractors or future stable states of the Unterelbe as articulated by the policy action system therefore do not represent the full attractor basin but rather, the projected attractor basin, i.e. the part that

is observed and understood.

The main target for the future stable state of the Unterelbe is a deeper Unterelbe with little room for a contextual development. The reason for this is that such an integral development would require more time and resources, which contravenes the basic point of this operation, i.e. a quick and efficient deepening in order to facilitate larger ships and maximise profits. A closer look at the plans reveals that there are some concerns within the policy action system about the current developments on the transportation of dredged material, the lack of disposal sites and the consequences of these developments on the future state of the Unterelbe. There are some premature ideas about improved management of the sediments and in the end the planners settle for aquatic dispersion in the Unterelbe. Again, efficiency is key and this measure is not expected to threaten the future desired state of the Unterelbe.

There are also some ideas about compensation measures that are required to keep the Unterelbe in the desired future state. These include the creation of floodplains and the realignment of dykes. However, although there are some general ideas that such changes are required to reinforce the stability of the Unterelbe once it is deepened, these ideas do not really come to fruition. Plans by the HPA and BWA to implement aquatic compensation measures are also meant to compensate for negative side effects following the deepening. Again, though, these plans are articulated much less than the plans for the actual deepening and are also subject to the clause that compensation depends on the establishment of a clear link between the deepening operation and the (possible) damage.

With regard to the societal environment and its actors, the policy action system opts to serve the demanding parties such as shipping and trading companies exclusively and not to address the concerns of those who oppose the deepening. The policy action system hopes they will not stir enough opposition to delay or cancel the plans. Altogether, the projected attractor basin contains a deeper Unterelbe and a relatively simple operation to achieve that desired state. Although there is some awareness that the operation could lead to unfavourable side effects, the possibility of sudden sediment accumulation is not forecast at this stage. In addition, while societal resistance is expected, it is thought that this will diminish in the light of further economic growth.

5.3.1 Consequences of selection and action *(December 1999 – October 2004)*

The policy action system attempts to achieve the future stable state of the Unterelbe it desires. The tidal river and estuary are deepened in order to meet the demands of the port and its primary stakeholders, while the concerns of actors who oppose the deepening are not addressed. In other words, the choices made in the selection of the pressures through the selection patterns mean that some of these pressures are addressed (urgent deepening) while others are not. This affects both the physical system and the societal environment.

The physical system displays the characteristics of a system under the strain of anthropomorphic modifications. A number of developments point to this. Oxygen depletion during the summers is associated with the deepening as the proportional relationship between the depth and the surface area of the water column changes and less surface area coupled with deeper water means less oxygen absorption. Depletion of oxygen occurs more frequently after the deepening.

The impact of the actions by the policy action system on sediment behaviour has more direct consequences for the policy action system itself. It can choose not to address the issue of oxygen depletion but the issues with sediment transportation and sediment accumulation threaten the stability of a deeper Unterelbe without negative consequences. Following the deepening, the physical system has reached a new stable state but besides a deeper river and estuary that stable state includes a changed tidal regime and changed sediment transportation, which in fact leads to doubled sediment accumulation in the harbour basin from 2004 onwards.

The new situation stems from centuries of repetitive strain on the physical system through deepening operations, the construction of dykes and the closing-off of tributaries. The most recent deepening operation adds to this strain, resulting in an increased tidal range, flood dominance in the river and estuary and increased sediment accumulation. At the heart of this reinforcement lie two decisions made during the planning and execution of the deepening.

Firstly, poor compensation fails to address the unfavourable side effects of the deepening. There are only vague ideas about compensation during the planning stage and in the years after the deepening, these plans never really come to fruition. Compensation is fragmented and often not connected physically to the Unterelbe so that negative effects from the deepening are not levelled out. Secondly, the dumping strategy chosen earlier contributes to the ongoing

pressure on the physical system. The policy action system opted to disperse the sediments back into the Unterelbe but as it turns out, this only reinforces the sediment accumulation.

The deepening of the Unterelbe turned out to be a mixture of negative and positive feedback loops. The negative feedback loops occurred with regard to the deepening itself as the depth was achieved as planned and it did not require much extra effort to maintain that depth. Similarly, the tidal range increased, although less than expected by the engineers. However, the deepening helped to shift the equilibrium of the tidal regime that partly determines sediment transportation in the Unterelbe. The new equilibrium includes a much-increased upstream transportation of the accumulation of sediments in the harbour basins. Although the policy action system expected a minor change in this sediment transportation in its projected attractor basin, it turned out to be a major one instead – hence constituting a positive feedback loop between the action and the result. Worse, it turned out to be an unfavourable result, as the increased sediment accumulation requires increased dredging efforts to maintain the harbour basins at the required depth.

Heavy rainfall in Central Europe during the summer of 2002 leads to peak discharges of the Elbe and, consequently, to problems with high water levels in Hamburg, Niedersachsen and Schleswig-Holstein. It sparks a debate on the safety of the dykes and the effect of continuous modifications that result in a diminished capacity to dissipate peaks in the water level. However, in the aftermath of the flooding, this issue disappears from the public discussion.

The selections made by the policy action system also have an effect on the societal environment. The shipping companies get the deeper Unterelbe they wanted. However, a conscious decision was made not to take concerns from opposing actors into consideration during the planning of the deepening. A consequence of this is that the relationship between policy action system and its opposing actors continues to sour and it provides an incentive for these groups to continue their resistance against further modifications with renewed energy. The groups are now granted the right to complain legally and this increases the risk for the policy action system that future plans will meet stronger and more real opposition – real in the sense that the court can decide to block a new deepening because of the objections from these groups.

Mutual relations between the federal states alternate between trust and distrust during the period following the deepening. At first there is rapprochement between them as a deal is brokered in which Hamburg agrees that a deep-sea

port will be built at Wilhelmshaven rather than at Cuxhaven. Hamburg extends this gesture as Niedersachsen and Schleswig-Holstein agree with a deepening of the Unterelbe.

However, in a CDU victory during the 2001 elections Gunnar Uldall replaces Erhard Rittershaus as senator of BWA. Uldall has always been an adversary to cooperation on the deep-sea port and he pulls out of the project. After that, the relationship between the federal states relapses into the same pattern observed prior to the earlier deepening, namely that of cooperation alternating with opposition.

The decision made by Niedersachsen and Schleswig-Holstein to submit the banks of the Unterelbe to the Habitat directive is a move that counters Hamburg's decision to compete with the new port at Wilhelmshaven. This forces Hamburg to comply with the rules of the directive, thus potentially delaying a new deepening, while at the same time it relieves the two federal states from locating Habitat areas elsewhere so that they have more freedom to develop the deep-sea port. The concerns of Niedersachsen and Schleswig-Holstein regarding the increased risk of flooding and collapse of dykes as a result of the previous deepening are not addressed and therefore carried over to the new planning process.

The political change in Hamburg therefore means two things. Firstly, it adds to the selection pressure to have the Unterelbe deepened once again, preferably before the deep-sea port at Wilhelmshaven gets developed. Secondly, it means that the rapprochement between Hamburg on the one hand and Niedersachsen and Schleswig-Holstein on the other relapses into its previous state of mutual distrust.

While the political change in Hamburg has consequences for the debate over the Unterelbe, the political change in the federal government does not. The coalition agreement between the SPD and the Grüne threatens the plans to have the Unterelbe deepened because it decides to halt all projects on the Elbe. The federal plan for infrastructure released a little later reconfirms that new projects will not be supported. Hamburg needs financial support from the federal government to go ahead with this project. However, after silent negotiations, the federal government accepts that the deepening will go ahead but Hamburg will now have to pay a considerably larger portion of the total costs compared to the previous deepening.

In sum, the selections made by the policy action system during the planning and execution of the deepening operation are not without consequences.

The accumulation of singular policy decisions regarding the nature of the policy action system and consequently, the Unterelbe, puts a constant strain on the physical system that results in a change in its state that partly fulfills the desires of the policy action system (a deeper Unterelbe) but also brings with it sudden increased sediment accumulation and a changed tidal regime that may threaten the future ambitions of the policy action system.

The singular focus on the desired state of the Unterelbe also has an effect on the societal environment of the policy action system because the drive to have the Unterelbe deepened means that societal concerns about the utilisation of the river are not addressed and diverted to the future. This is reinforced through the political change in the senate of Hamburg. The change in the federal government, however, does not alter the feasibility of a new deepening but it does mean that Hamburg has to deliver the funds for the deepening itself. In other words, the selection pressure to continue the utilisation of the Unterelbe as an economic asset gains momentum through the political change but at the same time, this continuous drive regenerates the societal opposition against further modifications of the Unterelbe.

5.3.2 The actual attractor and its selection pressures *(Dec. 1999 – Oct. 2004)*

The selections made by the policy action system through the selection patterns lead to a string of decisions regarding the physical system and with that, the societal environment that add to the pressure on both. Together with the occurrence of events, this pressure results in changes to the stable state of the physical system and the societal environment that in turn exerts selection pressure on the policy action system. In other words: the difference between the projected attractor and the actual attractor of the physical system and the societal environment puts pressure on the policy action system because the differences include an unforeseen and unfavourable situation.

Singular decision making, in which the project is narrowed down to a single goal and the decision is made not to address certain issues, results in the diversion of these issues. They are diverted to the future, meaning that they do not disappear but return as selection pressures later on. These pressures form a part of the new attractors.

The self-imposed pressure to deepen the Unterelbe is once again affected by the new stable state of the physical system that includes the changed tidal

regime and the increased sediment accumulation. Because of the high costs associated with these developments and because they may render further deepening physically impossible, they cast selection pressures on the policy action system to undertake measures to address these issues – either in combination with a new deepening or not.

Societal resistance has also not diminished but increased instead. The policy action system encounters this increased resistance precisely because of the way in which societal actors were treated during the previous deepening operation. Finding a way out with the environmental pressure groups becomes more pressing as well when it is ruled that these groups are now entitled to file a complaint during the Planfeststellungsverfahren – a completely different situation compared to the previous planning procedure.

The new state of the physical system also stirs concern among societal actors as they perceive that the previous deepening has caused exactly what they feared it would cause, namely an increased tidal range, the erosion of sandbars and beaches and along with that, an increased risk of dyke collapse. The policy action system encounters this resistance during the years that follow and especially during the planning process for the next deepening. It pressurises policy makers to adapt a new strategy in order to deal with these public concerns, as a new deepening is not likely to be accepted by the public and the neighbouring federal states without further protests.

It becomes clear that the policy action system has manoeuvred itself into a position in which its regime is increasingly challenged by the pressures it has attempted to divert away in the previous years. The selections made by the policy action system appear to backfire on it in several ways, in both the physical and societal dimensions of developing the Unterelbe.

5.3.3 Selection patterns *(December 1999 – October 2004)*

Responding to these pressures, the policy action system initially continues on its dominant course after the earlier deepening and shows little signs of adaptation to alternative ideas. Apart from the short period of time during which there are no immediate plans to begin another operation, the first calls for another deepening occur in the year 2000. These calls gain momentum when Uldall is appointed as a senator and a decision is made to pursue a deeper Unterelbe before the construction of the port at Wilhelmshaven gets underway. However, as discussed

in the previous section, from this time to the autumn of 2004 the regime of the policy action is challenged as the pressures increase. The pressure increases to such an extent that the policy makers are forced to respond by changing the system's regime to address these pressures. In other words, the pressures start to determine the space of possibilities available to the policy action system, which compromises the degree of freedom available to the policy-makers.

As mentioned before, the policy action system was initially tempted not to deal with its *connections* in a different way than it had done previously. A short period of time where relationships were eased changes once actors from within the policy action system, most notably HPA, HHLA and the new senator of BWA, call for a new deepening operation. This call prompts the customary outcry from the environmental pressure groups, Niedersachsen and Schleswig-Holstein and the municipalities within these states. This response is an expression of the existing dissatisfaction that was barely addressed during the planning of the previous deepening. The announcement of a new operation merely triggers an already-existing pressure rather than causing a new one.

The pressure is reinforced by the way in which the policy action attempts to handle its relationships, which is initially characterised by a repetition of the same regime of keeping actors with alternative or opposing ideas at a distance. Policy-makers use the same phrases to reassure the actors that no damage will be done and that safety will not be compromised. This time, however, the environmental pressure groups are entitled to complain. The federal states also realise that they have been snubbed by the decision to go ahead with the deepening without supporting the Wilhelmshaven deep-sea port and that they might obstruct a new operation. In addition, policy-makers remember the protest of the fishermen and fear a repetition of such events.

Even though these non-cooperative stances are a result of the decisions of the policy action system itself, it is now forced to adapt to these circumstances. Changing its regime, however, proves to be difficult. For example, the environmental pressure groups are invited to a meeting with Uldall, which is a start, but since the meeting is used to exchange viewpoints both sides are pessimistic about the outcomes. There is also an attempt to improve the relationships with Niedersachsen and Schleswig-Holstein when Hamburg re-announces its support for the deep-sea port in autumn 2004. These events signify a realisation among policy-makers that it will require more effort to gather public support than before.

The most important response to the increased selection pressure,

however, is the appointment of Heinrich Reincke as a mediator at the request of Niedersachsen and Schleswig-Holstein. His main targets are the federal states and the municipalities within them. The primary goal of the mediation process is to find the weak spots in the plans before they are submitted during the Planfeststellungsverfahren. However, in the course of the process the mediation will also help to soften the relationships between the different actors. At this stage, however, the mediation process has just begun so no immediate results can be seen.

As far as the *composition* of the policy action system is concerned, it is carried over from the period preceding the previous deepening. Again a clear demarcation between those who agree with a new deepening and those who do not is maintained. The first cautious attempts to reconnect with these adversaries do not involve including these actors in the policy action system. They are consulted and provided with information from the planners and any useful information they have is incorporated, but they are not granted any more rights than these. They remain outsiders to the policy action system, whose composition therefore is no different from before.

Research plays an important role during this phase. A pilot study and a cost-benefit analysis are carried out in order to assess the feasibility of a deepening. The monitoring programme is meant to deliver data for this assessment. Included in the pilot study are a number of measures to deal with the current physical developments. The most important one is the proposal to construct sub-aquatic disposal sites in the mouth of the estuary using dredged material from the deepening in order to solve both the issue of storage capacity and the dampening of tidal energy. The inclusion of such additional measures and the expectation that they will work to solve the problems improves the feasibility of a next deepening.

BAW models the worst-case scenario with a computational 3-D model that includes strong tidal pumping and upstream transportation of sediments as the point of departure. A deepening operation that incorporates the additional measures including the sub-aquatic disposal sites would still be feasible, but some within the policy action system hope that this worst-case scenario will not occur at all in order to be on the safe side. Regardless of the next actual attractor of the physical system, all simulations indicate that in the best case scenario, the current unfavourable developments can be stabilised, but not improved.

A monitoring programme was set up after the previous deepening in order to monitor the changes that took place after the operation. It was originally

scheduled to run for 10 to 15 years but actors inevitably want to know what the consequences of the previous deepening were once a new deepening is planned. The monitoring programme is therefore required to deliver results only a few years after it is initialised and well before morphological changes appear.

The policy action system states that no major changes have occurred as a result of the deepening and this is used in the public debate as an argument to plan a new deepening. There are two flaws, however. The first is that the monitoring programme shows a clear increase in the tidal range which worries some researchers in the policy action system, although at this stage this is not admitted to in the public debate. Secondly, the early release of the monitoring report means that no effects of the deepening can be observed because it takes more time for the effects to reveal themselves. The hurried nature of the monitoring report is revealed when sediment accumulation and the tidal pumping effect appear after the report is published.

Unbeknownst to the public at this stage, there are some actors within the policy action system who are concerned about the consequences of the deepening in terms of erosion, loss of flat-water areas and an increase in the tidal range. Researchers struggle with the complex causation but are quite convinced that anthropomorphic changes, including the deepening, have caused unfavourable developments. This is only partly admitted to in public as it is deemed risky, since complete admittance could fuel more resistance to a new deepening.

Initially it is maintained that everything is fine but this claim is abandoned later on. However, the contents of both the pilot study and the cost-benefit study continue to be promoted to prop up the argument to adversaries that they simply have to believe that a deepening is possible. The actual stable state of the Unterelbe is revealed through research and forces a search for alternatives within the bandwidth of the situation forced upon the policy action system.

Regarding the *scope*, it first appears as if the policy action system is aiming for a more comprehensive development of German ports along the North Sea coast. There is consensus among the port authorities of North Germany that enough shipping transport exists to justify an extension of the current capacity. The deep-sea port at Wilhelmshaven is one element in what is called the German Sea Port Concept. However, when Uldall is appointed as senator, the decision is made to not to support Wilhelmshaven and instead to aim for a quick deepening of the Unterelbe before the port at Wilhelmshaven becomes operational. With this turn of events, the policy action system opts again for a more singular scope. The deepening of the Unterelbe is functional in staying ahead of Wilhelmshaven

although the two were originally intended to complement each other. The end result of this is that the planning of the Unterelbe's deepening is accelerated and developed autonomously from other projects in the region.

Although the scope of the previous deepening had also been narrow, compensation provided a means to expand that scope. Actual compensation concerns terrestrial measures to dilute the current land use because aquatic compensation turns out to be too difficult to materialise. A considerable number of compensation areas are physically located separately from the Unterelbe. Within the HPA there are quite a few ideas for sound compensation but these evaporate in the discussions over the allocation of hectares. In the end, the BWA attempts to evade the compensation measures altogether by arguing that there is no clear causal relationship between the deepening and the consequences, and that it is therefore not obliged to provide any compensation at all. It concludes the scope of the previous deepening in this way, leaving it as limited as it was before.

Initially, the plans for the new deepening are similar to those of the previous one: a quick operation with minimal costs. However, increasing selection pressure from the physical system forces the policy action system to redefine the scope of the project and it now attempts to combine the deepening with measures aimed at the reduction of the tidal energy and the upstream transportation of sediments. The scope of the project remains limited but not as much as was originally intended as it is inescapable that the unfavourable physical developments need to be addressed. At this moment no complementary measures are planned.

During this period, the policy action system is put increasingly under pressure because of the choices it has made in the past. In return, these pressures determine the bandwidth of the policy options that the policy action system can select from. In other words, the attractor basin representing the possible future stable states of the physical system and societal environment is limited and imposed upon the policy action system because the current states are partially unfavourable. Being unfavourable, the policy-makers are forced to address these issues in one way or another, which limits their freedom of choice in the attractor basin. In other words, there is pressure to adapt.

In this state, the policy action system continues to display a strong preference for the common regime with regard to the selection patterns: keeping the opposition at bay and deepening the Unterelbe as quickly as possible. However, this state is increasingly being challenged. As such, the policy action

system displays the characteristics of a system under increasing pressure that is starting to realise it has to deal with these pressures and that the current regime of selection patterns may not be sufficient in order to avoid further problems. Consequently, the conditions under which the Unterelbe can be further developed are dictated by the outcomes of earlier choices made by the policy action system. The pressures stemming from the previous episode become selection pressures; they influence the workings of the policy action system and its course in the management and development of the Unterelbe.

Decision making that is singular both in process (connections, composition) and content (scope, research) may not work that well – at least, that is the feeling that some actors within the policy action system come to have. The mismatch between the monitoring report that was published years ahead of its scheduled date, the decision to initiate another deepening based on this monitoring report and the emergence of sediment accumulation, in that order, is an example of how the singular nature of decision making in this case leads to increased selection pressures from the physical system and societal environment. This can be observed in the nature of the selection patterns that, eventually and reluctantly, display a willingness to adapt to the new situation. The search for measures to counter the unfavourable physical developments represents a first attempt to think beyond merely deepening. In addition, changes in connections and composition appear to be allowed in order to counter societal resistance.

The drive to deepen the Unterelbe once again remains strong. The act of planning this deepening exposes the policy action system to selection pressures from opposing actors, as discussed before, and with that it runs the risk of formal objections and consequent delays. However, at this time much of it does not seem to rub off on the policy action system. The European Commission has not followed up on its warning after the poor compensation. Also, threats from the federal government to withdraw support for a deepening do not materialise and support is provided for the deepening in the end. The policy action system seems almost untouchable. By continuing the planning of a new deepening with some supporting measures, it speculates that these solutions will diminish the tidal energy in the Unterelbe and slow down the tidal pumping. The risk is that if this does not happen, the problems will increase in proportion to the lack of effective measures. It is recognised that even if the measures have a positive impact on the physical system, the unfavourable developments will stabilise but not improve. Notwithstanding these provisions, the policy action system remains of a fairly singular disposition.

5.3.4 The projected attractor basin *(December 1999 – October 2004)*

During this time, a clear decision on the physical system has not been made. The primary goals are intersected by the pressures mentioned above. As such, the bandwidth of options the policy action system can choose from has changed and is limited because some options are no longer feasible given the circumstances. The temporal state is that the projected attractor basin is not yet fixed in a set of decisions regarding the Unterelbe as it is unsure what the future state of the Unterelbe should look like – the only certainty being that the afore-mentioned issues need to be addressed. The projected attractor developed earlier has become volatile under selection pressures.

With regard to the physical system, the policy action system still focuses on a deeper Unterelbe but, at the same time, understands that deepening it without consideration may lead to further problems before the current problems can themselves be solved. As a result, additional measures are considered but actors within the policy action system remain reluctant to enlarge the scope of the project and to extend the research programme into complementary areas. The working group Tide-Elbe is one of the initiatives undertaken. In taking such steps, the policy-makers hope to achieve a deeper Unterelbe while at the same time solving the problems it is facing.

Regarding the societal environment, an attempt is made to involve actors who oppose the deepening in the planning process. Originally, this is meant to serve the content, i.e. to find the weaknesses in the original plans, but in time, the garnering of support for a deepening becomes increasingly important. The policy-makers aim for a deeper Unterelbe without public resistance and thus, agreement from the opposition becomes a part of the projected attractor basin. The establishment of the mediation process is the main means to that end.

5.4.1 Consequences of selection and action *(October 2004 – November 2006)*

Following the decision to amend the plans for the Unterelbe and to establish a mediation process, the period between October 2004 and November 2006 is marked by the consequences of these actions but not by new physical changes that are either human-induced or caused by natural changes. However, the problem with tidal energy and sediment transportation continues to exist and puts pressure on the policy action system to find a solution. Oxygen depletion

occurs in the summer and serves as a reminder that all is not well with the Unterelbe.

The pressure to act on the physical changes in the estuary leads to changes within the policy action system with the establishment of a working group, consisting of the HPA and WSD-Nord, to develop a long-term vision for the Unterelbe with a broad scope. However, while the ideas in the long-term vision, such as the redevelopment of shallow water areas and the realignment of dykes, are developed to address the urgent matters with the Unterelbe, there is little connection between this process and the actual planning of the deepening because the two projects are completely disconnected from each other. There is also a realisation that the implementation of the Tide-Elbe Konzept will probably take much more time and resources to implement than a new, singular deepening.

The cautious rapprochement between the policy action system and its opponents continues to develop as an immediate result of the ascertainment that the pressures from these opponents need to be addressed. This results in the establishment of a fund to cover the costs of dyke repair following a new deepening, funds to combat sedimentation of the small ports causing hindrance to recreational shipping and an invitation to discuss the deepening during the mediation process.

At the same time, the policy action system still sticks to its old routines so that although there is a little more openness, opposing actors are not granted much access to the decision making process. These actors wish to see the cost-benefit analysis that apparently proves that a new deepening is feasible, they want to discuss the development of the North-German sea-port concept rather than having the Unterelbe deepened alone, they want the policy action system to consider complementary measures that promote the ecological and safety dimension of the Unterelbe rather than only the economical dimension. All these desires remain largely unaddressed.

With its two-fold response to the pressures –attempting to garner more public support while maintaining the old regime – the effect on the societal environment is not as large as the policy-makers may have wanted it to be. Most actors opposing the deepening continue to view the policy action system as fully driven by a desire to deepen and regard the mediation process as a negotiation process at best and a campaign to promote the deepening at worst.

Although the policy action system presents the mediation process as a change from the past and although some opponents find it laudable, it

is unsuccessful in removing the adversaries' overall scepticism. For some, the mediation process offers an opportunity to negotiate a way out of the situation, for example by offering support for the deepening in return for funds or other forms of compensation such as the fund for dyke maintenance and the dredging of the small ports. For them, the mediation process offers a possibility to vent their concerns and the compensation measures for damages are a consolation that the policy-makers in Hamburg are willing to include their wishes in the planning process of the deepening.

However, those who do not benefit from such a deal – most notably the environmental pressure groups – are not tempted to accept this. For them, the mediation process does not yield concrete results. The reason for this lies in the continuous string of decisions made by the policy action system in the past that has created a mutual distrust that a mediation process of this extent cannot undo in the short term given the offers from the policy action system. From this perspective, the mediation process is not regarded as a change from the past but rather, as another component of the same regime, i.e. the regime that previously arrived at the singular decision to deepen the Unterelbe.

The policy-makers' attitude when facing opposition reinforces the lack of societal support. Although HPA has admitted that it is suffering from the developments in the physical system, it does not provide more insight into this problem and its continuous reassurance that the next deepening will not do any harm to the environment only serves to annoy the environmental pressure groups. There are fears among policy-makers, however, that more openness, such as providing access to data or research reports, may delay or postpone the deepening. During the mediation process, the policy action system continues to decide on the scope of the discussion. When the discussions move in an unwanted direction, they are simply cut off.

The discussion in this section has shown how the policy action system is captured by the pressures resulting from its previous (singular) decisions that limit the possibilities for creating support among opposing actors. Although attempts are made to address the selection pressure from the environmental pressure groups, the continuous singular nature of the policy action system only confirms to these groups that it is still working along the lines of the old regime that these groups so despise. Although there are attempts to alter this regime, change is difficult because of the seemingly unstoppable planning process, the reluctance to include ideas from the working group Tide-Elbe Konzept and the lack of effect of the mediation on some of the opposition. Even though this process

shows some results, it has failed to convince the more stubborn oppositional actors thus far. Both sides share a history shaped by the decision made by the policy action system not to incorporate the concerns from the opposition. Now that the opposition has become more vocal and has more options to obstruct the planning process, this stance of the policy action system backfires in its ability to achieve its goals.

5.4.2 The actual attractor basin and its selection pressures *(October 2004 – November 2006)*

The measures implemented by the policy action system to address the selection pressures from the physical system and the societal environment yield fewer direct results than desired by the policy-makers and the actual situation does not change very much. Some portions of the societal environment are more willing to accept the deepening if they are offered something in return. Others, however, have not changed their stance and thus not much changes in the state of the societal environment. The post-scriptum of this case study shows that societal resistance is continuing to grow and that attempts to stop it are in fact fueling this resistance.

Similarly, the physical system does not change as well. It has arrived at a new equilibrium that proves to be stable for the time being. Because there are no new physical changes made by the policy action system, this equilibrium is maintained. Even more so, the way in which maintenance dredging is carried out reinforces this through circle dredging. Thus, the actual stable state of the physical system is as unfavourable as the state of the societal environment, or at least the part that refuses to accept the deepening, but these states emerge out of the string of singular decisions made by the policy action system. Thus, the situation has become too locked-in to be changeable without major investments.

5.5 Final observations *(October 2004 – November 2006)*

The structural observations concluded in 2006, which, in a way, is an artificial ending imposed by the practical constraints of research. From October 2004 to November 2006, the policy action system attempted to deal with the selection pressures it was being subjected to, or, in other words, was in the process of

adapting its selection patterns for decision making to the new stable situation it found itself in. In doing this, it appeared to respond in two different ways. On the one hand, it continued to pursue an efficient deepening that needed to be realised as soon as possible. It used the same methods that it had previously: keeping opposing actors at a distance, revealing as little as possible about the research results and carefully guarding the scope of the discussion so as to avoid any change or further delay. On the other hand, it showed that it was willing to change something with the establishment of the mediation process and the working group. In terms of selection patterns, the connections dealt with showed a change whereas the composition of the policy action system remained stable. Nevertheless, it had to accept that more energy was required to gain acceptance. For example, the amound of funds had to be doubled for maintenance dredging.

The mediation process was originally intended to detect the possible weaknesses in the plan in order to avoid delays during the Planfeststellungsverfahren. However, due to a realisation that the current resistance was not diminishing, its scope was gradually enlarged with the decision to arrange financial compensation for possible damages and to place more emphasis on further explanation of the reasons why a deepening would be a good thing. This had mixed results. The mediation process remained focused on the process of garnering support while the contents were still very much determined by the policy action system. Similarly, the idea to develop a long-term vision for the Unterelbe that meets the erratic dynamics of the estuary and tidal river may have provided a way out of the situation, but so far was only marginally incorporated into the planning process, i.e. complementary measures were only considered when necessary in order not to cause problems for the deepening operation.

At the same time, however, the establishment of the working group signified that the policy action system was not as univocal as it was before about the uncompromised deepening of the Unterelbe. Drafting a long-term vision requires more time than the planning of a deepening and is less concrete. As such, the long-term vision was considered to be a different project, which simultaneously indicated that the confident statements that deepening do no harm and that unfavourable consequences stem from other causes had been abandoned. The policy action system now began to accept that deepening operations are a part of the chain of (unfavourable) issues with the Unterelbe.

With regard to research and scope, it seemed that the policy action system was willing to extend its goals but was still very much aware of the

risk of delaying the current planning process. Research included worst-case scenarios with low fresh water discharge and strong tidal pumping. The societal environment, however, was not convinced that there would not be any damage to the foundations of the dykes along the Unterelbe.

Even so, it was difficult to find space to implement compensation measures because the areas that were prime candidates for the creation of floodplains were now areas where birds had formed their habitat, another consideration under the EU Habitat Directive. The ecological coin has two sides. It was very difficult to convert utilised land, such as agricultural areas and developed land, into flood plains or flat-water zones although they are considered desirable for compensation.

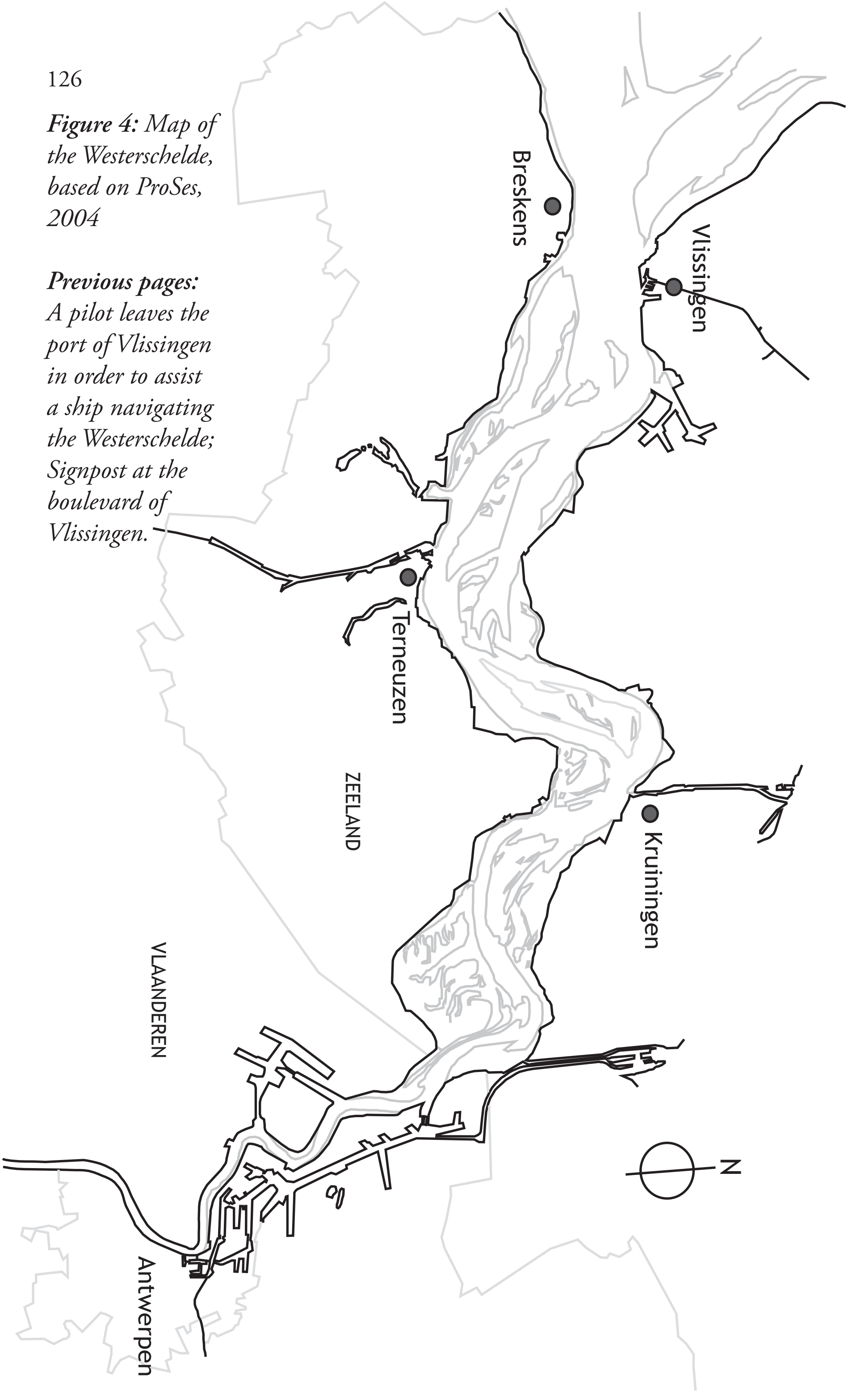
In sum, this shows that the current situation is more persistent than the policy-makers probably would have liked. However, as shown in these two chapters on the Unterelbe case, the current situation has emerged out of the string of decisions made by the policy action system over the past decade and, although it is now unfavourable, was essentially self-imposed. Selecting attractors from the attractor basin was driven by singular selection patterns that limited the projected attractor basin. However, the actual attractor proved to be different from the projected attractor basin and yielded unfavourable results – the possibility of which was overlooked because of the afore-mentioned singularity. Such singularity promises efficient decision making as it appears to push selection pressures that may interfere with the primary policy goal away.

Instead of disappearing, though, these pressures were diverted away to the future and they backfired on the policy action system by limiting what was attainable – it presented a fait accompli with which the policy-makers had to deal regardless of their own desires. Their response was two-fold but attempts to come to a more composite decision making process have yet to come to fruition because of hesitancy on behalf of the policy-makers and the responses not being strong enough to change the situation. In addition, public resistance seems to have increased as the policy action system pushed forward with its planning. Meanwhile, the physical problem of sediment accumulation and altered tidal regime continues to exist. A pattern has emerged in which the selection pressures that interfere with the policy goals are met with increased singular effort which in turn increases the selection pressure instead of removing it. A second case study is required to put the findings in the Unterelbe case in perspective. The Westerschelde case study is presented in the next two chapters.

Westerschelde

***Figure 4:** Map of the Westerschelde, based on ProSes, 2004*

***Previous pages:** A pilot leaves the port of Vlissingen in order to assist a ship navigating the Westerschelde; Signpost at the boulevard of Vlissingen.*



Chapter 6: Modifying the Westerschelde between 1993 and 2007

6.1 Introduction

The quaysides of Vlissingen, the Dutch harbour town at the entrance of the Westerschelde, provide a panoramic view of the estuary in the east and the North Sea in the south. In the distance, from the south banks, the village of Terneuzen and the Dow Chemicals industrial complex in the Braakman polder can be seen in clear weather. In the front, and depending on the tide, one can see the shoals and sandbars of the estuary whose ecology boasts a wide variety of flora, birds and fishes. At the same time, however, one cannot help but notice the large container ships that sail a stone's throw away from the quaysides between the Dutch North Sea and the port of Antwerpen in Belgium. Judging by the way these vessels swing back and forth between the north and south banks of the estuary, it almost seems as if they are being navigated by drunken sailors. However, navigating the hidden irregularities and ever-changing morphology of the Westerschelde riverbed and guiding their ships through the narrow, meandering navigation channels demands much skill. Just one mistake could cause the ship to run aground on the shoals and sand bars or collide with another ship, something that has happened before in this area.

The view from Vlissingen provides an apt overview of this case. The limited depth and width of the estuary has prompted the port of Antwerpen to request for a deeper and wider Westerschelde. The Dutch government, however, is reluctant to meet this request as a deeper Westerschelde may put the safety of the vulnerable land behind the dykes at risk through erosion and the diminished dissipative capacity of the estuary. Altering the morphology of the river could also destroy the ecological value of the Westerschelde as a feeding and breeding ground for sea life. The Dutch government is unwilling to pay for environmental damage while Antwerpen could reap the benefits of a deeper Westerschelde.

The Flemish, on the other hand, argue that the Dutch are obliged to keep the port of Antwerpen accessible and point to the Treaty of 1839 that declares the separation of Belgium and the Netherlands. One of the articles in this treaty concerns the everlasting accessibility of the Westerschelde and this, the Flemish argue, means that the Dutch have to cooperate with any request to improve the accessibility of their port. The Flemish draw a direct parallel

between the blocking of the Westerschelde by the Duke of Parma during the war between Spain and the Northern Netherlands in the 16th century and the current reluctance of the Dutch to cooperate with them. Suspicion is also raised that the Dutch do not mind any restrictions on the growth of the port of Antwerp as some perceive that they are more in favour of the growth of the port of Rotterdam instead. In addition, Belgian proposals to construct a major channel straight through Zeeland in order to create a short-cut from the North Sea to the port of Antwerpen adds to the feeling among the Dutch that the Belgian parties are not sincerely interested in the Dutch concerns. However, as this case study shows, bilateral relations have improved with initiatives such as, the establishment of a joint administrative committee for the development of the Westerschelde.

This case study follows the attempts by the port authorities and the Flemish government to broker a deal with the Dutch after the Flemish part of Belgium has obtained its federal status in 1993, through the deepening of the Westerschelde in 1997 and 1998, the attempts to plan the future of the Westerschelde through a more sustainable framework and the agreement to deepen the estuary once again in 2005.

6.2.1 The physical system

The source of the Schelde River is located in France but it is in Belgium where it grows considerably in size and turns into a major river. From the city of Gent, it flows to Antwerpen near the Dutch - Flemish border. From the Dutch – Belgian border at 195 km to the North Sea at 355 km, the Schelde turns into a broad estuary called the Westerschelde. However, the tidal energy and salinity gradient stretch beyond Antwerpen towards Gent, thus turning it into a tidal river until the locks of Gent stop the tide. However, it is the Westerschelde that is the focus of this case study.

From the port of Antwerpen, the Westerschelde meanders through the lowlands of the Dutch province of Zeeland. Its estuarine character is marked by many tidal changes as well as shoals and sandbars that surface during periods of ebb and are submerged during periods of flooding. There are two main channels that run through the Westerschelde. These primary and secondary channels meander through the estuary and cross each other's paths at certain locations. The main transportation of water and sediments occurs through these channels.

High water during the tidal cycle enters the estuary through the straighter primary channel. This channel is also used by large ships for navigation while the secondary channel is used for inland river vessels. The secondary channel meanders more than the primary channel and is the main channel through which water returns to the sea during periods of ebb. There are barriers or thresholds of sediments at the locations where the primary and the secondary channels cross that determine the river's navigational depth.

As with the case of the Unterelbe, the delta here has also been shaped by human use. The Romans were among the first to build settlements along the banks of this river. They called the river 'Scaldis', which is where the Schelde got its name from. These Roman settlements marked the beginning of a population growth and soon the area began bustling with trade as the water in the delta allowed for efficient transportation. The flood plains were initially used for agriculture but the land began to be used for other purposes later as well, such as salt mining in the peat lands, the rearing of cattle and the production of fabric. The period between the 13th and 16th century was marked by a number of high tides and storms such as the Sint Elisabethsvloed in 1430, the Sint Felixvloed in 1530 and the Allerheiligenvloed in 1570 that destroyed many settlements and claimed many lives. When the largest settlement of Saeftinghe was destroyed, its location was turned into a large wetland called the Verdronken Land van Saeftinghe which is now a protected nature area.

Ever since humans have begun to settle along the Westerschelde, they have tried to find means to protect themselves and use the river for their benefit. As with the Unterelbe case presented in Chapter 4, there are five types of anthropomorphic changes that have had an impact on the development of the Westerschelde estuary.

The first type of change, which is also the primary means by which people are protected from the river, is the construction of dykes. The first dykes were relatively small because of limited technology and knowledge. In the past, when a dyke was breached, people were often unable to bridge the gap and would simply build new dykes at a right angle to the collapsed one, following the path of the newly created body of water. This has caused the geometry of the estuary to become quite angular overall. As technological knowledge improved, the ongoing struggle against the water was dealt with through land reclamation of shoals and holms, which in effect reduced the total surface area of the estuary. The 1953 disaster marked the start of the Deltawerken project that involved the extension of many dykes and the closing off of the main arms of the sea. Only

the Westerschelde was kept open in order to provide the port of Antwerpen with unrestricted access to the North Sea.

The second anthropomorphic change is that the land behind the dykes was converted for predominantly agricultural use. The soil in Zeeland is very well-suited for growing crops and has always yielded a good harvest. This has provided an incentive to increase its surface area at the expense of the water. The construction of new polders continued well into the 20th century but was stopped in more recent times. The idea of converting the polders back into flood plains is not open to discussion in Zeeland, however. Not only do farmers fiercely oppose the loss of valuable agricultural land, there is also a widely shared sentiment that the land that was once captured from the water through personal sacrifice should never be converted back. This debate is one of the central themes in this case study.

As technology improved, another type of anthropomorphic change began to appear: people began to bridge bodies of water. The delta consisted of many islands that gradually began to be linked by manmade constructions, leading to the emergence of the Walcheren peninsula and some branches and rivers. As a result, the Westerschelde lost even more surface area where excess water could be stored.

The fourth type of anthropomorphic change that has been made to the estuary is that it has been deepened and widened as a measure to keep the port of Antwerpen accessible to the largest ships. The consequent mining of sand and maintenance dredging, coupled with the natural dynamics of the river, have had an impact on the way the estuary has evolved. However, the manmade changes may threaten the multi-channel character and the subsistence of gullies transversely on the shoals and sandbars of the river, which are vital for ensuring a well-functioning estuary.

A number of predictions have been made on the future morphology of the estuary. Some believe that the system will collapse into a single-channel system while others believe that it will continue as a simplified multi-channel system with deeper channels and higher shoals, with yet others believing that the system will not change at all. Many of the debates in this case study centre around answering this question in order to think up measures to preserve and improve the morphological state of the estuary for improved navigation, ecological development and increased protection against high tide.

The fifth and final type of anthropomorphic change is the dumping of toxic waste into the Schelde. For a long time, the three countries in the Schelde

river basin used the river as a convenient way to dispose of contaminants and it gained a reputation as an open sewer. However, stricter laws and tighter controls have reduced the amount of contamination in the water and sediments and this is not an issue during the time period studied in this chapter.

6.2.2 The policy action system and societal actors

While the Westerschelde is on Dutch territory, one of its main users is the Flemish port of Antwerpen, which is right across from the border with the Netherlands. Although the two countries cooperate on issues such as maintenance dredging, salvaging wreckages and piloting, the Dutch government remains the sole administrator of the Westerschelde. Within its own administrative borders, the Antwerpen port authorities are free to do whatever they please, but any change to the Westerschelde requires the consent of the Dutch authorities, much to the frustration of the Flemish.

At the beginning of this case study, the policy action system consists of a number of actors. The primary administrator of the Westerschelde is Rijkswaterstaat Directie Zeeland (Waterway and Shipping Administration Directorate Zeeland – RWS), which is a decentralised department of the Dutch national Ministerie van Verkeer en Waterstaat (Ministry of Transport, Public Works and Water Management – V&W). Rijkswaterstaat has a long-standing relationship with the Rijksinstituut voor Kust en Zee (National Institute for Coastal and Marine Management – RIKZ) as it used to be a division of Rijkswaterstaat until it was made more distinct. RIKZ supplies the knowledge and information required by Rijkswaterstaat to make decisions. A very close relationship between Rijkswaterstaat and RIKZ exists, as evidenced by the fact that staff are often transferred between the two organisations, because the former is obliged to contract the latter for all research. While RIKZ often conducts its own investigations, the core research is sometimes tendered out to WL Delft Hydraulics. WL Delft Hydraulics is a public-private research institute providing knowledge and advice on estuarine management, among other things. It has a reputation for quality research using computational models to understand estuarine dynamics.

Two Waterschappen (Waterboards) who are responsible for the safety of the dykes and water management in the polders are involved in the policy action system of the Westerschelde, as changes to the estuary have consequences on the

dykes. Waterschappen traditionally represent farmers, who fear that a deeper Westerschelde involves a sacrifice of agricultural land.

Since the Westerschelde runs through the province of Zeeland, the provincial authorities, Provincie Zeeland, have a say in its future as well. They tend to oppose a deepening of the Westerschelde mainly because as the guardians of the (economic) interests of Zeeland, they see no reason why Antwerpen should reap all the benefits of a deepening of the Westerschelde when all it means for them is more investment in safety and ecology. In the course of this case study Provincie Zeeland agrees or disagrees with the deepening depending on the situation. The municipalities along the banks of the estuary take a similar stance.

The societal actors can basically be divided into two groups: those who support the further economic utilisation of the Westerschelde and those who do not. Many Flemish actors belong to the first group. The case study commences in 1993 when the Flemish federal state has been officiated, thus allowing it to broker deals more easily than when it had to cooperate with its Wallonian counterparts. At this time, the Havenbedrijf Antwerpen (Antwerp Port Authority - APA), an autonomous municipal administrative body, and the city council of Antwerpen are pursuing further economic development of the Westerschelde. They have to cooperate with the Vlaams Gewest (Flemish region), the Administratie Waterwegen en Zeewezen (Administration Waterways and Maritime Affairs – AWZ) and the Administratie Milieu- Natuur- Land- en Waterbeheer (Administration Environment, Nature, Land and Watermanagement – AMINAL).

The Flemish actors have their own affiliated research institute. The Waterbouwkundig Laboratorium Borgerhout (WL Borgerhout), located in the Borgerhout district in Antwerpen, is a public-private research institute that is a part of AWZ, carrying out the research that AWZ requires for policy-making. WL Borgerhout uses a scale model of the Westerschelde combined with empirical data to understand the estuarine dynamics. Later in the case study, they begin to work with computational models.

The group of actors who oppose the further economic utilisation of the Westerschelde consist mainly of agricultural organisations, environmental pressure groups and local people. The Dutch agricultural organisations are represented by the Zuidelijke Land- en Tuinbouworganisatie (Southern Association for Agriculture and Horticulture – ZLTO) while the Flemish farmers are represented by the Boerenbond (Farmer's Union). These organisations oppose a deepening because of the risk it poses to agricultural land. They fear

compensation will be required for ecological damage and worry that their agricultural land will be selected for conversion into natural areas. ZLTO, in particular, has very strong support from its members in Zeeland. The Dutch environmental pressure groups are represented by the Zeeuwse Milieu Federatie (Environmental Federation Zeeland – ZMF). They strongly oppose a deepening as long as it causes environmental damage. These groups feel that the estuary has already been modified too much and aim for some nature restoration. They feel that any further plans for deepening should be paired with sound research indicating the consequences of such a deepening.

Unlike the case of the Unterelbe, the composition of the policy action system and societal actors are altered as the case study progresses. At first, the policy action system is united in its refusal to deepen the estuary because it has no incentive to help Antwerpen and because of the fear of ecological damage and for the safety of the dykes. However, the situation changes considerably after several years.

6.3.1 July 1993 – December 1994

Setting the scene – accordance over a deepening – High-speed railway link. In July 1993, a constitutional change restructures Belgium into three federal states: Vlaanderen, Wallonië and Brussels. Negotiations over the deepening of the Westerschelde have always been linked to negotiations over the water quality of the Maas River in the east on Wallonian ground. Now that the Maas and the Westerschelde belong to separate administrations, it is easier for the Flanders region to broker a deal on the Westerschelde as the two issues are no longer linked. The newly independent Flemish government, the port authorities of Antwerpen and the Dutch state publicly declare their political will to decide the future of the estuary.

The local governments in the Dutch province of Zeeland no longer intend to obstruct a decision but are unhappy with the intentions of the three parties above as they expect that Zeeland will be burdened with the inconvenience of a dredging operation while the profits will go to the Antwerpen. The port authorities, on the other hand, continue to worry that the Dutch will obstruct a deal on the port of Antwerpen in favour of further development of the port of Rotterdam. These two ports are located a mere 100 km apart from each other and are engaged in fierce competition. The port of Rotterdam's assurance that

there is no conspiracy does not reassure the Flemish.

In an attempt to speed up the negotiations over a deepening of the Westerschelde, the Flemish Minister Van den Brande proposes linking these negotiations with negotiations over the construction of a High Speed Train Link (HSL) between Brussels, Antwerpen, Rotterdam and Amsterdam. This issue is stalled because of disagreement over the location at which the railway will cross the border. The Dutch accept the proposal by Van den Brande, with the Dutch Minister of Public Works, Maij-Weggen, taking the position that a deepening of the Westerschelde will only take place if an agreement can be reached on the HSL. This in effect delays negotiations over the Westerschelde. Minister Van den Brande's proposal is regarded as a tactical faux pas among the Flemish parties as instead of speeding up the process through a package deal, the linking of the two issues causes a delay. Nevertheless, an informal agreement concerning the Westerschelde and the HSL is signed by the end of 1994.

The Dutch state is ready to move forward with the negotiations that have, as described by Meijerink (1998), now dragged on for almost 30 years. The Dutch Prime Minister Wim Kok agrees to speed up the decision-making process behind closed doors without waiting for the formal agreement scheduled for January 1995. The Prime Minister and the Minister of V&W, however, are not ready for the largely unexpected opposition from the local governments and environmental pressure groups.

6.3.2 January 1995 – January 1996

Faster decision-making – no ecological compensation – start of BOWS- delay at the court. A formal agreement on the Westerschelde is signed in Antwerpen on January 11, 1995. Prime Minister Wim Kok and his Flemish counterpart Van den Brande sign the deal, signifying the importance of the agreement and emphasising that the cross-boundary squabbles have come to an end. Away from the public eye, however, there are disagreements on various issues. For instance, there is disagreement on whether the newly-decided-upon deepening operation will be carried out by a Flemish or a Dutch dredging company, with both sides wanting to take up the job. To the Flemish it goes without saying that a Flemish company will do the job but Dutch companies argue that a job of this size requires a European tendering process, which would enable them to make a bid for this operation.

The main thrust of the agreement is that the thresholds in the estuary, the locations where the primary and secondary channels cross, will be deepened because the current depth of these areas obstructs shipping traffic. The volume of dredged material is estimated at 15 million cubic metres and maintenance dredging works, aimed at keeping the thresholds at the right depth, are expected to add another 11.7 million cubic metres of dredged material annually. Rijkswaterstaat plans to use these sediments to reinforce vulnerable spots in the estuary, i.e. the areas where shoals and sandbars are degenerating. It also intends to use rocks and boulders to protect these weak spots and develops plans for the creation of flood plains through the realignment of dykes and the conversion of agricultural areas.

Rijkswaterstaat is aware that dumping sediments in the estuary may cause ecological damage. A report 'Stram of Struis' ('Rigid or Robust' – LG) published by RIKZ outlines concerns over the ecological state of the system. Flanders agrees to pay 44 million Dutch guilders to compensate for this damage but at this point there are no suggestions as to how this damage should be compensated. Rijkswaterstaat asks a consulting company, Heidemij, to provide advice on this matter. Meanwhile, environmental pressure groups are critical of the fact that the agreement to deepen has not been coupled with sound research over the (possible) ecological damage to the river. These groups demand for an EIA to be conducted. However, in an attempt to accelerate the decision-making process, the Dutch government decides that an EIA is not required. The local municipalities of Zeeland and environmental pressure groups bring this up to the European Parliament, which calls for action from the European Commission. The Commission asks the Dutch state for an explanation and states in 1996 that the state was justified in forgoing an EIA.

In another attempt to speed up the process, the Dutch state attempts to merge several permits required for the deepening into one. However, this is met with resistance. The permits for land use are issued by the local government and three municipalities refuse to cooperate. In addition, the environmental pressure groups argue that a deepening does not fit into the framework of the existing permits as these do not match the new plans. These groups also think that the permits have been violated in the past because they were stretched beyond their original purposes. They fear that the merging of the permits will make it easy to move from the current stage of the operation, where research is conducted and shipwrecks in the estuary are located and cleaned up, to the next stage of the deepening without any consequences. The merging of permits would

reduce the number of opportunities to file a formal complaint. Therefore, the environmental pressure groups, including ZMF, Vereniging Natuurmonumenten and the Antwerpse Milieufederatie, lodge a complaint with the Dutch Raad van State (Council of State). However, by the end of December 1995, some withdraw their complaint and team up with Rijkswaterstaat instead to search for solutions.

Pending the decision to deepen, the local governments and some national actors unite in the Bestuurlijk Overleg Westerschelde (Administrative Consultation Westerschelde – BOWS). This group was formed at the request of Rijkswaterstaat, following the Management plan Westerschelde. The goal of BOWS is to discuss developments within and around the Westerschelde and focus on restoring the ecological state of the estuary. It is assumed that previous dredging operations for both deepening and maintenance have caused ecological damage to the Westerschelde and the actors in BOWS feel that some sort of restoration is required. They commission a consortium of RIKZ and Heijdemij to investigate how the ecology could be restored.

6.3.3 February 1996 – October 1996

No support for ecological development – reapplying for permits to deepen. RIKZ estimates that the next deepening will cause approximately 100 hectares of shoals and flood plains to disappear, along with 380 hectares of shallow water areas. It presents a report on February 12, 1996 where it proposes three ideas for restoring the ecological state of the river as compensation for the deepening. The first idea is to convert polders back into intertidal areas for brackish water through the realignment of dykes, or 'ontpolderen' (de-poldering). The second idea is to improve existing nature areas on the existing shoals and banks of the Westerschelde. The third idea is to construct nature areas on the landside of the dykes, which basically involves converting agricultural land into nature areas while preserving the existing main lines of defence against the water from the Westerschelde. Eighteen concrete project proposals are put forward, among them the creation of intertidal areas on agricultural land in the regions of Zuid-Beveland and Zeeuws-Vlaanderen. The total cost of these projects exceeds the 44 million guilders that the Flemish government has agreed to contribute. The Provincie Zeeland, which is the chair of BOWS, expects the Dutch state to pay for the remainder, with a total budget of 88 million guilders.

The plans are presented to the public in the first few months of 1996 in a series of meetings with local stakeholders during the open planning process. There is fierce resistance to the plans to realign the dykes and create intertidal areas from farmers, water boards and citizens. These groups feel that the work that Zeeland has done should not be undone through the realignment of dykes and the sacrifice of agricultural land. The water boards argue that relocating dykes that were built through considerable investments would be effectively destroying capital. Societal resistance is considerable; the plans are seen as a major intrusion into the history of Zeeland.

The plans are also not supported at the national level. Many members of the Dutch parliament think that the plans are a waste of money and also express that Zeeland has risen from the water and thus should not be given back to it. The Dutch and Flemish governments fear that the BOWS plan will give the deepening operation bad press as it would make it seem as if deepening the estuary causes much ecological damage. This could not only delay the current deepening but jeopardise plans for future deepening operations as well.

This lack of national support, together with pressure from the water boards and farmers and lack of societal support, leads BOWS to decide to put the plans back on the shelf. The episode is significant, however, as it is the first time in Zeeland's history that manmade operations in the Westerschelde are explicitly linked to environmental damage and the need for restoration. It is also noteworthy because it is the first attempt to discuss plans for the estuary in public. Moreover, it leads the Minister of V&W to install a commission to advice her about the right decision.

The planning for the deepening is again delayed when in June 1996, due to questions posed by some environmental pressure groups, the Dutch Raad van State rules that the Ministry of V&W and Rijkswaterstaat have not properly followed legal procedures when planning the deepening of the Westerschelde as Rijkswaterstaat had attempted to fit the deepening into the framework of the law on pollution of surface waters. The Raad van State decides that a deepening of this magnitude also requires permits in the framework of environmental legislation. The permit applications have to go back to the beginning all over again.

In August 1996, when formal approval to start the deepening of the Westerschelde is still pending, salvage workers, the Dutch navy and Rijkswaterstaat begin to clear wreckage from the estuary so that dredgers will not be hindered when they begin work.

6.3.4 November 1996 – May 1999

Commissie Westerschelde – a long-term perspective – starting MOVE *– Lex Specialis – deepening.* In late 1996, the Dutch Ministry of V&W decides to instate a special committee to restore the relationships that have been disrupted during the BOWS consultation process and to investigate solutions for nature compensation. This Commissie Westerschelde (Commission Westerschelde) invites all actors to make their opinions heard. They are allowed to submit their own proposals on the future of the estuary which the commission draws upon when formulating new plans. These new plans are then discussed with the Waterschappen, the municipalities, the Province, farmers and environmental pressure groups during a consultation process. The commission issues its final plan in August 1997.

The commission has found a way to deal with the varied interests of different actors by viewing the perspectives on the Westerschelde on different timescales, as not all claims can be realised at the same time without the results being compromised. In the short term, the commission proposes to conduct nature restoration only when degeneration is directly caused by the dredging activities required for the deepening. This is in fact what is required under environmental legislation. For this to happen, a causal relationship between the dredging activities and the loss of nature must be proven. As shown in the Unterelbe case in Chapter 4, this is very difficult to do in practice. In the long term, the commission proposes a more structural approach to nature restoration in order to reverse some of the unnatural characteristics of the Westerschelde that have emerged after centuries of landside-oriented development of the estuary. This long-term goal involves the implementation of more far-reaching measures such as the realignment of dykes and the conversion of utilised land for nature and flood plain restoration or, as the commission calls it diplomatically, "gedeeltelijk terugzetten van dijken." ("partially putting back seawalls" - LG) The commission deems such an operation necessary but realises that it is impossible to achieve in the short term. The commission also recommends drawing a more concrete long-term vision on the future of the Westerschelde in which the different perspectives can be further elaborated upon and grounded in research. A similar plan can also be found in the national policy paper on water management published around that time.

The societal response to these ideas remains mixed. Farmers are still worried about losing their land to the construction of flood plains. Other local people also oppose the proposals. The idea that Zeeland has been built on the

water and should therefore not be given back continues to persist. ZMF does not publicly emphasise its involvement in the behind-the-scenes debate as it is aware of these sentiments and, despite its desire for more ecological development, decides that it is better to stay clear of such a strong emotional issue at this time.

The Dutch government is now also prepared to accept the execution of the deepening operation. It circumvents the remaining resistance in parliament through a special law that exempts the project from any further obligations regarding planning procedures. It does so because it feels that the common legal route for spatial changes will further delay the deepening. The dredging works start on July 1, 1997. On March 17, 1998, the Dutch and Flemish governments take up the recommendation of the Commission Westerschelde to establish a working group on the proposed long-term vision. The dredging operations in the estuary are completed in April 1999, after which they move to the mouth of the estuary.

While the dredging operations are being carried out, the authorities take the opportunity to make changes to the dredging and dumping of sediments during maintenance operations. In the past, dredged material from the eastern part of the estuary used to be dumped in the area currently being dredged. However, RIKZ suspects that this has a unfavourable impact on the estuarine dynamics in the eastern part of the Westerschelde and therefore decides to move the dredged material to the western part of the estuary instead.

A monitoring programme is implemented in tandem with the operation in order to observe the morphological changes that take place as a result of the deepening. This programme is called MOVE, which stands for MOnitoring VERruimingswerken (Monitoring Deepening Operations). MOVE also monitors the changes in the sand mining and sediment dumping strategies described earlier. The programme begins in 1996 and is scheduled to run for 10 years, after which the final results will be presented (in 2006). There are, however, longer-term plans to build MOVE into a more extensive research programme that monitors the morphological changes in the estuary beyond these 10 years.

6.4.1 May 1999 – September 2000

Long-term vision – another deepening? – a critical evaluation. Based on the Commission Westerschelde's advice, the working group on the long-term vision

of the Westerschelde, called the Technische Schelde Commissie (Technical Schelde Committee – TSC), is established on January 7, 2000. It consists of people from the Rijkswaterstaat and the Administratie Waterwegen en Zeewezen (AWZ) from the Flemish ministry of Public Works. The project was led by two project leaders, one from each country. They attempt to draw up a long-term vision that can help to frame the discussions over the Westerschelde.

The port authorities of Antwerpen worry that research from the TSC and Dutch research institutes will take a long time and result in unfavourable outcomes that do not serve their interests. They therefore decide to establish their own research group, called the PAET (Port of Antwerp Expert Team). This group is supposed to provide a counterargument to the perspective that the Westerschelde can no longer be deepened any further. Jean-Jacques Peters, the founder of WL Borgerhout, is contracted to head this group. Peters insists on having his independence guaranteed, i.e. the port authorities would have to accept the results of his research even if it finds that further deepening is impossible. Because of Peters' affiliations, WL Borgerhout conducts out PAET's research projects.

The TSC working group's agenda is established a week later on January 14, and it is decided that the long-term vision should be centred on the sustainable development paradigm. This means that the working group envisions that further development of the estuary is balanced between economy (further deepening of the navigation channel to allow for larger ships to reach Antwerpen), ecology (nature restoration and development of the estuary in order to compensate for the dredging activities and land reclamation activities) and safety (protection against flooding and reducing the risk of accidents with tankers carrying chemicals to and from the port of Antwerp). The ensuing document is called the LTV 2030, short for Long-Term Vision 2030, as the vision is aimed to be realised within this time frame. The Flemish actors request for the working group to release this document by the end of 2000, with the demand that a new deepening be considered in the research.

In mid-2000, RIKZ staff decide to invite Peters to participate in a meeting of the LTV 2030 working group. This causes much unhappiness because, as a representative of PAET, Peters' research agenda is regarded by many to be biased in favour of the port authorities. Peters does, in fact, criticise the ideas and approach of the working group. He argues that the current unfavourable state of the estuary can be put down to two factors. First, he argues that the estuary has a natural tendency to degenerate, i.e. shoals will naturally become higher and

channels will naturally become deeper. In other words, nature itself may pose a threat to the stability of the estuary. He calls the result of such developments a simplified system, a system that consists of a very limited number of channels with relatively high shoals in between. Therefore, instead of destroying the morphology and ecology of the Westerschelde, deepening operations may actually help to improve it. Some other actors such as the water boards agree with Peters' observation that a simplified system could emerge because of natural developments. The second factor that degenerates the morphology of the estuary is a rigid and inaccurate dredging and dumping strategy. However, Peters feels that dredging alone is not the cause of all the problems in the estuary.

To counter these two negative influences, Peters proposes a concept that he calls 'morphological dredging'. This concept encompasses the idea that by actively changing the river's morphology through dredging and dumping, the capacity of the estuary to keep itself at the desired depth can be regenerated while the dimensions of the shoals and sandbars can be maintained without requiring much additional help. He also suggests that dredged material can be used to rebuild shoals in the estuary. This would take care of a number of issues by decreasing maintenance dredging, taking care of the storage of dredged material, improve ecological development and perhaps even allow for another deepening operation without causing ecological damage.

Peters' ideas are received with much scepticism in the working group, by both the Dutch and the Flemish AWZ. Many believe that PAET has a hidden agenda and that morphological dredging is in fact a deepening in disguise. They also feel that his proposals do not have enough grounding in scientific research and are based on very general ideas. They are not willing to start experimenting on the Westerschede because it might lead to further degeneration. As a result of this challenge, Peters goes back to develop his ideas further, with the help of WL Borgerhout and a number of international experts.

Also during this time, the port authorities of Antwerpen are preparing a new request for a deepening operation, as they consider the depth attained during the deepening of 1997 and 1998 to be insufficient for the future. As with the City of Hamburg in the previous case study, they are unable to neglect the fact that larger ships are already on the drawing boards. The main reason for this new development, however, is that the port authorities have made a major investment in the construction of a large dock, the Deurganckdok, at the west banks of the Westerschelde, despite strong societal protests. The port authorities fear that an empty Deurganckdok will cause further unrest and financial losses, especially

The AS Africa demonstrates the challenges of navigating the Westerschelde. South of Vlissingen it passes a stone's throw from the coast.

since they are already planning to build another new dock, the Saeftinghedok, which will require the removal of the village of Doel. For this reason, they are eager to do anything to attract more and larger ships to justify the construction of the docks.

While the current depth of the river is sufficient to receive modern ships, ships are unable to enter and leave freely at any time. The high tide creates a small window of opportunity as the tidal energy pushes the water from the North Sea into the estuary, thus creating additional depth in the navigation channel because of the high water level. The restricted timetable means that the largest ships can only enter the port during high tide and leave during the next high tide. Ships may sometimes have to wait out at sea or inside the port for the appropriate times. A deeper Westerschelde would lift the restrictions on the movement of ships. The port authorities are therefore preparing a request to deepen to a depth of 14 metres.

However, the port of Antwerp encounters a stumbling block. The deepening of the Westerschelde in 1997 and 1998 and the preceding planning process have been jointly evaluated by the Dutch Algemene Rekenkamer and the Belgian Rekenhof (both National Courts of Audit). Their report, issued on January 18, 2000 strongly criticises the foundations of the entire operation. This criticism is three-fold. First, the courts point out that a proper cost-benefit analysis for the operation was never carried out, resulting in unforeseen excess costs and a lack of clarity about whether or not the deepening had resulted in a net gain. Secondly, the report noted that the Flemish government had failed to inform the Flemish parliament about the relative costs and benefits of the operation and of its exceeding costs. Thirdly, compensation measures for the loss of ecological areas were never put in place even though money had been reserved for this. The fallout from this report will continue in the following years as it attracts the attention of the European Commission because of official complaints lodged by the ZMF and the Stichting Natuur en Milieu.

The report throws the relationship between the different actors into disarray. The Dutch parliament now issues a statement saying that any new request to deepen the estuary will not be granted. The Flemish parliament is concerned that its government had failed to inform it about the excess costs. The port of Antwerp is now under pressure from two opposing sides – while one side feels it would be best to maintain a low profile for a while, the other side wants to move forward with submitting another request as the prospect of larger ships and the opening of the Deurganckdock loom. Although the report has generated bad press, there is also good news as 2000 is the year in which the port has seen much growth. However, the port authorities decide not to submit a new request for deepening at this time.

Meanwhile, the Dutch state considers submitting the Westerschelde to the European Habitat Directive. As with the situation in Germany described in Chapter 4, both the Netherlands and the Dutch have at this point submitted too few areas to the Directive, which attracts the attention of the European Commission. In a letter to Parliament, junior-minister Faber states that the Westerschelde is one of the prime candidates for submission.

6.4.2 October 2000 – December 2000

Another cross-boundary clash – progress with LTV. Although a new request to deepen would probably be met with renewed societal protests, the port authorities now put more pressure on the Dutch actors to start thinking about it. However, the Dutch parliament rejects further modifications in one single motion. The parliament reasons that there are too many concerns over safety and ecology, and that it has already done enough to help Antwerpen, including a recent deepening of the Westerschelde and the salvaging of many wreckages in the estuary.

The Provincie Zeeland, a number of municipalities, water boards and environmental pressure groups from both the Netherlands and Belgium are also against any further deepening. They fear that increased shipping traffic will increase risks through the accelerated erosion of the embankments. They are also concerned about the perceived degeneration of the natural state of the estuary.

The Flemish actors, above all the port authorities' Chairman and Antwerpen Alderman Leo Delwaide, are infuriated and accuse the Dutch of protectionism over their ports. The Ministry of V&W replies that while it is understood that Antwerpen wants a deeper Westerschelde, it must wait for the work of the LTV working group to be completed before the discussion can continue. Delwaide considers this a deliberate attempt to obstruct further deepening and threatens to file a complaint with the European Court of Justice. He reasons that this is, after all, a matter of opposition between member states. The Flemish government, however, is not really in favour of such an approach. Firstly it has learnt that this is not the way to deal with the Dutch culture of negotiations. Secondly, it is still participating in the LTV working group and does not want to disrupt that process.

The LTV working group, in the meantime, is working hard to complete its report. It has been conducting research on various aspects of the Westerschelde, including morphology, sediment transportation, the relationship between morphology and ecology, risk management regarding the dykes along the estuary, the deepening of the estuary, navigation and nature compensation. It has also sought a second opinion on its research.

6.4.3 January 2001 – December 2001

Releasing the LTV – societal response – responding to the EC - start ProSes. The final LTV 2030 report is presented to the ministers of both countries on January 18. 2001. It lays out four possible scenarios with regard to the future of the estuary. These scenarios range from doing nothing (the 'zero' option) to an instant deepening to 14 metres.

The first scenario is that the current depth of 11.6 metres, independent from tide, is maintained and combined with more extensive nature restoration. This option is unsurprisingly not favoured by the port authorities and has merely been included because of legal obligations, i.e. because it is compulsory to investigate a scenario that is a continuation of the current situation. The second scenario involves a deepening of 60 centimetres and compensation through the creation of new nature zones. The third scenario involves deepening the Westerschelde in several steps from 13 to 14 metres independent from the tide. The idea is to monitor the results after each step in terms of consequences for the multi-channel system and the shoals. In this scenario the working group does not exclude the possibility of deepening to 14 metres, but only if monitoring shows that this is possible and no damage to the natural system is observed. This scenario requires considerable investment in compensation measures. The fourth scenario involves an instant deepening to 14 metres. The working group is not in favour of this option as the consequences are unknown and the risks are therefore high. The working group emphasises that the morphology of the estuary is the key factor in any change to the Westerschelde.

The release of the LTV report coincides with the release of the PAET report on morphological dredging. The PAET report emphasises the need to understand the long-term evolution of the estuary, i.e. the trend over hundreds of years. It argues that natural developments may not necessarily lead to a better estuary and that it is sometimes necessary to work against nature in order to promote a healthy estuary. This goes against the shared belief of the policy action system. PAET also makes a statement that the LTV is a good start with a sound point of departure but that it is not a finished product and should do more to consider the long-term developments than it does now.

On February 5, 2001 the ministers of both countries, Steven Stevaert (Vlaams Gewest) and Tineke Netelenbos (Ministerie V&W), commit themselves to continuous cooperation over the future development and management of the Westerschelde by signing the Memorandum of Kallo. The Flemish government

issues a statement in May that out of all the scenarios proposed in the LTV, it would opt for the gradual deepening of the Westerschelde to 12.80 metres (the third scenario). The decision to choose a less radical scenario is made with Dutch sensitivities in mind; an instant deepening to 14 metres would probably not go down well with the Dutch government. Besides, it is also considered very expensive. Even Leo Delwaide agrees with this. The government supports the foundations of the LTV and calls for the "onverwijlde" ("immediate" – LG) execution of a cost-benefit analysis and an environmental impact assessment. The Flemish government stresses the future management and development of the Westerschelde should be shared between the two countries and that research should become a bilateral matter. It also wants to keep the option open to deepen even further in the future, as research from the Policy Research Company suggests that the estimated costs of dredging – for both deepening and maintenance of the depth – will be earned back three to five times.

The environmental pressure groups are the first to criticise the government's decision. Although the third scenario looks like a compromise, they believe it will be impossible to execute. As it takes a long time before morphological changes become visible, these groups point out that it would be impossible to tell the consequences of the deepening so soon after the operation. They worry that each step in deciding a further deepening will be an outcome of political negotiations rather than of monitoring ecological changes.

The port authorities are also not entirely happy with the LTV. They feel that a deepening can take place much sooner and more efficiently than through the current procedure. They suspect that the Dutch authorities are not being cooperative and that this research is not serving the interests of Antwerpen. They therefore demand counter-research. There is also a desire to find out whether deepening and maintenance can be carried out more efficiently. PAET's idea of using dredging to restore the estuary rather than stopping dredging may provide an answer for the first issue. In addition, their idea of using dredged material on the spot may improve the efficiency of dredging and dumping. Thus, although PAET's research has played a marginal role in the debate so far, it now becomes connected to these questions and is championed by the port authorities and the Vlaams Gewest as an alternative to the Dutch research.

Peters believes that the best way to prove the utility of morphological dredging is by conducting an empirical in-situ test somewhere in the estuary. This test could prove that it is possible to use dredged material from the deepening and maintenance operations to improve the morphological and ecological

condition of the estuary. Such a test could also show that the current dominant way of doing research, i.e. through computational models, is insufficient. Peters pleads for methodological triangulation in research by pairing computational models with empirical tests and including the use of scale-models. So far, these ambitions exist only on paper and cannot be easily executed as PAET depends on WL Borgerhout, which in turn depends on the AWZ, which cannot provide the resources to do more research.

Before the Dutch government can respond to the Flemish statement it has to deal with a rather urgent matter. On September 29, 2001, the European Commission officially warns the Dutch state that it has taken insufficient compensation measures for the previous deepening. The Dutch state was already made aware of this warning in May and was given two months to respond, with an extension given till the end of September. As it has failed to respond in time, the formal warning is publicly given.

The European Commission notes that although plans to realign dykes and to create flood plains had been drawn up by the Dutch, nothing much has actually happened. Societal protests in 1996 led the government to abandon its plans to convert agricultural areas into flood plains and attempts were made to restore old creeks at the inland-side of the dykes instead. However, the European Commission feels that this has got nothing to do with restoring damage to the estuary, as there is no direct relationship between what happens in the estuary and what is done on the other side of the dykes. The European Commission is also unhappy with the fact that no concrete plans for compensation were made when the deal to deepen was signed. The Commission finally allows the Dutch state more time to prepare its defence or come up with concrete measures and emphasises that compensation must be made in connection with the Westerschelde.

The Dutch state responds by the end of October. It claims that it has taken sufficient compensation measures and believes that the European Commission is not right in refusing to consider nature restoration inside the dykes as compensation. It argues that the Commission's warning will not reduce societal protests and as long as the conversion of agricultural areas is out of the question, the measures proposed by the Commission are unrealistic. The Dutch state also argues that the creation of a slufter at Rammekenshoek should count as a compensation measure. However, its size of 10 hectares is far below the originally intended target for compensation. The Province Zeeland also intends to convert the small ports of Kruiningen and Perkpolder into nature areas but

this is planned for the year 2003, when the ferryboat between the two ports will stop operating if the new Westerschelde tunnel running under the estuary is completed on time. On the sidelines of this discussion, local authorities in Zeeland emphasise that no new deepening will be considered before the current affairs have been solved. Rijkswaterstaat is well aware that the creation of flood plains will provoke resistance and that, at the same time, if it is found guilty of breaching the rules for compensation, it will take many years before the European Commission arrives at a final decision.

A month later (in December 2001), the Dutch finally respond to the Flemish statement regarding the LTV. A working group led by Joan Leemhuis-Stout has drafted this response after collating the opinions of different Dutch actors. BOWS is also consulted and they state that they support the report but also believe, given their past experiences, that a sound cost-benefit analysis and an EIA are necessary in order to determine whether further deepening is indeed a wise move. The minister expresses this very same opinion in a letter to the Dutch parliament. She also expresses that the LTV's paradigm of sustainable development should be followed up on.

While the governments of both countries seem to agree with the goals stated in the LTV 2030, other actors are not too happy with the document. Environmental pressure groups, in particular the ZMF, fiercely oppose the plans. The ZMF states that the consequences of the previous deepening are not yet known and there is, therefore, no sound foundation for making a decision. Moreover, they perceive that the commission is willing to favour the economic perspective over the ecological perspective. While the environmental pressure groups demand sound research before any further deepening, they feel that the commission overrides this argument by stressing the economic importance of the port of Antwerpen of the Flemish region.

ZLTO, which represents the farmers, also does not support the plans, especially where it concerns the construction of flood plains and the realignment of dykes through the sacrifice of agricultural land.

The year ends with a decision to start a new bilateral cooperation agreement to put the LTV 2030 into practise. The TSC establishes a project-based organisation called ProSes, which is short for Projectdirectie Ontwikkelingsschets Schelde-estuarium, or Project Directorate (for the) development (of a) development outline (for the) Schelde estuary. This organisation is tasked to develop a concrete outline for the Westerschelde for the year 2010, based on the LTV 2030. Rather than developing this outline in a classical fashion, i.e.

developing it within the organisation, ProSes aims to operate as a forum in which actors from all sides are invited to join, express their views and conduct research. This input is supposed to be used in the final proposals, which should answer three questions: Is it possible to deepen the Westerschelde and to deepen and broaden the Zeeschelde once again? Is it possible to restore and reinforce the degenerating nature? Is it possible to improve safety around the Westerschelde and especially the Zeeschelde? The result is called an outline or development plan, as it should be more specific than the generalised LTV 2030, but should not act as a fixed blueprint and legal binding decision.

6.4.4 January 2002 – December 2002

ProSes – debating the estuarine dynamics. ProSes begins to establish itself as an organisation and to recruit its core members during the fall and winter of 2002. Many of these members are recruited from actors within the existing governing structure in both the Netherlands and Flanders. Huub van Zwam of Rijkswaterstaat and Jos Claessens of AWZ jointly head this organisation to emphasis the bilateral nature of the process. The Memorandum of Vlissingen, singed by the two countries on March 4, 2002, confirms the contents and processes of the tasks for ProSes and reconfirms the viewpoints of the actors regarding the future of the estuary.

The people running ProSes establish two tracks within the organisation in order to answer the questions laid out for them: decision-making and research. Within the first track concerning decision-making, stakeholders are brought together to state their goals and intents and garner support for decisions not only within ProSes but also with the policy action system and the societal environment. To do this, various actors are brought together in the Overleg Adviserende Partijen (Consultation Advising Actors - OAP). OAP advises the decision-makers on the results generated by the actors in the second track on research. Stakeholders such as ZMF, local municipalities represented by BOWS, the Provincie Zeeland and water boards Zeeuws-Vlaanderen and Zeeuwse Eilanden are involved in this track. Their role in the process is different from before as instead of being asked to respond to plans, they are themselves actively involved in drawing up the plans.

During negotiations over the previous deepening operation, the main difficulty with societal resistance was that the policy action system did the

actual negotiations over the deepening, while the societal actors were exclusively involved with the negotiations over the nature compensation and restoration through the BOWS initiative. Both the deepening and nature restoration were part of the same issue, i.e. the further development of the Westerschelde, but were kept separated because the policy action system feared that linking the two issues would cause delays. This meant that the societal actors were excluded in the policy debate and their discussions over ecological development were not linked to the deepening. The establishment of the OAP by ProSes is an attempt to avoid repeating this exclusion.

The role of agricultural organisations in ProSes is complicated. The Flemish organisations are purposefully left out of the OAP process due to past negative experiences and their inability to appear univocal. In addition, ProSes does not want to spend too much of its limited time and resources addressing the issue of agriculture, as it is not explicitly stated in its mandate. These Flemish organisations themselves express that they do not wish to be included in the process, as they would see it as an expression of agreement to give up land for safety measures as proposed in the Flemish Sigma plan. On the other hand, the Dutch agricultural organisation ZLTO is involved in the OAP although its role is minor compared to the other stakeholders. While it is upset by the prospect of the potential conversion of agricultural areas and regards ProSes as a real threat, its stance changes slightly later on when it realises that ProSes is the most suitable and serious forum to deal with its interests.

ProSes reasons that it has to stick to its tight deadlines and high ambitions. Although it is engaged in an interactive process, it does not want to run the risk of exceeding the time it has been allocated and the scope it has been allowed. Since agriculture is not explicitly addressed in the mandate (which comprises economy, ecology and safety), ProSes feels that it should spend little of its limited resources on agriculture. Another reason for exclusion is that ProSes aims at completely equal participation and inclusion of the Flemish agricultural organisations would create a slight disequilibrium in favour of the Flemish actors. Because of these considerations and the aforementioned stances, agricultural organisations are not very well-represented in the OAP.

The second track in ProSes concerns itself with the research that is necessary to make sound policy decisions. There are several research areas that need to be addressed in separate working groups: morphology, ecology, navigation and a societal cost-benefit analysis (SCBA). The SCBA will be done by the Dutch Centraal Planbureau (Central Planning Bureau – CPB) and the

VITO (Flemish Institute for Technological Research). The strategic environmental impact assessment (SEIA) is carried out by a combination of large consultancy firms from the Netherlands and Flanders such as Delft Hydraulics, Arcadis and Technum. This is coordinated by ProSes and it establishes working groups to advice them in this process. There are also working groups on ecology and other aspects.

The working group supervising the research on morphology is staffed with people from WL Delft, RIKZ, Technical University Twente, Bureau Getijdenwateren, WL Borgerhout and Rijkswaterstaat but also from ZMF. The actual research on morphology is carried out by WL Delft, together with Alkyon and, in part, by WL Borgerhout. Due to the limited time frame, ProSes has to rely on existing research to fill the gaps in knowledge about the physical workings of the estuary. It hopes to investigate a limited number of scenarios regarding the future of the estuary. PAET's research is included in ProSes' programme in order to investigate the obligatory alternatives. There is considerable resistance to this from some actors such as Rijkswaterstaat and RIKZ, as they fear that PAET will be biased and only promote a deepening. Peters' defensive stance against the dominant methods of research and his alternative opinions also annoy some in the research track.

Initially, ProSes seems to be the competitive stage for two divided groups of actors. Actors including the port authorities and the municipality of Antwerpen are very critical of the approach used by ProSes. They consider it their right to demand, and to receive approval for, another deepening. They point to the Treaty of 1839 in which the Dutch state promised to keep the port of Antwerpen accessible through the Westerschelde as evidence of this. The Dutch, in turn, point out that this commitment does not necessarily translate into a further deepening of the estuary as the port is currently already accessible. Leo Delwaide from the port authorities and alderman of Antwerpen is especially vocal in his resistance to the approach used in ProSes. He argues that there is no need for further negotiations and repeats his threat to present the matter to the European Court of Justice. Delwaide believes that it will be easier to obtain approval for the deepening through lawsuits and regards the establishment of ProSes as a deliberate attempt by the Dutch to prevent further development of the estuary. Because of his straightforward and confrontational approach, other actors are given the impression that his stance represents the general point of view of the Flemish, although this is not the case. The Flemish parliament, for example, is more willing to give ProSes a chance.

In opposition to the port authorities and the City of Antwerpen is a large group of actors who are doubtful about the necessity of the deepening and about its potential consequences on ecology and safety. Rijkswaterstaat argues that since little is known about the effects of the previous deepening, it is useless to talk about a new one. ZMF adds that it does not wish to obstruct a deepening as long as research can prove that deepening does not harm the estuary's ecology. So far, this has not been thoroughly researched and it casts uncertainty on the decision-making process. Delwaide and his colleagues regard these uncertainties as part of an attempt to obstruct the deepening. The Dutch decide to do more research, even though there is not much time for this.

WL Delft Hydraulics is nominated to carry out morphological research. It is asked to write a proposal outlining the options given the budget available. WL Delft proposes to make extensive use of computational models. There are two reasons for this. First, limited resources do not allow for extensive research and a computational model is the best way to get the most results within these constraints. The second reason is the issue of irreversibility. Many Dutch actors believe that the Westerschelde is a complex system that is on the verge of collapse. They believe that any manmade change in the estuary, however small it may be, can cause total degeneration. The use of computational models allows researchers to experiment with different types of changes without potentially harming the estuary itself.

WL Delft proposes using a number of models. Estmorf and Sobek are two models with which a number of developments within an estuary can be simulated but there are higher expectations of the Delft 3-D model. This is a relatively new model, also used during the LTV process, that can deal with a very large number of variables and can calculate in three dimensions, which is crucial given the complexity of the morphology of the Westerschelde. The problem, however, is that this model has not been fully developed and tested yet, nor has it even been validated. Besides, some experts, including those from the Technical University of Twente, believe that its sophistication and ability to handle great detail is a disadvantage when dealing with such a vast surface as the Westerschelde. The supporters of the model do acknowledge that Delft 3-D is not as developed as they would like it to be but argue that it is still the best available model. In the end, Sobek is used as the primary computational model, even though this model is also criticised.

The decision to focus on computational models is accepted among Dutch research institutes but not accepted by Flemish actors in general and PAET in particular. The port authorities suspect that the models are drafted and operated with a bias against the further deepening of the estuary. PAET is more outspoken and argues that research should triangulate with the use of scale-models and empirical tests in combination with computational models. Pairing these methods and taking into account the long-term developments of the Westerschelde over thousands of years would give a much better impression of what would and would not work. Computational models are not able to do all that because they are calibrated with the available data that usually only goes back a few decades. PAET and WL Borgerhout argue that too much emphasis is placed on the outcomes of the computational models. They accuse WL Delft of not being clear about the uncertainties that surround these outcomes and for presenting the numbers as unambiguous. WL Delft defends its choice of methodology by stating that the restrictions of ProSes do not allow for more well-rounded research and that, although Delft 3-D has not been fully developed, it is still the best available model at this time. Some Dutch actors also think that the approach of PAET is too intuitive and lacks scientific underpinning.

PAET also argues that the current research does not take into account the role of hard points, groynes and dykes in the geometry of the Westerschelde. Peters alleges that the influence of these factors on the morphology of the estuary are underestimated in the current research. He believes that the current geometry has negative consequences as it creates turbulence where it should not and deprives the estuary of room for change.

Most participants in the working group are dissatisfied with the way in which it operates. From the onset, they have been put under considerable pressure to deliver quick results with little room to investigate certain aspects in more detail. The first few working group meetings are spent squabbling over models, procedures and research focus. Research reports are delivered very late and there is not much time to read them and prepare a scientifically grounded point of view.

During this summer, a Belgian skipper is arrested for sailing his tanker on the Westerschelde while drunk. He wanders off the navigation route and is considered a danger because there are still gasoline fumes in the tanks. This incident provokes some debate in the local newspapers over the question of whether the Westerschelde is a suitable navigation channel.

6.5.1 January 2003 – October 2003

MOVE – morphological research – collisions in the Westerschelde. Despite all the issues, the establishment of ProSes marks a change in the debate over the Westerschelde. During the winter of 2003, it encounters a stumbling block: its budget is cut back and it has to limit the scope of the research programme even further than its already limited scope. As there now really is no time to let the model run alternative scenarios, ProSes is urged to go ahead with the Delft 3-D model.

In a ProSes meeting in June 2003, a preliminary nature development plan is presented which has been developed by RIKZ, the Flemish Institute for Nature Protection and the University of Antwerpen. This plan is discussed among the ProSes participants, who decide that the plan is too extensive given the limited time and resources available to the group. The scope is therefore narrowed down to a number of concrete nature projects that deserve further development. These include the creation of intertidal areas through the conversion of agricultural land. Although the participants would like to investigate more options, they are under tremendous pressure to show concrete results in a short period of time.

The MOVE monitoring programme, begun in 1996, has delivered some initial results. The preliminary MOVE report is released on June 16, 2003. The report aims to indicate the consequences of the previous deepening and provides clues about the feasibility of a new deepening. However, RIKZ warns that there are a few problems in discussing these indications. Firstly, the previous deepening operation has taken place too recently to see any clear changes. Morphological developments typically appear after about 15 years, so any observations over a shorter period of time cannot be clearly linked to the deepening. The data in the report covers the period until 2001, which is only four years of useable data, while RIKZ expects that any changes caused by the previous deepening will only appear around 2011 to 2021. Until that time, any observation is difficult to interpret and cannot be used with confidence in the current debate over a new deepening operation.

The second problem with the indications put forward by RIKZ is the complex causation in the estuary. It proves to be very difficult to separate natural developments from anthropomorphic ones. Even if the manmade developments can be disentangled from the natural ones, it is still extremely difficult to relate a certain development to a particular operation. The deepening operation in 1997 and 1998 was not the only anthropomorphic change that took place in recent times; a deepening was also done in the 1970s, there was and continues

to be maintenance dredging work done and the geometry of the estuary has also changed over the years. It is therefore rather complicated to attribute any changes specifically to the particular deepening that was done between 1997 and 1998.

The way in which MOVE was set-up based on hypotheses regarding the consequences in the estuary also proves to be rather problematic. In hindsight, the researchers realise that some parameters did not need to be investigated while others may have required more monitoring than expected. RIKZ therefore warns that any observations made in the report must be treated with caution in terms of their causes and consequences.

With these caveats in mind, the MOVE report presents a number of observations. The clearest development is the increase in the tidal range in the eastern part of the estuary; the water level is higher during high tide and lower during low tide than before the deepening. This was as predicted, but there are no clear clues as to what has happened with the total tidal volume in the estuary. With regard to the morphology, the report concludes that the surface of the shoals has remained more or less stable and increased in height, and that the shallow water areas have also remained stable. This is different from what was predicted because before the deepening, the surface of the shoals had been increasing while the amount of shallow water areas was decreasing. However, the trend fluctuates so it is hard to tell whether the observations are long-term trends or just temporal changes. With regard to ecology, the report concludes that no effects have been observed yet.

RIKZ had also been tasked to evaluate the maintenance dredging works. Maintenance dredging in the Westerschelde mainly involves keeping the thresholds at the desired depth, as these are the primary locations where sediments accumulate. The average volume of dredged material between 1999 and 2002 was 11 million cubic metres annually and is increasing slightly. RIKZ notes that most dredging at the thresholds has remained stable while dredging at the edges of the shoals has increased. Hence, it can be concluded that it is the broadening of the navigation channel, and not the deepening, that has caused the increase. Besides the volume that is deposited within the estuary, some 2.6 million cubic metres of sand are mined annually for industrial purposes. The report concludes that the limits that have been set on the dumping of sediments endanger the multi-channel character of the estuary.

RIKZ also concludes that the estuary is exporting sand. This is a change from the past, as the Westerschelde was importing sand for a long time, which

justified mining it. This policy needs to be reconsidered given the fact that this is no longer the case. However, the main question that had been posed to MOVE – whether the estuarine dynamics have remained stable or are disappearing - remains difficult to answer because of a lack of data and because it is not clear what defines estuarine dynamics. RIKZ believes that more information is required to understand the morphology, but other actors exploit this lack of a clear relationship to champion their own cases.

Most of the Dutch actors see the lack of clear observations as an indication that new dredging operations should be postponed until the effects of deepening and broadening are more obvious. The Flemish actors, on the other hand, interpret the results of this research very differently. Headed by Leo Delwaide and Jan Blomme of the port authorities, they state that the reason why no clear indications have been found is not because the effects have not yet occurred, but because there simply is no effect from the deepening. They argue, then, that it is quite possible to deepen the estuary again as there are no indications that it will have an unfavourable effect on the Westerschelde's morphology.

Although MOVE may not have a decisive role to play in ProSes, it has become part of a long-term research programme called LTV/O&M (Onderzoek en Monitoring – Research and Monitoring). This programme is aimed at improving the understanding of long-term developments in morphology and ecology and to develop methods to investigate them. The programme runs synonymously with and is partially connected to the ProSes research programme.

At this stage it becomes clear to everyone that, because morphology can not make exact predictions, it is probably impossible to provide concrete and clear-cut indications that policy-makers can use to base their decisions on. The Delft 3-D computational model is considered to be underdeveloped for its task within the working group at this time.

Apart from its criticisms of the Delft 3-D model, PAET also argues that the current way of thinking in the working group on morphology is too clinical and has become disconnected from the realities of the estuary. Peters calls for a more experimental and intuitive approach to understanding the Westerschelde. He states that people should not be afraid to conduct in-situ testing but this is met with reservations. Many participants, among them Rijkswaterstaat, RIKZ and WL Delft, believe that the state of the estuary is less than ideal and are afraid that tampering with it will cause further decline. Peters, on the other hand, believes that people are just afraid of new and perhaps strange ideas. The two stances are separated along the Dutch - Flemish divide. There are, in fact, Dutch actors such

as ZMF and Bureau Getijdenwateren who feel that PAET's ideas are worth a try.

Rooted in the LTV process, PAET continues to want to conduct an empirical test to prove the theory that morphological dredging will help regenerate the estuary. It is dependent on WL Borgerhout and AWZ to arrange for the materials and setup required for the test. In addition, a permit issued by Rijkswaterstaat is required and PAET views any delay in granting this permit as deliberate obstruction. ProSes demands a second opinion for the research before it will agree to an empirical test. However, there are actors within the working group who are willing to investigate PAET's ideas further and the proposal is not removed from the research programme. ZMF, for example, thinks that a deepening is unavoidable and believes that Peters' alternative will be better for the Westerschelde as it may introduce more estuarine dynamics. This is still hidden from the public view, however, as the image of ZMF supporting a representative from the port is considered not to go down well with people in Zeeland.

While there is a lot of discussion over the issue of whether morphological dredging or a deepening will cause or resolve environmental damage, there are very few actual connections between the morphology and ecology working groups. As little is known about the exact relationship between morphology and ecology, participants agree that a connection between the two groups is desirable.

Partial tuning between the groups takes place because some people, such as Vincent Klap of ZMF, have joined both groups. Respondents agree that little is known about the exact relationship between morphology and ecology. Throughout the course of this year there is some rapprochement between Peters and his opponents. Some people feel that Peters' ideas may be interesting and Peters is himself open for discussion and willing to consider other ideas. Although total harmony has not been achieved, the rows that took place when ProSes was first established are gone and discussions have become more constructive.

There are some in ProSes who voice the opinion that the problem may not be the deepening of the estuary but rather the dredging and dumping for maintenance works. The policy change on maintenance dredging after the previous deepening, in which the dredged material from the eastern part of the estuary is now dumped into the western part instead, has resulted in a decrease of the dredging volume. Also, the way in which dredging works are currently conducted is a cause for concern. Some people, including Claessens and Peters, argue that the current method of sediment management has become rigid and does not move in tandem with morphological dynamics. They argue that since

the morphology of the estuary is constantly evolving, the rigid structure of dredging permits issued based on coordinates clash with this dynamic. They therefore champion a more dynamic approach to sediment management in the estuary, something that was first proposed during the LTV process. That means more flexibility in the dumping of sediments. The dredging cannot be flexible as the sills are on fixed locations.

While this discussion is taking place, real emergencies are surfacing in the estuary itself. On July 23, the tankers Pelican 1 and Maersk Bahrain collide on the Westerschelde. The Pelican is loaded with chemicals and it takes salvage workers one week to tow the ship from the banks of the estuary. Just one month later, on August 13, a similar accident occurs at the Nauw van Bath, in the eastern part of the Westerschelde. The wreckage of the Grande Nigeria and the Nada V is instantly salvaged. Those who oppose the deepening use these events as proof that the shipping traffic on the Westerschelde has reached its limits and that further deepening will not help to prevent such accidents. They reason that a new deepening will not meet the criteria of increasing safety. To them, new, larger ships carrying chemicals pose a real threat to the villages along the banks.

6.5.2 November 2003 – December 2003

Preliminary proposals – assessing the in-situ test. ProSes releases preliminary proposals to the public in November 2003. The most important statement it makes is that further deepening of the navigation channel is feasible. At the same time, it recognises that there is still no way to determine the effects of deepening on the estuary's ecological state. Another proposal it makes is to relocate a number of dykes further away from the estuary in order to restore flood plains and create ecological areas. The Braakmaan creek near the town of Terneuzen is deemed suitable for this. ProSes hopes that it can convince people that the creation of intertidal areas is unavoidable. In the newspaper de Volkskrant, its spokesperson, Frank d'Hondt, argues that previous attempts have failed because the decisions were imposed on farmers and water boards. He therefore believes that a better strategy is required to sell the idea to the local people. The third proposal from ProSes is to investigate the construction of the Overschelde. This plan involves a new channel running from the Westerschelde to the Oosterschelde through Zeeland that features a number of locks that will be opened during high tide to allow excess water to flow from the Westerschelde to the Oosterschelde in

order to maintain a safe water level, which is important for Antwerpen as well. The last proposal put forward is to investigate an alternative if new knowledge finds that deepening would be too harmful. This alternative scenario involves the development of the ports of Vlissingen and Zeebrugge. The problem, however, is that the working group thinks the construction and operation of such outports would cause more environmental damage than the deepening of the Westerschelde. This is part of the SCBA.

These preliminary proposals presented to the public forces actors to be outspoken about their views. The agricultural organisations oppose the proposals because they fear losing agricultural areas. ProSes has already been warned not to use the 'o-word', i.e. 'ontpolderen', in public even if the political climate changes in favour of creating flood plains. It does mention it nevertheless and ZLTO uses this to distinguish itself as the farmers' patron. There will be no support from them for the proposals.

The Provincie Zeeland feels that ProSes has done too little to keep local actors satisfied. Its deputy Thijs Kramer believes that ProSes harms the cause by discussing everything in public, thus forcing actors to assume their traditional roles, i.e. either against or in favour of a deepening, instead of being cooperative. For example, all local political parties have statements in their programmes that oppose a deepening, so it would take a lot of diplomacy to change their stance. Kramer himself has to deal with his double role of being the deputy of the Provincie Zeeland and the chairman of BOWS, in addition to being a past member of ZMF. This means that he has to be very careful with what he does and generally thinks that ProSes interferes with his careful attempts at garnering support for the proposals.

The Dutch government now has to decide on the funds for nature development. If the deepening is realised, it will have to contribute to compensation and in the face of that, it announces that it will allocate fewer funds for nature development. This in interferes with the mission and ambitions of ProSes and it is forced to tone down its plans in order to keep it (financially) feasible, much to the chagrin of ZMF and other environmental pressure groups.

AMT completes the feasibility assessment of the in-situ test in September. It intends to dump dredged material from the main channel into the edges and tips of the shoat at Walsoorden. Following research by WL Borgerhout, it is decided that the idea is feasible and PAET now has to present the plans to an independent group of experts for a second opinion. This second opinion is released on October 3, with the experts acknowledging the feasibility of the proposals. This makes

it possible for PAET to apply for a permit with Rijkswaterstaat. However, the volume that PAET wishes to dump is too large to fit into a permit and may require an EIA. As this would take more time than obtaining a permit, PAET downsizes the volume of dredged material it intends to dump. This provokes criticism from Rijkswaterstaat that the test cannot be that well-planned if the intended volume can change so easily.

In the meantime, there are still discussions within ProSes about whether the empirical test should be a part of its programme at all. Some believe that such a test, which is new and experimental research, should be placed in a long-term research track rather than being a ProSes assignment since ProSes had to use existing, and not new, research. They feel that the test has entered ProSes through a loophole, because of the obligation to investigate alternatives. Peters, in turn, feels that the test should be a part of ProSes because it raises the possibility of solving the problem of storing dredged material while at the same time combining a deepening with ecological development.

6.5.3 January 2004 – August 2004

Less ecological development – squabbling. As ProSes' mandate expires at the end of 2004, it is under considerable pressure to design the Ontwikkelingsschets 2010 (Development Outline 2010) for the Westerschelde. However, there are a number of events that precede and influence the outlines of its proposals.

In response to the ministerial decision to cut back on ecological development, the environmental pressure groups send a letter to the OAP in June 2004 to explain their concerns about the lack of ecological development in the plans for further deepening and increasing safety. OAP then urges the Dutch government to allocate more funds and the minister gives in.

The minister's change of heart causes the environmental pressure groups to reconsider their own point of view on the ProSes process. The ZMF now changes its point of view from a complete and total rejection of the dredging activities towards support for the Flemish proposal of morphological dredging if it can restore the ecology of the Westerschelde. In an interview with the Dutch newspaper NRC Handelsblad on July 30th, Vincent Klap of ZMF explains that their concern is not the deepening itself but rather the strategy for dredging and dumping of the dredged material. The ZMF begins to openly state its sympathy for the PAET discourse of pairing a deepening with the possibility of an improved

morphology and ecological development. It also decries the dredging and dumping strategies employed by the Dutch which may have a negative impact on the estuary. Apart from supporting the fact that morphological dredging may be good for the estuary, the ZMF also hopes that supporting PAET and, indirectly, a new deepening will cause the Flemish actors to be more willing to raise funds for nature restoration. This is the first time the port of Antwerpen and the Dutch environmental pressure groups publicly adopt the same point of view.

The amount of funds allocated to nature restoration is not increased instantly. The prepublication of the plans among the members of OAP causes the ZMF to state that it believes that the plans will never pass the Council of State because the nature dimension is underdeveloped. In response, the budget is increased in order to safeguard the overall goal of the development plans.

In August 2004, seven nature organisations from Belgium and the Netherlands, including the Vogelbescherming Nederland and the WWF, start a new initiative called 'De Schelde Natuurlijk' (The Schelde Naturally), which is a large-scale campaign meant to bring the natural dimension of the Westerschelde into the public focus and to emphasis the ecological value of the estuary in the ProSes project. While the initiative is the responsibility of the nature organisations, it finds diverse partnerships among its sponsors: the Dutch Ministry of Agriculture, Nature and Food Quality, the Ministry of the Flemish Community, and the Dutch municipalities of Terneuzen and Borsele. To celebrate the start of this campaign, the Dutch Minister of Agriculture, Nature and Food Quality, Cees Veerman, delivers a speech in which he praises the initiative while stressing that the environmental pressure groups should not count on extensive funds to restore and preserve nature. While funds will be provided for the obligatory compensation, there are very limited funds available for anything else.

Meanwhile, the ProSes proposals are beginning to be publicly debate among the regional and local governments. The deputy of the Province of Zeeland Thijs Kramer struggles with his multiple roles in the OAP, Provincial Council and BOWS. Other political parties accuse him of not being open enough about what is going on at ProSes. These parties demand that ProSes releases the OS2010 to them before it is officially released next month, but ProSes refuses. However, it cannot prevent some details of the plans from being leaked to the public, one of which is to reopen the Braakmanpolder at Terneuzen. The Braakman was the last sea arm to be closed off around 1952. Changing ideas about the desirability of this closure have led to the proposal to reopen the northern part of the Braakman

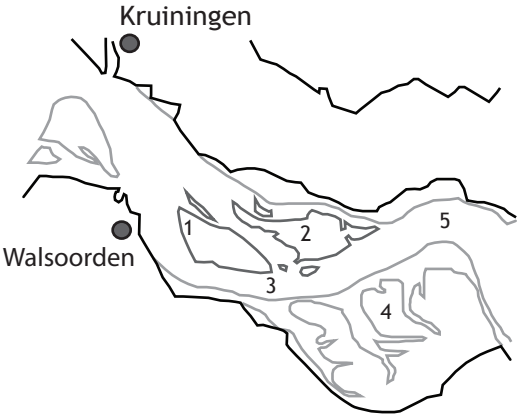


***Figure 5**: The complex of shoals where the in-situ test is carried out.*
1 - Walsoorden shoal
2 - Valkenisse shoal
3 - Valkenisse channel
4 - Verdronken Land Saeftinghe
5 - Strait of Bath

Based on WL Borgerhout, 2003.

as part of the measures to compensate for nature loss. The council of Terneuzen, however, intends to develop industries in the polder, in a similar vain as Dow Chemicals Benelux, a large chemical complex near the village. Reopening the Braakman would make these industrial developments impossible.
After the proposal to do an in-situ test at Walsoorden has been found to be feasible by a second opinion, WL Borgerhout is granted a permit to conduct the test on behalf of PAET. The test itself remains controversial but sceptics are confident that the test will at least settle the discussion.

The empirical in-situ test is conducted at the end of the summer. The shoal of Walsoorden (*figure 5*) is selected as the test site as the tips of the shoals are considered to be degenerated. The test should prove whether it is possible to use dredged material to help the shoal to regenerate itself while at the same time improving the self-deepening capacity of the channel next to it. If it works, the test will solve many issues, including the storage of dredged material (at the edges and tip of the shoal), a decrease in maintenance dredging (because sediment accumulation in the channel decreases) and ecological development (through regeneration of the shoal). Half a million cubic metres of sediments are disposed of around the shoal and this seems to rebuild the shoal in an efficient manner. Informally, PAET concludes that the test is a success as the actual results reflect the predicted results. Although the results are supposed to be released to the public next month, ProSes announces its success immediately in the NRC Handelsblad newspaper. However, it acknowledges that a longer monitoring period is required and a final report is scheduled for release in 2006.

6.5.4 September 2004 – December 2004

Test at Walsoorden – publishing the OS2010 – societal response. September is an important month because of two events. The first is the formal presentation of the results of the test at Walsoorden. This coincides with the second important event, which is the release of the OS2010 by ProSes. The empirical in-situ test at Walsoorden is an attempt by PAET to prove that the concept of morphological dredging is feasible. Apart from that, the test is also meant to refute criticism from WL Delft, RIKZ and the Technical University Twente that the Flemish proposals are based on gut feelings rather than on well-founded research.

The favouorable outcomes of the empirical test serve as a trigger for the policy process. Firstly, it reinforces to the port authorities and its associated actors that a deepening is possible without considerable ecological damage. It also provides a way out for other actors because the test combines two ostensibly conflicting dimensions and is even considered to promote the ecological state of the estuary. Actors such as the ZMF and the Provincie Zeeland regard the outcomes as an indication that the deepening of the estuary does not necessarily harm the ecology but may improve it instead. Other actors such as Rijkswaterstaat and WL Delft are taken by surprise, as they have not expected that the test would be successful. They admit that the PAET proposals are interesting but at the same time caution against too much optimism about the test results. They argue that this was a local test and given the non-linear nature of morphological developments in estuaries, it is impossible to generalise the results to the whole Westerschelde. These actors observe, with some regret, that policy-makers do not seem to be very concerned about these limitations and simply embrace the solution that PAET offers.

For policy-makers, evidence that a deepening can help the estuary rather than harm it is too precious to let go of. It is now easier for them to broker a deal on the Westerschelde because they can focus on the economic dimension without being criticised for environmental destruction. This does raise a few eyebrows, however, from actors who have been less intensely involved in ProSes such as municipal councils, who wonder how it is possible that a relatively small test can dramatically alter the stance from an outright rejection to acceptance of a deepening of the Westerschelde.

The results from the test at Walsoorden coincide with the conclusion of the Ontwikkelingsschets 2010. The final proposals are released on September 10, 2004 and published in the OS2010 document and in the local newspaper

Provinciale Zeeuwse Courant. The main proposal is to deepen the Westerschelde to 13.10 metres (independent from the tide) to promote shipping to and from the port of Antwerpen. The proposed depth is exactly what the Flemish actors had targeted for during the LTV 2030 process, including a keel margin of 12.5 percent. The broadening does not just include the deepening of the navigation channel but also the widening of the Zeeschelde in Flemish territory. This is the area near the newly-built Deurganckdok. The Zeeschelde will be broadened to 500 metres. The OS2010 states that all operations will have to be based on the systemic characteristics of the estuary, which implies that pragmatic use of the Westerschelde exclusively for deepening is out of the question. It also emphasises the need to manage the morphology in a way that promotes ecological development.

ProSes is also explicit about the need for a more flexible dumping strategy. It points to research that has found such a flexible strategy to be helpful for both the ecological and morphological development of the estuary. It proposes to dump the dredged material at both the mouth of the Westerschelde and within the estuary. It also states that more research is required to understand how dredged material can be used to promote ecological development. One section of the proposal is dedicated to the test at Walsoorden. Because the results of the test were unavailable at the time that the document was printed, ProSes recommends that, if the results turn out to be favourable, it should be investigated whether this dumping strategy can be incorporated into the actual dredging operations. If the results of that investigation are also positive, ProSes recommends the immediate application of flexible dumping. This would allow for the possibility of introducing flexible dumping into the management and development of the Westerschelde.

The proposals include the establishment of a monitoring programme to find out if the dredging operations cause any undesired effects. If they do, the costs of recovery will be recouped from the perpetrator. Although the port authorities were initially against this proposal, they succumb to this demand in the end, knowing that it is claimable through European legislation anyway and because they assess that it will be very difficult for a monitoring programme to prove that the deepening has exclusively caused a certain unfavourable development.

The safety dimension is promoted through the partial elevation and partial realignment of dykes and the construction of flood plains along the Zeeschelde. That means that ProSes aims for the conversion of agricultural land into nature areas and flood plains. The project Overschelde, however, is

no longer considered as a proposal. It has proven to be too expensive and it is deemed undesirable to mix the relatively clean water of the Oosterschelde with the more polluted water from the Zeeschelde and the Westerschelde.

A number of decisions are made with regard to the ecology while others are postponed to the summer of 2005. A number of areas are allocated for nature restoration where an estuarine environment will be created. This means that theses areas will be open to fresh, salt and brackish water and subject to tidal changes, thereby creating wetlands and inter-tidal areas. These areas are projected to be a total of 2000 hectares large. Many flood plains are to be created in Flemish territory. The sections on ecology also emphasise the importance of the morphological dynamics of the estuary and that these should be taken into account in the dredging and dumping strategies. This resonates with the ideas proposed by PAET, even though formally the results of the test at Walsoorden are not taken into account in the proposals.

The costs of the operation are estimated at 215 million euros. Compensation and additional measures for the ecological dimension are estimated at another few hundred millions of euros. It is also suggested that the management and development of the Westerschelde should be a bilateral issue rather than solely a Dutch issue.

The OS2010 provokes a wide range of reactions. On the whole, the actors involved with ProSes support the proposals but there are quite a number who express strong opposition to it. Although the participants feel that ProSes has come to a reasonable compromise, it still suffers from the image that it is dominated by the lobby to deepen the Westerschelde. There is much criticism on the proposals regarding the ecology from the actors involved with 'De Schelde Natuurlijk'. They are very disappointed with the proposals for nature restoration and call this "tuinieren voor gevorderden" ("Gardening for advanced students"-LG) with disdain, declaring that they will challenge the proposals in court.

A number of municipalities and water boards in Zeeland state in the local newspaper that once again the province has to bleed because of the desires of the Antwerpen. The actors voicing this view include the council of Terneuzen, the major and aldermen of Vlissingen, the municipalities of Sluis and Hulst, and the water boards Zeeuws-Vlaanderen and Zeeuwse Eilanden. This viewpoint also reaches the Dutch parliament. For example, Member of Parliament Geluk from the liberal party VVD calls for a revision of the 1839 Treaty of Separation between the Netherlands and Belgium in an attempt to avoid another request for deepening. This is in turn met with comments from the port of Antwerp.

The chief executive of the port, Eddie Bruynickx, is reported as saying that there will never be an end to the deepening of the Westerschelde: "Er moet een open perspectief zijn om in de toekomst wis en waarlijk nieuwe aanpassingen te doen." ("We need an open perspective on the future to enable another deepening." - LG) This only serves to fuel the debate further.

The Provincie Zeeland maintains an ambiguous position. The council rejects the proposals altogether and criticises ProSes for the way it has dealt with the interests of the province. In fact it is taken by surprise that the deepening is approved. The province had long asssumed that a deepening would never take place and that meant that the interest in ProSes was only rising during the final months. On the other hand, it knows that it will also gain from the deepening. Deputy Kramer is quickly made aware that it is not easy to obstruct a deepening and decides to start an autonomous negotiation process with the Dutch state in order to safeguard the interests of the province. He does this outside the ProSes process because he feels that ProSes has harmed the interests of the Province. He believes that ProSes was too unaware of the feelings and interests in the province and blames ProSes for disturbing the fragile balance between different actors in Zeeland. ProSes has, in his opinion, concentrated too much on rational arguments and research instead of focussing on support and a sound deal that addresses all interests. Such an approach is also considered to divert the discussion away from the issue of intertidal areas and the realignment of dykes.

The agriculture organisation ZLTO opposes the plans because it is of the opinion that the port of Antwerpen benefits much more from the operation than do entrepreneurs in Zeeland. Together with the Flemish Boerenbond – the latter being admitted to the OAP only during the closing stage of the project – ZLTO also rejects the plans for nature restoration because it feels that these proposals come at the expenses of agricultural land. ProSes argues in OS2010 that agriculture was not a part of its assignment and that it has therefore not developed a perspective on this sector. However, at the same time, it admits that the proposals may have unfavourable effects on agriculture and recommends that these should be investigated in more detail. ZLTO is dissatisfied with this perspective. Environmental pressure groups, on the other hand, argue in local newspaper Provinciale Zeeuwse Courant that much more natural development is required, i.e. more flood plains and further realignment of dykes.

Meanwhile a number of other reports are released. The cost-benefit analysis, carried out by the CPB and VITO, shows that the Netherlands will also benefit from the deepening. This serves as a counterargument for the position

that Antwerpen is the only party that stands to gain anything from the operation. For Vlaanderen, the expected net gain is projected to be between 0.6 billion and 1.2 billion euros. Zeeland is expected to gain between 0.4 and 0.7 billion euros. The port of Antwerpen will gain a market share in container transport of approximately 3 to 4 percent because of the deepening. However, the report also states that this gain in market share will diminish after awhile when other ports catch up. In addition, it is reported that deepening beyond 13.10 metres at this point in time has a lower cost-benefit ratio. However, port authorities and shipping companies publicly demand deepening beyond 13.10 metres. The port authorities state that the plans to deepen have been delayed to the extent that they have become obsolete.

The Provinciale Zeeuwse Courant conducts a survey to find what the general public in Zeeland thinks of the proposals. Fifty-five percent of the people oppose the deepening of the Westerschelde. Older respondents are slightly more strongly opposed than younger respondents. The people in favour of the deepening indicate that they feel that Zeeland should be a good neighbour to Flanders and as such should accept changes to the Westerschelde.

ProSes begins the public hearing and consultation meetings on October 15, 2004. These meetings take one month to complete and are meant for private persons, companies, interest groups, governments and political parties to voice their points of view regarding the proposals put forward in the OS2010. The result of the meetings is that 190 responses are collected, of which 125 are from Flanders and 65 are from the Netherlands. Reactions mainly concern the measures for nature development and the way the objectives of in the OS2010 will be put into practice.

6.5.5 November 2004 – July 2005

The high-speed railway again – societal resistance against natural development. The Flemish parliament approves the OS2010 but the Dutch parliament is in no hurry. The negotiations at the end of 2004 are an echo from the past as the issue of the HSL, the high-speed railway link between Belgium and the Netherlands, rears its head once again. The Dutch state reproaches the Belgian state for 'losing' 17 minutes of the projected time it takes for trains to travel the trajectory. Eight minutes are seemingly lost due to a mistake in the calculations on the Flemish part of the track, and nine minutes can be gained from additional changes to the

track. There is also disagreement over the frequency of the service. The Dutch government says it had agreed on a regular service between Den Haag and Brussel and Breda and Brussel. The Belgian minister Vande Lanotte does not want to meet this demand as he thinks it will be unprofitable and would put a large strain on the Belgian national railways NMBS, which is already suffering from the burden of over-investment. The Dutch parliament in turn demands that the Minister of Public Works and Transport Carla Peijs send an ultimatum to the Belgian government that no deal on the HSL means that the Dutch parliament will not agree to the deepening of the Westerschelde. For the Flemish parties, this is a grisly rendezvous with the past as the negotiations over the Westerschelde are once again linked to the negotiations on the HSL – but the Dutch minister states that she does not intend to link the two issues.

These frictions continue until March 2005. Then the two ministers Peijs and Vande Lanotte declare that they have reached an agreement over a number of issues and sign a memorandum of understanding (Memorandum van Overeenstemming Den Haag). With this, the deepening of the Westerschelde is approved and is planned for 2007. The Flemish government agrees to pay the lion's share of the costs of dredging and both countries share the costs of nature reservation, totalling 400 million euros. Both countries will also reserve funds for the improvement of the road connection of the Westerschelde tunnel with the Flemish road network, while the Dutch state will finance a tunnel at Sluiskil under the channel between Gent and Terneuzen. The Provincie Zeeland, and especially its deputy Thijs Kramer, does not take much notice of the results achieved in the ProSes process and starts an autonomous negotiation process in which it argues that it is always made to suffer from Antwerpen's plans. Notwithstanding the outcomes of the cost-benefit analysis, Zeeland manages to convince the Dutch state to allocate 100 million euros for investment in infrastructure and societal affairs.

A few months later, a deal is also reached between the Dutch state and the Provincie Zeeland. The Minister of Agriculture, Nature and Food Quality stresses the importance of ecological development, even if no immediate compensation for the deepening is required. In turn, it promises the province that it can have more influence on nature development. Upon confirming this deal, the provincial council agrees to the OS2010. However, the debate around natural development beyond the obligatory compensation measures continues unabated. There continues to be considerable resistance among agricultural organisations against natural development.

6.5.6 Final observations

Societal resistance – replicating Walsoorden – a deepening without compensation? The case did not draw to a close after the case study was concluded. The policy action system continued to prepare for the creation of flood plains and spent most of 2006 making plans and offering opportunities for stakeholders to voice their complaints. Societal resistance and the long EIA procedures led to a delay in the planning of the actual deepening. Although the Flemish parliament agreed with the deepening and with the creation of nature areas and flood plains, permission from the Dutch parliament to move forward with the plans was still pending at the time of writing in early 2007. The policy action system intends to start the dredging operations sometime in 2007. However, it cannot execute the operation until societal protests are dealt with through proper procedures. This societal resistance is mainly aimed at nature development and is considerable, as evidenced by the numerous articles published in local newspapers and the establishment of the action group 'Red Onze Polders' ('Save our Polders' – LG)

The creation of intertidal areas through the realignment of dykes is considered essential for the compensation measures. However, it is not considered acceptable among many people in Zeeland and ZLTO's withdrawal of support because of the inherent sacrifice of agricultural areas prompts other stakeholders to also withdraw their support. The environmental pressure groups will only support the deepening if compensation is carried out, which in turn depends on the availability of agricultural areas. The Minister of Agriculture and Nature insists on the realisation of at least 600 hectares that are directly connected to the estuary, but also states that the pending deepening will not require any compensation at all. However, the negotiations between the Provincie Zeeland, ZLTO and ZMF remain at a standstill; with ZLTO's withdrawal, the conversion of agricultural areas into natural areas has become a very distinct possibility.

Meanwhile, the in-situ test at Walsoorden was replicated in early 2007 and initial results confirm the outcomes of the first test. This reinforces the belief that morphological dumping works elsewhere in the estuary. The final MOVE report was published in the summer of 2007 and showed a general decrease in the natural dimension of the estuary because the secondary channels are silting up, the total surface area of shoals diminished with 250 hectares and the clarity of the water decreased. The sand export to the North Sea has increased considerably. On the other side, the compensation of the previous deepening is still progressing and some hectares are slowly but steadily being gained, with

800 hectares now being planned. Still, very little compensation is physically connected to the Westerschelde and at this pace it remains up in the air whether all 800 planned hectares will ever come to fruition. Thus, the situation in 2007 is characterised by poor compensation from the previous deepening, a complete standstill regarding the development of the compensation for the next deepening, while the deepening itself might be executed. Altogether, this gives a strong impression that the progress that was made through ProSes until 2004 is starting to collapse and that the package is disintegrating.

Chapter 7: Analysis of the Westerschelde case

7.1 Introduction

The similarities between the start of the Westerschelde case as shown in Chapter 6 and the Unterelbe case are striking but deceiving. After decades of negotiations with Belgium and Flanders, the policy action system in the Westerschelde case feels pressured to give permission for a deepening operation. Following consensus over the high-speed railway link, the decision to deepen is made as well and the policy-makers pursue a quick deepening operation. The planning procedure for the deepening of the Westerschelde bears many of the same characteristics as that of the first deepening of the Unterelbe in terms of (attempting to) surpassing legal obligations and by excluding opposition.

Beyond that, however, the two cases diverge and become quite dissimilar. Doubts about the robustness of the Westerschelde become more central to the debate and result in attempts to move towards a different approach to the management and development of the estuary. The pattern of reciprocal selection that underlies this change is analysed in this chapter by understanding how the initial pressures lead to responses from the policy action system in terms of selection patterns and the projected attractor basin, how the physical system and societal environment respond to the consequent actions from the policy action system and how this results in pressure being exerted on the policy action system to alter its routines.

7.2.1 Initial selection pressures *(July 1993 – May 1999)*

Years of negotiations over the Westerschelde have not delivered the expected results and have led to a sense of urgency to conclude a deal over the deepening of the Westerschelde. It nevertheless takes another few years before agreement over the deepening is reached. It is the Flemish actors (port authorities, City of Antwerpen, the Flemish government) rather than the policy action system who pursue a deepening. Thus, the pressure to deepen the Westerschelde is not self-generated pressure from the perspective of the policy action system but rather selection pressure stemming from a specific group of actors from the societal

environment.

Besides the pressure to deepen the estuary there are a number of other pressures. The strongest pressure, and the one shared by actors in the policy action system including Rijkswaterstaat, is not to give in to the desire to deepen. There are three categories of motives for opposition. Firstly, there are actors who feel that a deepening will only benefit the port and city of Antwerpen while the Dutch region does not benefit at all by facilitating a deeper Westerschelde. Secondly, there are actors, mostly united within environmental pressure groups, who oppose limitless deepening because of environmental concerns. From this perspective, the Westerschelde has been damaged from decades of modifications, especially because of the consecutive deepening operations. Some actors in the policy action system adopt this stance as well. Thirdly, and connected to the second concern, there are actors who fear that a deepening will require the provision of compensation for environmental damage. Such compensation would occur at the expense of agricultural areas and would probably also require the realignment of dykes, which is a very sensitive topic in the region. This group of actors consists mostly of farmers and local citizens, although this concern also resonates within the water boards.

Physically, no immediate pressures are observed apart from a number of developments that may indicate a trend. Some researchers state that the eastern part of the Westerschelde is becoming increasingly rigid and that this harms the dynamism of the estuary and therefore, the ecological value that is connected to this dynamism. However, this poses no immediate selection pressure on the policy action system. Still, some actors oppose an operation because of certain trends in the physical system.

The division of Belgium into federal states means that the Flemish actors now have more freedom to negotiate a deal over the Westerschelde without being hindered by the negotiations between the Netherlands and Wallonia. The Flemish proposal to link the negotiations with those over the high-speed railway link initially causes further delays, but once a deal regarding the link is put in place, agreement over the Westerschelde is imminent. These two factors accelerate the decision making process.

When the decision to deepen is about to be made, the pressure to expand the operation into a more versatile development of the Westerschelde to include nature restoration gains momentum through the BOWS initiative. However, these plans do not have popular support as much of it involves the realignment of dykes and the restoration of flood plains and shallow water areas. The proposals also

conflicts with the pressure from Flemish actors to go ahead with the deepening. The policy action system has to respond to these diverse pressures by selecting from among these pressures.

7.2.2 Selection patterns *(July 1993 – May 1999)*

Since the management and development of the estuary is a Dutch affair and since there is no perceived benefit from a deepening, there is initially no desire to comply with the Flemish' wishes without compromises. At the same time, however, there is a sense that the further blocking of a deepening operation harms the relationship between the two countries. It is especially at the political level that it is felt that the Flemish actors should be granted a deepening. The policy action system therefore displays an ambiguous stance: opposing an operation on the one hand but realising that it is reasonable to grant a deepening on the other. Once an agreement is reached and the deepening has to be planned, the policy action system acts relatively quickly.

The handling of *connections* by the policy action system is not one-sided as it alters its stance from rejecting a deepening towards accepting one. In doing so, it alienates actors who oppose the deepening as it ceases to block any more changes to the estuary. At the same time, the policy-makers are compelled to cooperate with the Flemish actors in order to plan the deepening. This provides an incentive for the opposition to organise itself within the BOWS initiative in an attempt to counter the pressure to deepen. Actors from the policy action system become members of BOWS as well but the system opts not to support the BOWS proposals out of fear that it may lead to further delays, as the proposals suggest that previous deepening operations have harmed the estuary. Policy-makers fear that such an association will put the current planning at risk as it may lead to further protests if people consider the intended deepening to be harmful.

In a similar vein, the policy action system attempts to avoid delays by constantly reducing the opportunities for the opposition to submit formal protests, for example, by skipping permits and using a special law to bypass legal obligations. Only when the environmental pressure groups file a complaint with the Dutch Council of State does it begin to think about an alternative way of dealing with the opposition. BOWS provides this platform, even though its proposals are kept away from the planning procedure for the reasons stated in Chapter 6. The pressure from BOWS conflicts with both the pressure to deepen

and the pressure not to change anything at the cost of agricultural areas and dyke realignment. As this may interfere with the primary goal (deepening), the policy action system tries to remove this pressure by establishing the Commission Westerschelde. The commission decides that any proposals that would widen the scope of the current planning and require a change in dealing with the connections and research should be postponed to the long-term. This decision is supported and the immediate chance of further delays in planning is diverted to the future.

Altogether, this means that the *composition* of the policy action system remains fairly stable but slightly ambiguous. Fear that the planning of the deepening will be further delayed creates a seemingly clear demarcation between supporters of the deepening (Flemish actors) and the facilitators (policy action system) on the one hand and the actors opposing the deepening for various reasons on the other. At the same time, however, there are some actors from the policy action system who choose to engage with BOWS. Furthermore, the Commission Westerschelde is also later established by the policy action system. This reflects the ambiguous stance among policy-makers regarding the desirability of the deepening of the Westerschelde. However, at this stage the planning of the deepening only involves the actors who are traditionally assigned this task and other actors are not allowed to interfere with the deepening.

Research regarding the deepening of the Westerschelde is meant to facilitate the planning and execution of the operation. Therefore, no radical alternative scenarios are investigated, nor does the research delve into adjacent areas. The pressure to get the deepening through causes the policy action system to decide to skip the environmental impact assessment as carrying it out would mean that more time must be allocated to research with an uncertain outcome. The use of a special law exempts the policy action system from this obligation. During this phase, research is conducted only to serve the primary aim, i.e. to find the best way to deepen the estuary. Knowledge about the developments within the physical system is available but is rather fragmented among the actors in the policy action system.

The *scope* of the project reflects the ambition to deepen as quickly as possible and is therefore narrowed down to a deepening and the obligatory compensation. However, since a quick operation is the primary goal, the issue of compensation is not really thought through and at the time of planning there are only a few ideas on paper that are not very concrete. Compensation remains neglected and not much is planned, as witnessed by later attempts that are either

fragmented or abandoned altogether because such measures will require changes from within the basin, which means that some form of dyke realignment is almost inevitable. However, this is costly and is met with fierce societal resistance.

The main pressures on the policy action system are either to deepen the Westerschelde or to refrain from doing so. By itself, it is not adverse to modifications of the estuary but it prefers not to do so if it is not absolutely necessary. This necessity arrives with the agreement signed between the two countries. Unlike the state of the policy action system during the first period of study in the Unterelbe case, in this case there is ambiguity within the system from the beginning. Through the selections it makes, it then attempts to conduct a deepening of the estuary while simultaneously remaining receptive to alternative ideas, even if these ideas are very marginal at this stage.

Connections and composition are limited in order not to delay the deepening but not in the sense that the actors wish to create a clear demarcation between those who support and those who oppose a deepening – after all, the policy-makers themselves are unclear on this matter. Similarly, the scope is narrow and research is aimed at supporting the decision rather than investigating and comparing different scenarios. At the same time, however, the policy action system refers to BOWS and the Commission Westerschelde as outlets for alternative ideas expressed in a broader scope. In this way, it finds a way to deal with its ambiguous stance regarding the deepening. However, the selection patterns show the diversion of pressures in order to safeguard the rapid execution of the deepening operation. Given the way it plans and executes the deepening, the policy action system can be characterised as being singular in its nature.

Although the manifest nature of the policy action system is singular, it does leave room for alternative ideas and this forms the foundation of the developments that will take place in the years to follow. The changes in scope, research, connections and composition that will appear later on, e.g. the decision to develop a more comprehensive long-term vision for the estuary, are already enclosed in the mutual relationship between the disposition of the policy action system and the selection patterns. The pressures to develop the Westerschelde in a different way from before, i.e. to do more than merely deepen, are not just diverted away from the current project but facilitated to continue to exist although they are not directly incorporated into the deepening project. The singular character of the policy action system during this stage is therefore not driven by absolute self-referential properties. The diverted elements will further contest the singular nature of the policy action system during the years that

follow. This is the subject of the following sections.

The nature of the policy action system at this stage shows adaptation towards the pressure to deepen but at the same time, it also facilitates an almost underground adaptation towards the pressure to develop the Westerschelde in a different way. The immediate stance, however, is towards deepening. Not much is known about the physical risks during the planning as ideas such as the chance that the estuary may change into a single-channel system if modifications are carried too far are not widely spread within the policy action system.

The haste to get things done and consequently to skip procedures such as the environmental impact assessment in order to avoid delays is inherently risky because if these omissions are not accepted it may well lead to (legal) issues and further delays that were to be avoided in the first place. This fear becomes reality when the procedures to acquire the permits have to be done all over again as the Court of State rules that the policy-makers have overstretched the original purposes of the permits. This reprimand is accepted by the policy-makers and does not lead to further evasive actions.

The lack of compensation measures also leads environmental pressure groups to complain to the European Commission. This attracts the attention of the Commission later on but at this point in time, the policy action system feels that it is unable to do much about this and decides to leave the issue alone for the time being. An official warning from the European Commission and the consequent procedures when the warning is not followed up may take quite a while and much can be done in the interim to remove this threat. In sum, the policy action system justifies to itself that the benefits of a deepening in the way it has been planned are worth the risk.

7.2.3 The projected attractor basin *(July 1993 – May 1999)*

During the planning of the deepening operation, the policy action system formulates its goals for the future state of the estuary, and based on the current state of the Westerschelde, it also formulates the means to that end. In the vocabulary of the theoretical framework, it develops an image of the future attractor basin from which it chooses an attractor as the desired future stable state of the physical system and the means to reach that state. The selection pressures push the policy action system towards a deepening and through the selection patterns, it defines a projected attractor basin.

Clearly, the deepening of the Westerschelde is the main goal and complementary measures are not considered for inclusion in the process except for the obligatory compensation. Ideas about such complementary measures are actually under development because some actors feel that they are necessary to reinforce the ecological side of the estuary after a long period in which it has primarily been considered a navigation channel. However, at this stage it is perceived that developing such measures is not feasible in the short run and full development would result in delays for the execution of the deepening. The main reason for this is that public resistance against changes such as the realignment of dykes could hamper such plans.

Legal obligations include compensation for damages incurred by the deepening operation. Compensation is rather undefined at the time that the deepening is carried out as a side effect of the policy action system's hurry to get the work done. Although it is not defined as part of the future attractor, it remains a part of the attractor basin as it is investigated and deemed necessary in the long run.

The policy action system understands that whatever it decides, it will not receive full consent from the societal environment as the desires of those actors are mutually conflicting. Instead it accepts that the deepening will provoke resistance from a certain part of the societal environment while serving the portions of society that requires the deepening, e.g. the Flemish port authorities. This leaves a number of actors dissatisfied but that is taken for granted and, if possible, is dealt with in a legal way. At the same time, it is acknowledged that the concerns of those who oppose the operation are considered relevant and shared by the policy action system. Again, these are diverted away for the time being, with the intention to deal with it later on. In any case, these concerns are known and acknowledged as being relevant and are therefore a part of the projected attractor basin.

7.3.1 Consequences of selection and action *(May 1999 – December 2002)*

The main consequence of the selections made and the actions carried out is a deeper Westerschelde as part of a singular project, i.e. a project with a narrow scope. The deeper Westerschelde does not appear to have any immediate unfavourable side effects, so the operation constitutes a negative feedback loop, i.e. it achieves the expected stable equilibrium. In fact, it is unclear what the

direct consequences with regard to the estuary are. So far, no dominant trends of change have emerged after the deepening is completed, nor does a radical change in certain dimensions of the estuary, such as the ones observed in the Unterelbe, occur. Because there are no clear favourable or unfavourable changes – the changes that take place are generally perceived as favourable by respondents – a discussion on the impact of anthropomorphic modifications is begun. Rather than focusing on a particular physical development, this discussion centres on the different interpretations of the overall long-term development of the estuary and the desirability of more changes favouring increased depth.

The constant haste that prevailed over a more comprehensive development perspective for the Westerschelde leads to dissatisfaction among actors in the policy action system. A working group is established in response to the selection pressure to develop a more comprehensive plan before engaging in another deepening operation. It is aided by the policy action system's reluctance to discard such ideas altogether in the earlier years. The working group consists of actors from within the policy action system as well as members of the Flemish government, in keeping with the desire to manage the Westerschelde in closer cooperation between the two countries.

Its principal point of departure is the idea that further development of the estuary must be done within the framework of sustainability. This is carried over into the long-term vision process that in turn formulates the assignment of ProSes: to develop a concrete plan in which a deepening is paired with ecological development while maintaining or improving the safety conditions along the estuary. Thus, the earlier decision to leave room for ideas other than the deepening that the policy action system was planning at the time sets off a chain reaction of subsequent policy initiatives that finally lead to the establishment of ProSes.

Although the (singular) deepening of the Westerschelde has not (yet) resulted in any major physical changes other than a deeper channel, the singularity attracts the attention of the European Commission. A narrow scope, limited research and relatively closed connections were supposed to safeguard the project from further delays but this now backfires on the policy action system as the EC decides to investigate the lack of compensation measures. In a similar vein, the nature of the operation sparks off an investigation by the Courts of Audit in both countries. Their main finding is that the previous deepening lacked the founding it required.

Upon observing that the policy action system is not very willing to facilitate another singular deepening after the previous operation is completed.

the port authorities establish the Port of Antwerp Expert Team to counter the idea that further deepening of the Westerschelde is harmful and to prevent potential delays. Although the general idea behind this initiative – that further deepening of the estuary should be possible – is not new to the discussion, it is now underpinned with scientific findings by PAET that show that a deepening could promote the morphological state of the estuary. The ideas conflict with the ideas from the official working group and LTV but they are confronted nevertheless.

It appears that the selections made and actions undertaken have led to a singular deepening that has so far not resulted in clearly unfavourable physical consequences. This fact, together with the uneasiness among many actors with the nature of the operation and the consequent decisions to start new initiatives to address this uneasiness, leads to changes in the approach towards the estuary in the years that follow. In other words, during these years the deepening results mostly in social rather than physical changes.

7.3.2 **The actual attractor and its selection pressures** (May 1999 – December 2002)

The operation leaves the Westerschelde deepened and this corresponds with the expectations regarding the projected attractor basin made by the policy action system. Although there are no immediate unfavourable changes, there are many actors who wish for a different development in the future. The first pressure from the new actual stable state of the estuary is therefore to search for a more comprehensive development of the Westerschelde. This is reconfirmed through a subsequent string of initiatives in pursuit of such a development. Substandard physical compensation for the deepening attracts attention from the European Commission and the Courts of Audit. Their findings add to the pressure to adopt a more considerate approach towards the Westerschelde.

There is also pressure not to develop such an approach but these follow in response to the change in the policy action system's stance rather than from the actual physical state. The PAET initiative pressurises the policy action system to take on a different stance, namely that a deepening can be paired with ecological development, in effect arguing against the generally perceived dichotomy between economy and ecology. When confronted with the reluctance of others to deepen, this again leads to friction. A lack of unambiguous physical developments results in a discussion that centres on the different interpretations of the development

of the estuary and the desirability of more anthropomorphic changes.

Similarly, social unrest in Zeeland about the possible consequences of compensation and nature development on land-use exerts pressure not to modify the Westerschelde at all. This pressure continues to exist as the policy action system has difficulties addressing it – and had not even addressed it at all during the previous period. Because such concerns were unaddressed, these actors are adverse to any decision making that alters the state of the Westerschelde, regardless of the possible content and outcome.

In other words, the actual state of the physical system conforms to the intentions of the policy action system while at the same time, it is doubtful whether another operation is desirable. The actual social realm is as expected, with the Flemish actors demanding a new deepening while the many actors in the Zeeland province oppose any change. Together with the other pressures, this leads to a diffuse mix of pressures on the policy action system. Although there were no major unfavourable developments after the deepening, it still puts pressure on the policy action system because of the dissatisfaction among many actors regarding the actual state of the estuary.

7.3.3 Selection patterns *(May 1999 – December 2002)*

The actual state of the physical system and the societal environment leaves a diffuse mix of different selection pressures on the policy action system to which it responds with a diffuse stance. What prevails is the pressure to alter the singular regime that shaped the previous deepening. The selection patterns channel this pressure through the regime of the policy action system. Because it is the policy action system itself that is dissatisfied with the previous regime, the pressure to change is partly self-generated. This resonates in the nature of the selection patterns. During this stage, there is a blending of the policy action system with the actors who are not (yet) a part of this system. The demarcation between the system and other actors becomes increasingly unclear as the policy action system searches for a way to facilitate and respond to the diffuse mix of selection pressures it is subjected to.

A sensitivity to alternative approaches to the development of the Westerschelde and the ensuing pressures from the societal environment cause the policy action system to be careful not to cut off its *connections* with actors who are not a part of the system but who generate selection pressure nevertheless. A

series of commissions and working groups are set up to develop these contacts. Consecutive groups of actors developing plans for the Westerschelde are staffed with people from the authorised governmental organisations (such as Rijkswaterstaat), local authorities (such as municipalities along the riverbanks) and non-governmental organisations (such as the environmental pressure groups).

Although a number of actors find each other in their desire to develop a more comprehensive plan for the Westerschelde, the policy action system has markedly more difficulties in connecting with the port authorities and the city of Antwerpen as it is not eager to facilitate another deepening so soon after the previous operation. The port authorities in turn establish PAET. The almost accidental connection between the policy action system and the other social actors working on the long-term vision on the one hand and the actors in favour of another rapid deepening on the other is strained and results in mutual irritation. Within the policy action system there is considerable resistance to establishing and maintaining a connection with PAET as it is regarded as an extension of the lobby to have the estuary deepened.

The way ProSes is arranged with the decision making and stakeholder track and the research track explicitly aims at further connection of the different actors rather than maintaining a distinction between them. It is therefore inevitable that the port authorities are offered the opportunity to become a part of the decision making process. It also means that PAET is included in the research track of ProSes. This leads to friction as the some actors from the policy action system find it difficult to accept this group into their research work. However, such inclusion is embedded in the structure of ProSes.

The only connections that are not established are with the agricultural organisations and with civilians without the intermediary role of their representative organisations. The policy action system fears that the agricultural organisations will obstruct any discussion and are therefore passed over deliberately. Even though this compromises the extent of the connections, it is through this approach that the policy action system channels the different selection pressures into the decision making process rather than selecting one and diverting others. Although most actors are reluctant to accept another deepening, this option is not excluded beforehand.

As a consequence of this way of dealing with the connections, the *composition* of the policy action system alters. Formally, decision making is still delegated to the core members of the policy action system, i.e. Rijkswaterstaat

and the Ministerie van Verkeer en Waterstaat. However, it accepts that it depends on others, such as the Provincie Zeeland and the municipalities, to engage in a planning process that does not have too many hurdles. Besides, the agreement to develop a supported plan means that any proposal requires consent from societal actors as well if possible.

These considerations mean that the composition of the policy action system changes. It is no longer restricted to those formally delegated to make binding decisions over the Westerschelde; it is now also open to actors who are asked to approve a decision. These actors are not given decision making power but agreement that consent among the participants is required before a formal decision is made means that these actors are provided with the de facto opportunity to convert their pressure into a concrete policy decision. There are limits to how far policy decisions can be influenced but at this stage, this is not clearly indicated. In any case, the establishment of ProSes means that the composition of the policy action system now encompasses most of the actors who are connected in their intention to draw a broadly supported plan for the future development of the Westerschelde.

Following the advice of the commission Westerschelde, the policy action system realises that it needs a more detailed study into the past and future physical developments of the estuary. This demand for more research is further articulated when ProSes is established. From the onset it is clear that the ambitions formulated by the policy action system require considerable effort. At the same time, it is clear that the *research* is strictly limited by the time and resources available. The researchers are therefore required to fulfil the ambitions with the means that are currently available. This work is routinely delegated to the usual contractors, including Delft Hydraulics, who attempt to meet the ambitions using the existing methods and tools and in combination with the existing research.

However, PAET also obtains access to the research process through the connections created by the policy action system and through the obligation to investigate alternatives. They question the dominant ideas on the Westerschelde and the way in which investigations are conducted. PAET's ideas go against these dominant ideas and are in many cases the opposite of what was generally taken for granted within the policy action system. While WL Delft Hydraulics places a strong emphasis on computational models, PAET stresses the importance of empirical observations. While many (Dutch) actors are adverse to in-situ experiments due to a fear that this can cause irreparable damage to the estuary,

PAET believes that the robustness of the Westerschelde allows for experimentation in the pursuit of knowledge.

The *scope* of the process is defined in the long-term vision LTV 2030 that frames the future of the Westerschelde within the sustainability paradigm of balancing between economy, ecology and safety. The policy action system is now adverse to another singular deepening and fears sanctions from the European Commission or other legal institutions. It therefore opts to combine further development of the estuary with extensive ecological measures as well as safety measures against flooding. While the previous deepening operation was strongly driven by economic interest, this new ambition widens the scope of the current project considerably as it means that any modification must take into account the development of other dimensions as well.

This three-fold ambition is carried over into the ProSes process where the policy action system agrees to develop a concrete plan for the future of the estuary in cooperation with societal actors and local governments. The inclusion of these actors signifies that the scope of the project will remain as wide as agreed to in the long-term vision. While this means that a decision favouring a singular deepening is unfeasible at this stage, it also means that a deepening is not excluded from the plans as such. At least in theory, the scope of the project at this stage is balanced between economy, ecology and safety. In practice, however, there is ongoing debate on which dimension should prevail.

Under the strain of the diverse mix of pressures discussed in Section 7.3.2, the policy action system attempts to facilitate and address these pressures rather than ward them of in the same way in which it attempted to facilitate previous attempts at a more comprehensive plan for the Westerschelde. However, prior to the previous deepening, it did not allow such plans to interfere with the actual planning, which resulted in the deepening being carried out in a singular fashion.

Adapting to the selection pressures and through the selection patterns, it inevitably channels alternative and sometimes conflicting pressures onto the decision making process, in turn challenging the regime that shaped the previous deepening and forcing the policy action system to adapt to these circumstances. Consequently, stances that were taken for granted in the confinement of the previous deepening operation are now questioned. The inclusion of other actors with alternative ideas and the shaping of scope and research based on those ideas resist the pattern of a self-referential circle in which actors acknowledge and reinforce their ideas without any critical examination. Dominant ways of

thinking are allowed to be contested and potentially replaced at a later stage.

This changing approach marks the first traces of a shift from a singular policy action system to a more composite action system in which singularity in policy-making is gradually replaced with a more composite approach. Such an approach is characterised by an increased diversity of actors, ideas, goals and stakes that are allowed to enter the decision making process. In this way, the policy action system accepts the conflicting pressures to be confronted in a more or less guided selection process. The case of PAET is the clearest example of how ideas that are deemed deviant find a way into the decision making, almost by chance, where they in turn begin to have an impact on the regime of the policy action system.

Altogether, these changes have made the policy action system sensitive to the possible unfavourable results of rash actions within the physical system. This becomes visible through the decision not to push through another deepening but instead, to frame a possible operation within a more comprehensive long-term vision that addresses some of the inherent risks of a singular deepening such as physical collapse but that also deals with the risk of being reprimanded by legal institutions and provoking societal protests. Secondly, the inclusion of more and more stakeholders in the decision making process is aimed at developing a proposal that can withstand criticism when it enters the actual planning stage where it is exposed to critical examination by outsiders. Thirdly, the policy action system displays risk aversion in its approach to sediment management. Among these actors it is assumed that further development of the Westerschelde can result in their most unfavourable scenario – that it is toppled into a single-channel system. They therefore prefer to know the full extent of the consequences of a possible operation. Computational models offer the possibility of calculating every change in advance and this allows experimentation without any real changes being made to the estuary. Then again, the perception that this is the best way to do research is contested by PAET, who argues that models simply create an artificial feeling of controlling risks, as these models can never mimic empirical reality. Furthermore, it argues that such an approach is unnecessary because the estuary will be able to survive some experimentation.

7.3.4 The projected attractor basin *(May 1999 – December 2002)*

In the process of channelling conflicting ideas about the Westerschelde into the decision making process through the selection patterns, the policy action system shapes the projected attractor basin. This basin is considerably wider than it was earlier because each of the actors who become involved in the process contributes their vision of the current and future stable state of the estuary and this adds up to the former projected attractor basin of the policy action system.

With regard to the physical system, it is now formally acknowledged within the policy action system that continuous deepening of the estuary without complementary measures would be pointless because of the danger of ecological degeneration. Many actors fear that another singular deepening may cause a transition from the current state of the estuary as a multi-channel system into a single-channel system. A single-channel estuary is associated with ecological degeneration and also presents a stable state that will be difficult to change. Advocates of this point of a view often refer to the case of the Seine estuary as an example of a physical system that has undergone such a change and emphasise that such a stable state has to be avoided at all costs (see also the discussion in Chapter 1).

From the above analysis, some actors conclude that that any further modification to the Westerschelde is harmful and that the discussion should focus exclusively on ecological regeneration. They emphasise that a history of anthropomorphic changes has harmed the estuary too much to justify another deepening and expect that any new change will damage it beyond repair. Other actors argue that modifications are not harmful by definition but that the estuary should be given some time before another operation is carried out.

Then there is a group of actors who contribute to the projected attractor basin by introducing the idea that a deepening could help avoid a physical collapse into a single-channel system rather than accelerate it. Although this is primarily considered to be a lobby from the port authorities, the ideas are not abandoned outright and continue to form a part of the projected attractor basin.

Altogether, these (conflicting) expectations about the consequences of human-induced changes to the stable state of the estuary provide a varied spectrum of the future attractor basin, i.e. they provide a more varied projected attractor basin than the one defined during the previous deepening. There is only one attractor that is not considered at this stage: a deeper Westerschelde

without complementary measures that is achieved through a quick deepening operation in the same way it was previously carried out. This is seen to present an undesirable future. Thus, the projected attractor basin is enlarged compared to the previous planning process. At this stage, however, no concrete decisions are made – the varied input on the projected attractor basin is valued and weighed.

With regard to the societal environment, there is a desire to garner as much public support for further changes to the estuary as possible. The policy action system understands that much of the feasibility of future operations lies with public support and it perceives the current situation as locked-in because of this lack of support. At the same time it accepts that it is not possible to satisfy everyone, most notably those who vehemently oppose any change to the status quo.

7.4.1 Consequences of selection and action *(December 2002 – December 2006)*

No major physical operations are undertaken in the estuary during the years that follow. Neither does a calamity such as the one observed in the Unterelbe case take place. A number of trends appear, such as an increased tidal range and a slight increase in the volume of dredged material, while other parameters, such as shallow water areas and shoals, remain stable. Overall, it is believed that these changes indicate fluctuations rather than long-term trends. Although it is logically impossible that the anthropomorphic modifications in the past have not contributed to these changes, actors have difficulties in pinpointing the relation between these modifications and the current developments within the complex causation of the estuary. Therefore, the release of the MOVE report results in considerable debate over the question of the causes of the changes, if any. According to those in favour of a new deepening, this means that a new deepening is without problems, whereas the opposition claims that more research is necessary before anything can be done. Both stances, and many other topics, are investigated and discussed during this period.

Channelling different perspectives, interests and goals into the policy action system leads inevitably to a clash between the different stances. Apart from the question of which interests should be served, a debate between the aspects of economy, ecology and safety, there is also a debate about the nature of the estuary, its workings, its current and expected future stable state and how these aspects can be investigated and understood.

The debate centres on two conflicting lines of reasoning. Discussions on the use of computational models versus empirical in-situ tests and on the interpretations of the observations in the MOVE report develop further and reveal two seemingly incompatible lines of reasoning. The first is the line of reasoning that had become dominant in the policy action system, as discussed in Section 7.3.4. The basis of this argument lies in the belief that the Westerschelde is a complex adaptive system that is in a stable but fragile state and that any anthropomorphic change can disturb this current stable state and topple it into an unfavourable equilibrium, i.e. a single-channel system. An operation is not deemed completely off limits but should first and foremost promote the ecological dimension of the Westerschelde.

The perception in this line of reasoning is that the fragility of the system does not allow for in-situ experimentation, so computational models have to be used as an alternative method of experimentation without causing real damage. Since these models require further development as knowledge is still scattered and coherent data collection has just begun, it is deemed necessary to first spend more time on research and suspend real operations for the time being.

The opposing line of thinking is that the Westerschelde is indeed a complex adaptive system, but one that is robust rather than fragile. The changes that are observed are considered inherent to the dynamics of an estuary and are also considered to be reversible. In-situ tests are therefore possible and necessary since the available computational models cannot generate accurate predictions on the future of the estuary. In turn, such a test may prove that further development of the estuary can promote both the ecological and economical dimensions, i.e. that a deepening can be combined with redevelopment of the ecology. In this line of reasoning there is no dichotomy between a natural and a deeper Westerschelde. Although the second line of reasoning has its root in PAET during the LTV process and at the onset of ProSes, it gradually begins to be considered as acceptable among other actors as well.

There are a number of factors that add to the momentum of these selection pressures. When the research budget is cut, the research has to be conducted within the available means and the computational approach becomes favourable as it is more or less readily available, even if the models do not yet work perfectly. Empirical in-situ tests require more resources and time and there is little willingness to allocate these as PAET and WL Borgerhout experience with AWZ and Rijkswaterstaat. The computational approach is also perceived as having a sound scientific underpinning whereas the empirical tests are perceived as being

too intuitive.

While these issues may have provided momentum for the cause of the first discourse, there are also a number of issues and events that promote the second discourse. During this period, actors become increasingly worried about the question of whether the computational models are up to the task of mimicking developments in the estuary. It is realised more and more that even if these models are fully developed, they are unable to provide exact predictions. An empirical test may have more accurate outcomes as it is carried out in reality rather than within the confines of a computational model.

A second cause that provides momentum to the second discourse is that there are a number of occasions where it becomes clear that nature development will not extend much beyond obligatory compensation if the Dutch government has its way. Some actors in favour of ecological development therefore are increasingly attracted to the proposals championed by PAET. If the deepening is carried out according to the concept of morphological dredging, it may regenerate certain aspects of the ecological dimension without requiring additional investments – thus saving another round of negotiations over nature development. Moreover, supporting these proposals may persuade the port authorities to be more generous with funds for ecological development in order to replenish the lower budget allocation in return for an acceptance of the deepening.

Together with these developments grows a willingness to grant PAET and WL Borgerhout the required permits and means to carry out an empirical test and after the second-opinion assessment turns out positively, an in-situ test is carried out at the shoal of Walsoorden. The results of the test appear to confirm the hypotheses and the test is deemed successful by many and completely unexpected by some. Objections that the test is too local in time and place to be generalised are drowned out in the response of actors who welcome the results.

As a consequence of the decision to merge the different perspectives rather than maintain a division between them, the dominant regime, which is already a change from the previous deepening, is now challenged once again as PAET obtains access to the policy process. The options it offers gain more momentum and support as it promises a more attractive package for all actors involved compared to the dominant way of thinking. Although the results of the in-situ test coincide with the publication of the development plan, these results are supported by most actors for the plans. In other words, by altering its regime in terms of connections and composition, the policy action system allows its own

goals and ideas on the estuary, i.e. no deepening of the estuary, to be undermined by the ideas offered by an outsider.

7.4.2 The actual attractor and its selection pressures *(Dec. 2002 – Dec. 2006)*

The physical system is in more or less the same state as before, save some changes as described before. As such there is no clear selection pressure from the physical system as witnessed in the Unterelbe case from 2004 onwards. Still, this state pressurises actors to adapt to a more considerate approach towards the future of the Westerschelde, so straightforward deepening is still out of the question. Despite the lack of unambiguous changes in the estuary, the resulting ambiguity over the physical developments puts a selection pressure on the policy action system. It fuels the discussion over the influence of human changes in the past and, consequently, the effects of future operations on the estuary.

The main change that occurs during this period is therefore in the state of the policy action system itself. Through its own decisions, it allows alternative ideas to reach the core of the decision making process. This allows the existing ideas and regime to become contested, which is discussed in more detail in the following section.

Taken together, the decisions lead to a plan for the Westerschelde estuary that receives considerable support from the actors involved as it pairs a deepening with ecological regeneration while maintaining the level of safety. A number of additional deals seal the fate of the plan and the deepening and its complementary measures are ready to be carried out.

However, the process stalls when it comes to the realisation of the complementary measures. It is precisely the actors who were barely included in the decision making process who are now resisting the proposals. Farmers as well as councils that had followed ProSes from a distance oppose a deepening because they fear that the compensation measures will involve the sacrifice of agricultural areas, as is the case. As highlighted earlier, this discussion is highly sensitive in the Zeeland province as these areas are considered to be valuable economic assets and form a part of the Zeeland identity. Also part of this identity is the struggle against the water. The realignment of dykes is considered a sin.

Consequently, the public protests delay the execution of the deepening, even though a rather broadly-supported plan had been put in place. The earlier decision not to include the agricultural organisations now backfires as it seems

as if these organisations and their associated supporters continue to have the ability to obstruct the further development of the Westerschelde if it is done at the expense of agricultural areas. Lack of societal support for the creation of nature areas in turn causes the environmental pressure groups to withdraw their support for the proposals. Apparently, the convergence of ideas, ambitions and goals that marked the composite policy action system does not correspond with the ideas of those who were less or not involved. Those actors are less than willing to cooperate with the plans.

While the ProSes process was meant to converge ideas and to build a plan that would promote a resilient physical system that could count on enough support to be carried out without too many hurdles, in actual practice not all hurdles have been removed as the fiercest opponents continue their resistance. As nature development is coupled with the deepening, obstructions to the creation of nature areas threaten the thorough execution of the ProSes package deal. This is different from what was intended by policy makers.

7.4.3 Selection patterns *(December 2002 – December 2006)*

As stated in the previous section, this period is first and foremost marked by changes in the policy action system that influences the decision making and the outcome in the form of the development plan for the Westerschelde. During these years, the ambiguous demarcation between the policy action system and the societal actors blurs further as the ProSes process continues to develop and actors become increasingly committed to it. The responses to selection pressures are in some instances not responses to pressures from outside the policy action system but rather, come from within the system, as its nature has becomes increasingly composite, i.e. through absorption of the actors around the formerly singular policy action system. In this way, it channels and incorporates the selection pressures within its regime where they are allowed to be confronted. Although this is a conscious decision, the effects are to certain degree surprising, as evidenced by the popularity of PAET's proposals during the later stages and the lack of public support despite all efforts to the contrary.

That most pressures are not neglected, save for the pressure to deepen without further considerations, is because of the selections made by the policy action system with a composite nature that allows for more connections. At the same time, there is an obligation to present a coherent and unambiguous

development plan, which means that the diversity of ideas became restricted during the closing stage of ProSes. As time progresses and the advantages and disadvantages of different options become clearer, it turns out that the original ideas favoured by the policy action system after the previous deepening become contested through the concept of morphological dredging and a number of events that reinforce this.

With regard to *connections*, the policy action system has become increasingly experienced in dealing with the selection pressures and the actors associated with these pressures. The port authorities tone down their demands; the tensions in the working group morphology become a little less strained as time goes on and mutual understanding develops over the possibilities and restrictions inherent in both lines of reasoning.

However, as the policy action system absorbs societal actors into its decision making process, these actors become partially disconnected from their backers. This becomes visible when the preliminary proposals are presented and again when the final development plan is publicised – with both events prompting societal resistance. The Provincie Zeeland, for example, feels that it cannot control the process and although its deputy is trying hard to find a good agreement for the province, its council does not trust the outcomes. Overall, the responses from the provincial council also display surprise that an agreement to deepen once again could be established and this shows that they were not very well connected to the process. A similar response can also be observed with a number of municipal councils in the region and with the water boards.

The agricultural organisations are added to the policy action system at the last minute and by then, it is too late to have any influence on the final plan. Their wishes are therefore not granted and they subsequently do not support the plans. The argument coming from the policy action system that agriculture was not part of the agenda is weak given the proposals for dyke realignment and the creation of flood plains that require the conversion of agricultural areas.

While the handling of the connections has done its job in bringing together opposing views into a concrete plan, it has at the same time led to some alienation between the 'new' actors joining the composite policy action system and their backers. This is inherent to the way the policy action system processes the pressures it is subjected to. It allows conflicting selection pressures to be confronted and combined but this creates a process – the afore-mentioned discussions – that is not shared with those who are not present in the ProSes process because actors have a limited capacity to handle connections.

Without being a part of this process, the differences between actors supporting one of the two pressures continue to exist and this causes frictions when the proposals are released. In other words, becoming a part of the composite policy action system has its advantages as ideas are not discarded but it also has some drawbacks as people who are not involved have difficulties understanding the process that took place and are less likely to support the outcomes as they have not experienced their development.

The *composition* of the policy action system remains stable throughout this period and its composite nature is maintained. At the same time, however, it is realised that there might be further resistance when the plans are released because not everyone has been involved. This leads to an attempt to get the agricultural organisations on board, despite earlier attempts to leave them out. Given the limited time left, this move does not have any impact. It shows that there is growing understanding that the agricultural organisations are important, if only because of their obstructive power. Their late inclusion in the policy action system does not prevent obstruction, as witnessed later on.

Research plays an important role during this period. First, there is the release of the preliminary monitoring report, MOVE. The results of the monitoring so far provide inconclusive indications on the development of the estuary. As such, the report does not steer the actual discussion as it was supposed to, but its inconclusiveness does spark a debate over the robustness or fragility of the debate. Similar to the Unterelbe case, the urge to go ahead with the planning wins over the consideration to wait longer for the morphological changes to reveal themselves.

The two discourses mentioned before are closely related to the way research is carried out. Decreasing resources mean that the initial research programme has to be downsized. There is less time to develop the Delft 3-D model further and while it is used nevertheless, it is also subjected to criticism because of its under-development. Sobek, the other model used, is also criticised. Besides, some people think that models are poor substitutes for reality and therefore cannot be completed relied upon. Consequently, there is increasing pressure to triangulate research methods with an empirical test. The combination of this test with the promise of ecological regeneration helps PAET's cause. The results are released too late to be included in the report, but there is still support from many for the concept of morphological dredging. Anticipating this, there is room within the proposals to include this way of dredging in the operation.

The main role of research during this period is therefore important

as the lack of clear indications of developments in the physical system mean that there is a need for alternative indications. While there are advantages and disadvantages to both approaches, it is the approach favoured by PAET that wins popular support because it offers the possibility to combine a deepening with ecological regeneration. Contrary to the computational approach, it also offers a solution for the future of the estuary and this proves to be a strength. Although the development plan for the Westerschelde does not centre on PAET's proposals, it is the same proposals that generate support for the development plan.

The start of the ProSes process was marked by a wide *scope* in which there was ample room to explore different options. However, this was narrowed down as the deadline drew nearer, less resources became available and the political and societal feasibility of different options became clearer. This is evidenced, for example, by the changes to the nature development plan. There is also considerable consistency with regard to the deepening. During these years, there is no moment where a new deepening is seriously questioned. This is not so because there were so many supporters for a deepening, as there were in fact not that many, but somehow this pressure is rather strong and is not really a matter of 'if' but of 'when'. Again, the option offered by morphological dredging is favoured because of the combination it offers.

However, the preliminary proposals still exhibit a rather broad scope. Along with the conclusion that a deepening is possible, it also suggests providing room for ecological development through the creation of flood plains and the realignment of dykes. Furthermore, it suggests investigating the development of outports. When it is announced that no more funds will be allocated to nature development a search for alternatives is begun, displaying the intentions of the actors involved not to accept a mere deepening without anything other than compensation.

The final proposals reflect the broad scope once again. A deepening is still deemed possible and is paired with the proposal to use changes in the morphology to promote ecological redevelopment. Changes to the regime of the maintenance dredging operations are also proposed. In addition, it is proposed to convert land back into flood plains and to realign dykes in order to create more room for excess water.

While the plans appear to offer a broad scope on paper, this is less so in reality. Decisions regarding further ecological development are postponed and societal resistance against the conversion of agricultural areas presents a hard to crack pressure. While a deepening is accepted and while much new support

is garnered through financial incentives, extended ecological measures turn out to be much harder to realise. Therefore, it must be concluded that the scope is narrowed down but for the time being remains broader than it was during the previous singular deepening.

The decision to search for a convergence of adverse ideas and goals with regard to the estuary in the decision making process through a different management of connections and composition and consequently scope and research has therefore led to two developments. First, it has allowed for the introduction of ideas that are not favoured by the policy-makers. When these ideas gain momentum, they contest the existing regime to the extent that they are incorporated into the final proposals. Much of this is due to the inclusion of PAET, the fact that it couples a method with a goal and a number of other events, most notably decreasing funds for nature development.

Secondly, when the process moves on it becomes increasingly important to narrow the variety down to a concrete and feasible plan. Consequently, the composite nature of the goals and scope is limited when the plan is drafted. This leads to some distancing between the actors who are fully involved in the ProSes process and those who are less or not involved. As a result, the latter do not share the process the composite policy action has gone through and this translates into societal resistance. In other words, the demarcation that once existed between the singular policy action system and its societal environment has now shifted to the demarcation between the composite policy action system and its societal environment.

The outcome of this process is two-fold. It leads to the widening of the scope and research programme during the initial stage of the process, with the inclusion of complementary and compensating measures that are meant to keep the estuary in a stable attractor without unfavourable results for all actors concerned. However, as time goes on and the plans become more concrete, their content is also contested because it does not go down well with those who were not a part of the process.

The results are therefore mixed: the decision to meet selection pressures by turning the policy action system into a composite action system leads to a plan with a wide scope that addresses a large number of environmental concerns and that is relatively broadly supported. At the same time it is inevitable that a composite policy action system has to limit its composite nature in order to draw up a coherent plan. At some point, ideas must translate into decisions and this inevitably means that diversity has to be limited. While the earlier period saw a

shift from a more or less singular nature to a composite nature, the current period shows a shift from a composite nature to a more singular nature. At the same time, the package deal is under substantial stress as it seems that a deepening might go ahead without nature development.

7.5 Final observations *(December 2002 – December 2006)*

Although the structural observations were concluded in March 2005, the case continued to develop and showed that the conclusion of the OS2010 had not yet led to an execution of the plans. The aftermath of the OS2010 saw that the composite nature of the policy action system and the package deal it had made continued to dissolve. While earlier in this case the scope had been highly diverse save for the possibility of a deeper Westerschelde without many complementary measures, at the time of writing in summer 2007, a singular deepening is becoming an increasingly likely prospect.

The case shows how diverging selection pressures on the policy action system were not completely warded off but instead, allowed to continue their existence through a number of policy initiatives that were a prelude to the ProSes process. When the Westerschelde was deepened in the mid-1990s, this was considered to be a suboptimal choice that led to the intention to use a different approach when discussing the future of the estuary. The perceived risk of arriving at an unfavourable attractor, i.e. a single-channel physical system, led to this more comprehensive approach.

Regarding the connections, composition, scope and research, the policy action system attempted to work its way from a broad perspective to a more concrete three-fold objective in the long-term vision to a concrete development plan formulated by the LTV and the ProSes process. The scope was further limited towards the end of ProSes when certain options had to be translated into policy decisions, some of which were not regarded as feasible.

Opposite this narrowing movement was a movement to connect different actors. This started off in a relatively narrow fashion because opposing actors could not get along very well. The commission Westerschelde therefore decided to keep them separated. The subsequent development of the long-term vision was a civil affair, with the participation of officials from the Dutch and Flemish governing organisations. The ProSes process represented a step forward as it allowed other societal actors to become involved. Further, it was decided

that a plan could only be made public with the consent of all actors involved.

Following this route, the policy action system enlarged its view on the attractor basin. It did so in the first place by allowing itself to search for future attractors beyond a mere deepening of the estuary. Once that was done, it allowed others to join in this process, further widening the view on the attractor basin.

This is clearly visible in the way in which the policy action system developed a broad perspective on the future of the estuary with which it entered the ProSes process. Following the admission of the other actors, most notably PAET and the ideas it promoted, the way in which this broad perspective was supposed to be realised was challenged. Thus, while the perspective itself was already broad, the means to achieve this perspective was subjected to pressure from the ideas offered by PAET. However, it was not just their ideas but also the discussions following the ambiguous MOVE report that fuelled the discussion on the development of the estuary.

Consequently, the scope was broadened from a singular deepening to a deepening as part of a more comprehensive development plan that included a deepening as well as the creation of flood plains and the realignment of dykes. The introduction of new ideas through the transition from a singular policy action system to a composite policy action system meant that there were two selection pressures within the composite policy action system. The perspective in which a deepening can be paired with ecological regeneration won over the perspective in which a deepening has to be postponed. In other words, the final proposals were heavily influenced by ideas that entered the process through a backdoor and despite attempts from a number of actors to exclude these ideas. However, this resulted in a plan that reflected the diversity of the actors present and therefore incorporated a wider view on the attractor basin than the one obtained by policy-makers alone.

During the closing stages of the case study, the decision to develop the plan in this way seemed to have backfired as the outcomes were rather progressive compared to the more conservative stances of many actors in Zeeland who had not been fully engaged in ProSes. Consequently, these actors opted to obstruct the execution of the plan. The case then progressed further but again, not in the way policy-makers had wished for. A deeper Westerschelde with compensation lagging behind is now not all that unthinkable.

Having now discussed two case studies, it appears as if there are two ways of dealing with the selection pressures from both the physical system and the societal environment: to divert them or incorporate them. Since the

Westerschelde did not suffer from the kinds of acute physical problems that emerged in the case of the Unterelbe, it is tempting to conclude that the former strategy is less useful in the management and development of estuaries than the latter. Why such a conclusion is unsatisfactory and how a comparison can reveal more subtle differences and similarities is the subject of the next chapter, in which the cases are compared.

Chapter 8: Through the Attractor Basin

8.1.1 Introduction

The first accounts of the case studies, in Chapters 4 and 6, presented these cases as they developed chronologically, showing how responses to selections were erratic and that the outcomes of certain decisions could appear in a different locality than expected. The second set of accounts, presented in Chapters 5 and 7, showed how selection pressures and the subsequent responses of actors defined the route through the attractor basin through time. In that process, the policy action system attempted to shape the physical system but was restricted in its possibilities because of reciprocal selection. In practice this meant that attempts to divert selection pressures away from the policy process because they were unwanted backfired in the end, thus compromising the policy options available to the policy action system.

It is through patterns of reciprocal selection that the physical system and the policy action system coevolve, and it is through this coevolution that human actors attempt to give shape to the physical system through intentional and perceptible selection. However, the cases have shown that the attractor basin is often limited not because of the selections made by the policy action system but because of the blind and unintentional effects of its previous selections and through the occurrence of events outside the actors' control.

The aim of this chapter is to compare the cases with regard to the disposition of selection, the disposition of policy action systems in response to these selections and the disposition of coevolution as the expression of the patterns of reciprocal selection between systems in order to understand what shapes decision making on estuaries and tidal rivers and in order to find different regimes for deciding the route through the attractor basin. Policy-makers deal with coevolution by attempting to decide on the route through this basin.

During this process, the policy action system is both the cause of and subject to perceptible selection (Section 8.2.2) as well as blind selection (Section 8.2.3). Change in response to pressures has an erratic and punctuated character because of the complex nature of the systems, which adds to the difficulties of managing and developing physical systems such as estuaries (Section 8.2.4).

Because of the erratic nature of system developments, decision making

over estuaries and tidal rivers is inherently uncertain (Section 8.3.1). The policy action system can respond by altering its selection regime between singular decision making (Section 8.3.2) and composite decision making (Section 8.3.3). The evolution between these two regimes is partially intended and partially unintended (Section 8.3.4). Consequently, it can be observed that both the attractor basin and the nature of the policy action system change regardless of and differently from the intended actions desired by the policy-makers (Section 8.4.1). Based on the combination of selections made by the policy action system and the selections cast upon them, different types of coevolution are discernable in the empirical cases, namely coevolution characterised by parasitism and coevolution characterised by interference (Section 8.4.2). The essence of the book's main argument is summarised in the six aspects of decision making coevolving systems (Section 8.5).

8.1.2 Two dissimilar cases, two dissimilar trajectories

Two estuaries in Germany, Belgium and the Netherlands had to be deepened to fulfil economic needs. What may have appeared to be a relatively simple task at the onset turned out to be a much more complicated affair. Both cases revolve around the perceived limited depth of a navigation channel through the estuary connecting the North Sea and a port. These estuaries and tidal river also constitute a highly valued natural water system. The desires of the port authorities clashed with the desires of environmental pressure groups, concerned citizens and other actors. Dredging a straight channel through the estuary and tidal river was deemed to be out of the question, as the estuarine dynamics would most likely have brought about an unfavourable response to the deepening that could have severely hampered the functioning of the ecological dimension, the safety dimension and even the accessibility of the bodies of water.

The initial decision to deepen the two estuaries was made in a similar fashion. However, although there may have been many physical similarities between the two estuaries, the social and political situations were quite different. When observed through the theoretical lenses of this book, the main difference lies in the fact that the actors aiming for a deeper Unterelbe formed the core of the policy action system whereas in the Westerschelde case, these actors were part of the societal environment, as witnessed by the reluctance of the policy-makers in the Netherlands to grant a deepening.

Furthermore, it should be taken into account that the starting points of these two cases did not coincide with the start of the decision making process over the estuaries. The decision making processes investigated in this book formed only one part of a long chain of decisions that preceded the case studies. Both the Unterelbe and the Westerschelde have been modified for centuries and these case studies analysed only one step in that ongoing process. The two cases have had a long legacy of decision making before the time span described and analysed in this book. Then they continued to develop in diverging ways during the decade that followed. In the Unterelbe case, the dominant way of thinking and acting was challenged by the unfavourable changes in the estuaries and the ensuing societal pressure. The policy action system in the Westerschelde case was challenged by the admittance of other actors into the decision making process and through, again, social unrest.

Thus, the two cases appear to have gone through three stages. The first stage was marked by the decision to deepen the estuary or tidal river. This decision and the process preceding the decision is characterised by singularity in terms of connections, composition, scope and research. This regime was challenged in the period that followed by selection pressure from both the physical system and the societal environment. While preparing for a new deepening, these selection pressures shaped the nature of the decision making process and the nature of the policy action system. In the case of the Unterelbe, the policy actors attempted to maintain their way of working but this was severely challenged because of unfavourable physical changes and because it provoked considerable societal resistance. It responded by reluctantly initiating a parallel process that addressed these issues while at the same time attempting to plan a deepening in the same fashion it had grown used to.

Decision making in the Westerschelde, on the other hand, was done through cooperation between many actors from both inside and outside the policy action system. This led to a more versatile long-term plan for the estuary than that which existed before. However, these intentions were hampered during the execution of the plan because of societal resistance from those who had been excluded from the planning process. This stalled the development of the idea to couple a deepening with nature developments, and the package deal then began to disintegrate. When the observations were concluded both cases were marked by decision making that was in many ways limited because of the responses to earlier decisions, i.e. the freedom to move through the attractor basin had diminished in both cases.

The routes through the attractor basins are determined by selection pressures stemming from the decisions made by the policy action system as well as those that are cast upon the policy action system. In some instances, these two are actually the same in different disguises as earlier decisions backfire, such as the decision to disperse sediments back into the Unterelbe or the decision not to involve the farmers around the Westerschelde. The chronological accounts in Chapters 4 and 6 showed that responses to selections, both favourable and unfavourable, can occur at different localities than planned and sometimes hoped for by the policy action system. Some stable states are locked-in to the extent that they are almost impossible to change, such as land-use and dyke alignment, as seen in both cases. Other stable states can be of a rather more temporal or even volatile nature, such as sediment transportation in the Unterelbe. Often in these cases, change had a punctuated disposition, which made it more complex to deal with it.

Chapters 5 and 7 showed how this (punctuated) change into stable states is driven by reciprocal selection and responses to selections in both physical and policy systems. The analysis in these chapters suggests that the process of reciprocal selection as dealt with by the policy action system may also be of a sequential nature. This is not the case, however. Sequential presentation is unavoidable in a written work but in both cases, selection pressures and responses often developed simultaneously and continuously through periods of stability and instability. During these periods, the policy action system receives and responds to feedback loops continuously. Such selection pressures proved to be of major importance for the way in which the cases developed. The way in which policy action systems dealt with these selection pressures says much about the relationship between decision making and its consequences for the process of coevolution, as decision making is both a source of and a response to reciprocal selection.

8.2.1 Dealing with real selection pressures

Decision making was conceptualised in Chapter 3 as defining a route through the attractor basin. A basin constitutes the possible future stable states of the object of decision making, in this case the Unterelbe and the Westerschelde. In order to make a decision, policy-makers evaluate the current state of affairs against the desired state of affairs and define the means to reach that desired state, e.g. deepening of the navigation channel in order to improve access to the

ports.

In the process of defining a route through the attractor basin, the policy action system is subjected to selection pressures that are processed through patterns of selection by defining the scope and research of the project and by shaping the connections and composition of the policy action system. The very act of selecting in itself causes selection pressures, sometimes intended and sometimes unintended, sometimes perceptible, sometimes blind. Either way, the pressures stemming from selection result in a limitation of the attractor basin as the situation that emerges as a consequence of the choices made renders a number of future attractors unfeasible.

In the case of the Unterelbe, it appeared that the singular character of the process and the content of the decision that promised a quick execution of the primary goal led to unfavourable results. This coincided with the planning of another deepening operation that was similar to the previous one in both process and content. A new deepening carried out in the same way as before became unfeasible because it would probably reinforce the unfavourable physical developments and because the opponents of the deepening were increasingly unlikely to accept the singular decisions regarding the Unterelbe. Compared to the situation preceding the previous deepening, it appeared that the selection pressures that were warded off had returned to the decision making process and it was clear that they could not be pushed aside in the same way as had been done before.

Such a process, in which selective pressures limit the number of possible future states, also occurred in the Westerschelde. Following the previous deepening operation, which was carried out in a similar fashion to the Unterelbe case, the policy action system decided to adopt a different approach in response to concerns about the physical state of the Westerschelde and social unrest. By changing its connections and composition, it allowed alternative ideas to enter the decision making process, leading to an outcome that was partly intended and partly unintended as newcomers to the process placed their mark on the final plan. However, in the act of changing its selection patterns with regard to both process and content in response to the selection pressures, the policy action system alienated certain portions of the societal environment who were not a part of this transition and could not agree with the plans. Consequently the entire plan disintegrated.

It can therefore be concluded that in both cases, the attractor basin was limited by the occurrence of selection pressures that often stemmed from earlier

decisions while others emerged without actions on behalf of the policy action system. In any case, such selection pressures select the attractor basin and the selection of attractors is not fully determined by the policy action system. To put it more radically, the physical system and the societal environment govern the policy action system rather than the other way around. This challenges the idea that administrators and engineers are decisive in determining the course of the physical system through the attractor basin, i.e. that they are able to fully control the environment they are working in. The next sections look at perceptible selection and blind selection in policy-making on physical systems in more detail.

8.2.2 The attempts to select perceptibly and intentionally

As discussed in Chapters 2 and 3, human actors have reflexive capacities and are able to act deliberately upon a given situation. In fact, the core task of the policy action system is to evaluate the existing situation and define the changes required to achieve the ideal situation. With this it attempts to shape the future attractor for the physical system. In other words, it engages in a process of perceptible and intentional selection of attractors from the attractor basin. Of importance here are the selection patterns of connections, composition, scope and research; all of which determine the setting in which decisions are made. Through connections and compositions, the policy action system assembles a group of actors who contribute to the definition of the attractor basin – ranging from the strongly self-referential grouping witnessed in the Unterelbe case and to lesser degree at the start of the Westerschelde case to the more diverse groupings as witnessed during the later stage of the Westerschelde case. Through scope and research, the policy action system sets the limits for what it wants to include in the decision and what investigations are required in order to understand how the desired stable state can be reached.

As shown in the previous chapters, these selection patterns are deliberately utilised and with confidence that they will lead to the desired results. Initially, it is thought in both cases that a deepening can be done without unfavourable effects and without the necessity of complementary and compensating measures. There is awareness that this could not be the case but this awareness is suppressed by the ambition to have the estuary deepened. The complexity of the physical systems is met with a clearly but narrowly defined operation in an attempt to maintain

a perceived order. In the following years, these singular decisions and processes leading to the decisions are challenged, either through selection pressures on the policy action system as witnessed in the Unterelbe case or from doubts within the policy action system that later transform into selection pressures as well, such as in the Westerschelde case.

In fact, the selection pressures resulting from the singularity in process and content exerted such a pressure on the policy action system that it could no longer be ignored as this would render a new deepening impossible beforehand. Approaching complexity with simplicity did not deliver the control over the attractor basin it had seemed to promise. In the case of the Unterelbe, the deepening had triggered a change in the tidal regime with increased sediment accumulation in the harbour basin. In addition, the level of social discontent had increased. In the case of the Westerschelde, the policy action system's decision to alter its routines led to further changes as the accidental inclusion of alternative actors meant that the existing scope and research had to be partially changed and some goals had to be partially abandoned. Besides, the decision to limit the actors who were allowed to participate in the policy action system meant obstruction from those who were excluded at a later stage. This led to further delays once the plans had to be executed.

As far as could be observed in this research, each of these pressures defined the attractor basin rather than the attractor basin being defined by the policy action system. In other words, the decisions made during the initial stage of the case studies later defined the attractor basin and with that, the policy options available to the policy action system. This marks a reversal in the nature of decision making in both cases, in which the possible future stable states are selected by the selection pressures from the physical system and the societal environment rather than perceptibly, deliberately and freely by the policy action system. In other words, perceptible and intended selection is partially replaced by blind selection.

8.2.3 The occurrence of blind selection

While the policy action system attempts to govern the physical system through perceptible selection that should lead to the intended consequences, it also faces blind selection and unintended consequences. As mentioned in Chapter 3, blind selection means that the attractor basin available to the policy action system is

enhanced because of the consequences of certain decisions that are unforeseen and unintended. What appears to the policy action system as unexpected and unintended is in fact rooted in the decisions made previously by the same policy action system. The complex causation renders the selection pressures seemingly detached from those decisions and they only become noticeable because of the unintended outcomes, hence the term blind selection.

In both case studies, there were a number of instances of blind selection because of earlier efforts to divert certain selection pressures away. Contrary to policy-makers' hopes, these pressures did not dissolve but instead backfired noticeably and interfered with the policy-makers' intentions. In the Unterelbe case as well as during the early stages of the Westerschelde case, attempts were made to ignore those actors who were unlikely to agree with the chosen course of action. During the later stages of the process, these actors were able to obstruct the planning of the new deepening.

Similarly, the decision to skip over procedures or to merge permits in order to speed up the decision making backfired as it attracted the attention of stakeholders and a number of (legal) institutions who protested against the way the planning was carried out. While skipping procedures and not addressing adversaries' concerns initially promised a swift execution of the deepening, it turned out that it also resulted in effectively obstructing the next deepening operation.

In a similar vein, but with a different result, the coincidental inclusion of PAET in the Westerschelde case can be viewed as blind selection leading to changes in the projected attractor basin beyond what the original policy action system had intended. The idea that deepening and nature development are contradictory goals was replaced, at least partially, by a combination of the two that provided an incentive for many to agree with a deepening.

Urgent physical problems arose in the Unterelbe case and appeared to be directly related to the deepening. Although that particular deepening was not the single cause of the physical change given the long history of singular decision making, it did function as the final trigger for the change in the tidal regime and consequently the rapid accumulation of sediments in the harbour basin. The new tidal regime proved to be a new stable state for the physical system that did not yield favourable results. In other words, decades of increasing pressure on the physical system resulted in a sudden change from one stable state to another with unfavourable effects.

Selection pressures can be reinforced through the occurrence of events

in the immediate vicinity of the focus of a case study that have an impact on the attractor basin. The electoral victory of CDU in Hamburg is an example of such an event, as it gave momentum to the planning of a new deepening operation in the Unterelbe case and postponed the development of the northern German seaport concept. The connection between the deepening of the Westerschelde and the high-speed railway link and the subsequent delays in decision making over the estuary because of delays in the HSL issue is another example of this.

Both perceptible and blind selection are affected by complex causation and with that, inherit the characteristics of complexity, i.e. disproportional and punctuated change that is sometimes reinforced through the occurrence of events in the immediate surroundings of the case. These have an impact on the attractor basin, i.e. they determine the feasibility of future policy options. In both cases, this did not always coincide with the options favoured by the policy action system. Ironically, both perceptible and blind selection are responses to the actions of the policy action system itself. What may seem like a sound decision at a certain point in time can return some time in the future as an unfavourable proverbial boomerang. Because their origins are ambiguous or only clear in hindsight and therefore unexpected, and because they have an impact on the range of the attractor basin, this process is called blind selection. Blind selection is a major factor in understanding the limitations of the policy action system when managing and developing physical systems.

8.2.4 Unintended, unobserved and unexpected

Perhaps the best way to understand the empirical erratic nature of processes and the inherent complexity of managing and developing physical systems is to look back at Chapters 4 and 6 where the cases were described chronologically. These case descriptions may seem under-structured and chaotic at times but it is in this shape that they occur to the policy-makers. The lack of structure and clear causation is carried over from the actors' experiences into these descriptions. Empirically, the causal patterns of action and response are distorted and lead to selective pressures that in turn lead to perceptible selection if there is an observed relationship between action and response. However, the occurrence of blind selection makes the management of physical systems problematic as the causality between action and response is unintended and unexpected and in some cases accidentally or deliberately overlooked.

However, it is not just the unintended and unobserved causation through positive feedback loops that drive the selection pressures causing blind selection; it is also through punctuated equilibrium that changes in the stable state are unforeseen but persistent. In the Unterelbe case, this was visible through the emergence of sediment accumulation that occurred firstly, a few years after the deepening was completed and secondly, without gradual change. A similar change, albeit with less unfavourable impacts, appeared in the Westerschelde case with the change from decades of sand import to sand export. Although the outcomes differ in impact and clarity, both cases show that increasing pressure from the decisions made by the policy action system does not necessarily lead to proportional gradual change in the physical system.

Changes can therefore occur without early warning signals because a certain action does not always result in an instantaneous response. Instead, such a change could appear elsewhere in time and place. Once it takes place, however, it can have a major impact and, significantly, cannot be easily undone. A change in the tidal regime or sand balance cannot be reversed overnight and requires considerable effort to be undone. In other words, the new stable state or equilibrium is persistent, sometimes to such an extent that it is effectively irreversible given the actual circumstances, e.g. when the costs of restoration exceed the funds available or when it is physically impossible to engineer changes.

Empirically, policy action systems experience a sequence of events whose causal patterns are often blurred, distorted and hidden from the view of the actors in the system. Such blind selection can have a defining impact on the attractor basin. The occurrence of punctuated equilibrium means that events can take place without any signs of change preceding the event. Still, a new state can be very stable, which poses a problem if it is unfavourable. Note that a stable state is different from a static state. Such a situation also determines the attractor basin. The options available to the policy action systems in the management and development of dynamic physical systems such as estuaries are not fully determined by the intended actions of the policy action system. How do policy action systems cope when faced with such a situation?

8.3.1 Types of policy action systems

Both cases have shown that policy action systems are continuously attempting to find the right response to the complexity they are subjected to in order to shift from the current state of affairs that is deemed suboptimal to the desired future attractor. In the attempts to alter this current situation into the desired situation, the policy action system is limited in its ability to determine the future because of the developments described in the previous sections. In order to have any impact on the current situation, the policy action system must respond by adopting or adapting. In other words, it has to decide whether its current regime should be continued or altered, depending on what it deems suitable in a given situation. This regime is marked by the selection patterns of connections, composition, scope and research, all of which enable the policy action system to generate diversity and selection in the attractor basin.

The process of adaptation to selective pressures through the continuation or alteration of the existing regime was a gradual one in both cases because, as observed, the nature of these policy action systems did not change overnight. Instead it appeared that in the different periods described in Chapters 5 and 7, the policy action system either attempted or did not attempt to alter some of its selection patterns when it realised that it was being subjected to a certain selection pressure. By changing its selection patterns, it gradually evolved from one disposition to another. While these regime changes fall within a certain bandwidth, it is still possible to use the case studies to discern two prototypes of policy action systems in response to selection pressures: the singular policy action system and the composite policy action system.

8.3.2 Singular policy action system

Any policy action system consists of multiple actors, as it is unfeasible to manage and develop estuaries with a single actor, given the many aspects of such an operation. These can include research on the physical consequences and economic feasibility of the operation, the planning of the operation and the application of permits. There are complex tasks at hand that require considerable expertise and knowledge.

Singular policy action systems attempt to deal with selection pressures by generating singularity in their selection patterns. When dealing with connections

between the policy action system and the societal environment, the policy action system opts to connect with those actors who support the shared goal, e.g. a deepening of the navigation channel. The composition of the policy action system is shaped in a similar vein. Access to the system is granted to those actors who share the same goal as the original members. A clear distinction is maintained between the system and the societal environment. It should be noted though that this does not necessarily mean that connections and composition concern a small number of actors. On the contrary, in both cases it concerned a relatively large group because of the many aspects of the complexity of the physical system. It is the diversity of actors that is limited rather than their number.

Singularity can also be observed with regard to the scope of the project: it is limited to a single goal and to the measures that are required in order to achieve this goal. A singular scope also results in singular research, i.e. research that is exclusively aimed at serving the goal of the project rather than exploring possible goals. It is used to answer the question of what is feasible given the goal (e.g. a deepening) and what measures are required to achieve it.

Singularity as a response to complexity is informed by the idea that managing and developing a physical system is complex enough as it is and anything that stretches beyond the original goal complicates matters further. Anything that could distract from the original operation is regarded as white noise or interference that could potentially delay or even postpone the operation. For instance, making connections with opponents of the intended operation could provide an opportunity for these opponents to obstruct the plans by channelling their resistance into the process. They are therefore barred from access to the decision making process beyond being informed about the intentions of the policy action system. Highly motivated adversaries appeared in both case studies, such as the environmental pressure groups in the Unterelbe case and the agricultural organisations in the Westerschelde case. Both had the potential to delay the plans of the policy action system, so it was a natural response for the policy action system to keep these actors at a distance.

A similar fate awaits the scope and research. Complementary measures are only considered if the original goal cannot be achieved without them. A wider scope is regarded as a threat to the operation as it could mean more work and therefore more delays and rising costs. This threatens the efficiency of the operation; narrowing it down to what is deemed feasible is the obvious

response to this. Planning a change to a complex adaptive system such as an estuary is a very complicated affair and if this is amalgamated with other projects it would increase the amount of effort required to plan everything carefully. Also, research that is aimed at other subjects is deemed unnecessary and inefficient because it is perceived not to contribute to a quick operation. Thus the next deepening of the Unterelbe had to address the changed tidal regime because the policy action system would face further problems if it had not done so. In the same way, the deepening of the Westerschelde had to address the erosion of the shoals in order to meet the criteria of ecological regeneration of the estuary.

In sum, singular policy action systems are characterised by singularity in connections, composition, scope and research that define the range or boundaries of actions. Singular policy action systems are driven by self-referential behaviour. There is a shared desire to achieve a goal and actors within the system are united by this goal – as witnessed in the Unterelbe case and in the Westerschelde case prior to the 1997 deepening. By defining a narrow scope and by exclusively involving those who support the goal, the policy action system draws a clearly defined boundary around the area of action. This reconfirms the righteousness of the goal and the means to achieving it as it is only debated among supporters. This in turn leads to the belief that the current regime regarding connection, composition, scope and research is appropriate given the situation as no interference is experienced. Thus, there is little incentive to change the regime and to connect with actors with opposing ideas. A vicious circle emerges in which the disposition of the current regime reinforces that regime without questioning the its correctness given the state of the physical system.

In other words, the singular policy action system relies on its own existing regime to generate diversity and to select the selection pressures. Because of its singularity in selection patterns, it defines a very limited projected attractor basin as this view is not questioned. Consequently, it remains firm in its belief that the projected attractor basin contains all available future stable states from which an attractor can be chosen. During this process, there is constant interaction between the nature of the policy action system and the selection patterns which each one reinforcing the other. Singular policy action systems are strongly purposeful and can act quickly but the inherent danger is an overly limited projected attractor basin and inflexibility when it provokes unintended, unexpected and unforeseen change. The persistence of this self-referential behaviour can be considerable.

8.3.3 Composite policy action system

Singular decision making in the face of complexity can exist for a long time but it bears risks because the response of physical systems to the selections made can be abrupt rather than gradual, as seen in the case of the Unterelbe. The observation here is that the common response to the subsequent selection pressures from the physical system is further stabilisation of the current regime in an attempt to shield off these pressures. A different type of response is to alter the regime to promote a more composite policy action system and, subsequently, composite decision making. Composite policy action systems are also composed of multiple actors, but contrary to the singular prototype, these actors are not united in their goals. The scope of the system is open rather than limited and the system is receptive to other ideas and goals with regard to the estuary. In other words, the main feature of a composite policy action system is its increased diversity compared to singular policy action systems.

Thus the composite policy action systems maintain connections not only with those who support a similar goal but also with those who do not have or have alternative ideas about the future of the physical system. This connection goes well beyond merely informing them about the plans to include consulting or advisory roles. When these actors and their ideas are regarded as full-fledged participants in the process, the composition of the policy action system is enhanced by the inclusion of such actors, which blurs the distinction between the supporters of a particular goal and those who oppose it as well as the distinction between the policy action system and the societal environment.

With an increased diversity of actors getting involved in the policy action system, the scope of the project is widened as these actors add their own views to the projected attractor basin, point out alternative futures for the physical system and alternative measures that can be implemented. This fusion of ideas leads to a more diverse projected attractor basin. In such a setting, research is also used to explore the basin rather than exclusively finding ways to reach the preferred single future attractor. Researchers seek an answer to the question of which goals do justice to the complexity of the physical system and what is feasible in the given situation. From that it moves on to find ways to achieve those goals as opposed to singular research that would skip the first step.

There are a number of motives for this way of handling the connections and composition of the policy action system. Policy-makers may feel that they can generate more support among adversaries because they are able to broker a

deal that allows the policy goal to be carried out. However, from the case studies, it appears that this change of regime also emerges out of a need to find a way out of the conflicting claims that rest on the physical system, such as the need for a deeper navigation channel and the need for restoring the ecological dimension and improving safety. The involvement of actors with conflicting ideas means that they contribute to the projected attractor basin because every goal or ideal has a line of reasoning behind it and it is this reasoning that shows that there are multiple possible future stable states of the physical system. It can also show that the proposed measures do not always contribute to the chosen future attractor. For example, in the Westerschelde case it was argued that another singular deepening could cause the multi-channel system in the estuary to collapse into a single-channel system, which could have major unfavourable consequences on the ecological state of the system.

This type of policy action system is therefore characterised by a composite nature with regard to connections, composition, research and scope. The issue of how the physical system should be managed is the subject of continuous debate between adversaries rather than supporters. Established ideas are questioned and may be replaced if an alternative that is perceived to be an improvement over earlier ideas is offered. The nature of the composite policy action system promotes the development of such alternatives as it is felt that a multi-dimensional complex physical system such as an estuary requires a considerate and comprehensive approach when it is developed further, i.e. complexity is met with complexity.

While singular policy action systems are driven by their self-referential nature, composite policy action systems are driven by their dissipative nature. The relative openness of such systems creates an opportunity for advocates of alternatives to be included in the process. In this way, they contribute to the projected attractor basin, making other actors aware of the multiplicity of the physical system. This occurred in the Westerschelde case when actors and their ideas from the BOWS initiative became more involved in ProSes and when PAET was granted access to ProSes. Such a change provides an incentive to broaden the connections and composition in order to develop an even more comprehensive view on the attractor basin. In singular policy action systems, the actors within the system may not be aware at all of the self-referential nature of the system, which accidentally reinforces this nature. Similarly, the composite nature of the composite policy action system is almost automatically reinforced through the ongoing expansion of the connections, composition and subsequently the scope and research outside the original intentions. This is because the boundaries of

action are not provided but instead, constructed by the perceptions of the actors involved. While this approach can lead to a more diverse and comprehensive projected attractor basin and consequently a smaller chance of unforeseen unfavourable responses to actions, the inherent danger is endless debating and continuous search without resolution and therefore, executive paralysis that does not lead to any development

8.3.4 Evolving disposition of policy action systems

While the argument in the previous two sections suggests that the prototypes of singular and composite exist as purely dichotomous categories, the differences are in fact much more nuanced. Both case studies show that the policy action system changes its selection patterns in order to deal with the selection pressures it is subjected to. In doing so it sometimes allows for a more composite nature while at other times it may opt for a more singular nature in accordance with what seems fit. The prototypes are not completely different systems but rather, they represent the extremes of a continuum of regimes that policy action systems handle when faced with complexity. Composite policy action systems are encompassed within singular systems because both types consist of multiple actors and have the potential to introduce alternative views on the projected attractor basin. Self-referential behaviour and adaptive behaviour are natural responses to complexity. The self-reinforcing nature of both types mean that any disposition is persistent but shifts can occur, as was temporarily evident in the Westerschelde case.

A closer look at the reasons for change or lack thereof is necessary in order to understand the evolution between a singular and a composite nature. The policy action system in the Unterelbe case was able to maintain its singularity for a considerable amount of time because it had the momentum to do so. The physical consequences were tolerable and the societal environment could be kept at bay through a discourse that emphasised economic gains and downplayed ecological and safety risks. After the deepening was completed, it soon became clear that a new deepening operation would have to address selective pressures from both the physical system and the societal environment. The policy action system acted in a two-fold way, with a dominantly singular response aimed at maintaining the momentum it once had. However, on the other hand it was forced to address these selection pressures by altering the regime in favour of

the development of a more comprehensive plan and by brokering a deal with stakeholders. The policy-makers were reluctant to change the regime, often preferring to rely on the policy action system's dominant way of working and the projected attractor basin it had defined from there because any change was perceived a threat to the deepening.

From the onset, the policy action system for the Westerschelde had doubts about a singular deepening but gave in to the pressure to deepen. After the deepening operation was concluded, it opted to come up with a more multi-faceted development plan out of a fear that another singular development would degenerate the estuary considerably. This marked an evolution to a more composite nature, a change that was deliberately set off but the consequent development towards the definition of the projected attractor basin was not fully controlled with the final choice consisting of the idea to carry out another deepening combined with nature development – something that was not favoured by many of the core actors in the policy action system. While the system displayed composite characteristics during the development of the plan, it developed more singular characteristics during the concluding stage of the case. As mentioned in Section 8.3.2, singularity promises uninterrupted and purposeful action by shielding off possible interference. While this allowed for the drafting of the OS2010 plan, one of the consequences was that it created another distinction between the composite policy action system and its societal environment, which later stalled the implementation of the plan.

A shift between a singular and a composite disposition can be started by intentional action from the policy action system. In the case of the Westerschelde, such a deliberate change occurred because the policy action system had always doubted the continuous modification of the estuary in favour of the economic growth of the port of Antwerpen. This is different from the Unterelbe case where the policy action system itself was and still is in pursuit of a deeper navigation channel. Consequently, it lacked an incentive to begin a debate with those who did not support that goal, whereas in the Westerschelde case such a debate was unavoidable. A number of policy initiatives facilitated this need, ranging from the broad discussions in the BOWS and LTV process to the concrete decisions in ProSes. The change towards singularity during the closing stages of ProSes was also a deliberate choice. A similar decision was made in the Unterelbe case by initiating the working group Tide Elbe in order to address issues that a singular regime could not handle.

While these changes are deliberate they are also often made reluctantly

Examples include the inclusion of PAET in the debate over the Westerschelde and the poor connection between the Tide Elbe Konzept and the planning of the deepening of the Unterelbe.

Any given state between self-referential behaviour and dissipative behaviour can exist without explicit awareness of the actors involved. The self-referential characteristics of the policy action systems in the Unterelbe case did not emerge because the policy-makers intended it to but because there was not enough awareness of what was taking place in the societal environment, as evidenced by the ill-judged way in which the societal actors were approached. This lack of awareness is then reinforced through the self-referential nature of the system. The composite characteristics of the policy action system in the Westerschelde case evolved in a similarly accidental way as the inclusion of most stakeholders, including the Flemish port lobby, PAET and the environmental pressure groups, led to a projected attractor basin previously not considered, which in turn led to previously unexpected policy proposals. Thus, a policy action system's shift between a singular and a composite disposition in response to complexity can be started deliberately but may continue unintentionally. At the same time, a current state of affairs can persist so that changes do not take place or are made reluctantly.

8.4.1 Systems under pressure

The act of managing and developing physical systems sets off reciprocal selection between the physical system, the policy action system and the societal environment. The physical system evolves because of the selection pressures stemming from the policy action system's decisions. At the same time, the disposition of the policy action system also evolves because of selection pressures. Blind selection pressures stem from the policy action systems' own actions, sometimes reinforced by events in the periphery, and carry with them the potential to define the attractor basin available to the policy-makers, thus effectively limiting the attractor basin. While the policy action system attempts to respond to these pressures by applying and changing its selection patterns, its disposition also changes between singularity and a composite nature – a change that is partially unintended.

In summary, then, when managing and developing the physical systems in the two cases, the policy action system influences the evolution of the physical system but the very act of doing this changes the attractor basin and the nature

of the policy action system in turn, hence the reciprocal nature of selection. In other words, the attractor basin and the nature of the policy action system are partially determined outside the intended selections of the policy-makers. They are changed by the selection pressures regardless of whether those actors like it or not. Thus, blind selection does not just limit the attractor basin, it also influences the nature of the policy action system.

By now it is clear how the policy action system influences the physical system and the societal environment and how, in return, these influence the nature of the policy action system and the policy options available to it. The ensuing mutual adjustment can lead to unfavourable results for one or more of the systems. By definition, singular policy action systems have a limited projected attractor basin and as such, run the risk of overlooking the possible future stable state of the physical system and the societal environment, as evidenced by the Unterelbe case. Composite policy action systems have the opportunity to obtain a more inclusive view of the attractor basin, which reduces the risk of overlooking an unfavourable attractor. However, even then it is not likely that the complete attractor basin is included in the projected attractor basin and that developments are understood. The danger that a certain decision may backfire continues to exist. The policy-makers can only hope that the final attractor matches the projected attractor basin and that (chance) events do not affect the outcomes. Indeed, the policy action system in the Westerschelde case has arguably been lucky so far. The point in that case is therefore not that an unfavourable physical change has been avoided but rather that the actors have managed to increase its projected attractor basin temporarily and with that, have increased its chances of avoiding unfavourable results.

8.4.2 Between interference, parasitism and symbiosis

Regardless of the policy-maker's efforts and intentions, the physical system, policy action system and societal environment evolve through reciprocal perceptible and blind selection that shapes the nature of both the systems as the route through the attractor basin. In other words, they coevolve. For the management and development of physical systems, it is vital to understand the patterns of reciprocal selection and the consequent direction of coevolution. Which patterns of reciprocal selection are beneficial to the systems and which patterns lead to degenerating results? As argued in Chapter 3, coevolution is always present

as systems affect each other continuously, but if this mutual influence leads to unfavourable effects for all the systems involved, this coevolution can be considered to be an interferential nature. If one of the systems benefits from the degeneration of the other system, this is deemed to be parasitism. Symbiosis only occurs if all systems benefit from their mutual interaction and adjustment.

The empirical cases showed that the disposition of coevolution can change accordingly with the changes in the nature of the physical system and the selection patterns deployed by the policy action system. Any disposition of coevolution is therefore not necessarily static, although it can be persistent. The Unterelbe has been under the strain of anthropomorphic changes for decades, especially after the Second World War when the focus of these developments was on the utilitarian function of the estuary, i.e. to promote shipping, to act as a discharge for contamination and to provide a safety dimension through the prevention of flooding. This occurred at the expense of the ecological function of the physical system. In this case, the economic utilisation coincides with the main goal of the policy action system. Therefore, following the argument in Chapter 3, this type of coevolution can be identified as parasitism because the economical dimension was promoted at the expense of reducing the estuarine characteristics of the Unterelbe and despite recent societal resistance.

This disposition changed from 2004 onwards as the physical changes backfired on the policy action system and the level of societal resistance continued to increase. From then onwards, the policy-makers were forced to respond to these developments at the expense of their own resources because failing to do so would render the goal of further deepening and economic development unfeasible. Since, in the newly-emerged situation, the policy action system freeloads on the same properties that the Unterelbe requires for its estuarine characteristics and because the outcomes were unfavourable for both the policy action system and societal environment, the type of coevolution changed from parasitism to interferential coevolution – with both systems drawing from the same resources but none of the systems involved benefiting from the situation. Decades of parasitism have worn out the resilience of the Unterelbe and because of the selections made by the policy action system, it progresses through the attractor basin with increasingly unfavourable results.

At the start of the Westerschelde case-study the coevolution between the estuary and its policy action system was similar to the situation in the Unterelbe case, barring the fact that the economic interests of the policy action system did not lie with a deeper Westerschelde. However, the Westerschelde estuary had also

been changed to suit shipping transport bound for Antwerpen and to protect the deep polders with their agricultural land use against flooding. While it was primarily the ports and the communities behind the dykes who benefited, the estuarine characteristics diminished because the surface of its riverbed decreased through progressive embankment and because the main channels were deepened. This situation is very similar to the Unterelbe case around that time, hence the type of coevolution is also parasitism.

The decision to facilitate alternative ideas about the Westerschelde and to channel it into the actual decision making process caused a change in the nature of coevolution towards symbiosis into a possibility. It was recognised that ongoing parasitism would not only damage the estuary but that such damage would also extend to the policy action system and societal environment. Loss of estuarine characteristics meant a loss of dissipative capacity against peaks in the water level and a loss of ecological areas that interfered with environmental legislation. As a result, the policy action system arrived at a plan that took into account most aspects rather than focussing exclusively on a new deepening. This potentially meant that the coevolution had changed from parasitism to symbiosis. However, despite the well-intentioned plans, nothing had yet come to fruition and for the time being, the plans were far from being implemented. As long as the plan was not executed as a whole, nothing really changed in the coevolution between the physical system, societal environment and policy action system, hence the label 'continuous parasitism'.

If the nature of coevolution is understood as the directional dimension of the route through the attractor basin, these cases show that changing the route is difficult. A route is path-dependent and was also locked-in in both cases because the investments required to change the current situation were considerable, both in terms of funds and in terms of creating support among actors. The Westerschelde case stands out in this regard, as the plans for the estuary were, in the OS2010, aimed at symbiotic coevolution whereas the actual developments show that another deepening without complementary measures was not unlikely at that stage.

Decision-makers have the potential to alter the route through the attractor basin and consequently to change the nature of coevolution. However, analysis of the two cases in this book point outs that even when this is realised among actors in the policy action system, they are still limited in their freedom to act because of complex reciprocal selection.

8.5.1 Six aspects of decision making in coevolving systems

In retrospect, this research began with the observation that systemic theories are gaining ground in thinking about ecosystems management, especially when it concerns coastal zones and estuaries. However, although much is known about the interactions between different ecological elements, little is known about the influence that the dynamics of decision making has on the physical systems. Decision making is still handled and analysed as the proverbial black box. On the other hand, the domain of public administration has a long tradition of analysing decision making but less is known among public administration scholars about the consequences of decisions on the physical systems and how the dynamics of these physical systems and the subsequent pressures impact the decision making process. In other words: the physical system as the object of governance is regarded as a black box.

Conceptually, there is a continuous string of loops between the policy action system and the physical system in which the societal environment plays an important role as well. Because it is assigned the task of formulating and then shaping the desired future of the physical system, e.g. a deeper estuary or more ecological development, the policy action system attempts to steer the developments of the physical system towards a new stable state. When the measures required to achieve that desired state are carried out, the physical system responds in a particular way and this response is then processed by the policy action system that, pending the assessment, decides whether or not to act.

Empirically, however, it appears that the physical system does not necessarily comply and that in the process of decision making, the policy action system may be subjected to multiple pressures that it can only partially control. Still, it is able to have an impact on the physical system and although this closes the feedback loop between the two systems, the outcome is often different from what was aimed for because the return is often disproportional to the action. To put it more precisely, the process of selecting the future attractor is influenced by the complex dynamics of the physical system and of the policy action system. There are six aspects of decision making in coevolving systems.

Firstly, it appears that the policy action system intends to make perceptible selections regarding the desired future attractor of the physical system. However, it is also subjected to blind selection stemming from earlier decisions that have adverse effects, accidental changes and events. The relationship between these decisions and the actual outcomes is obscured because of the complexity of

causation. The actual physical developments bring and keep the estuaries in an attractor that yields unfavourable results or the threat that this could happen soon. In both case studies, the policy action system had to respond to these problems – each in their own particular way – rather than remaining unrestrained and able to choose to do as they desired. In other words, the attractor basin is limited not by only by perceptible and deliberate choices made by the policy action system but, above all, by the actual physical developments – especially because the new stable states prove to be persistent.

Secondly, there appears to be an erratic relationship between the selections made by the policy action system and the subsequent responses. These responses do not evolve gradually and regularly with the actions from the policy action system but instead, display a punctuated nature with changes taking place elsewhere in time and with erratic results because of the nature of feedback loops. Therefore, the policy action system could face a new situation relatively unexpectedly, especially when the new situation is unintended. Together with the mutual complex causation between physical change and measures from the policy action system, this could render change unintended, unobserved and unexpected.

Third, upon facing this uncertainty, the policy action system responds to the selection pressures stemming from these situations in their own way by altering the selection patterns and with that, the disposition of the system. By and large, there are two types of responses. Singular policy action systems respond to selection pressures by connecting with those actors who support their goals and by shielding the process from those who oppose it. This results in a narrow scope of the project and consequently, in research aimed exclusively at finding the means to that end. The main reason for this approach is an attempt to keep the project under control as it is considered complex enough as it is without distracting factors. Any perceived threat to the original goal is actively diverted away.

However, such an approach can be rendered intolerable if the selection pressures that were diverted backfire on the policy action system. It is then forced to alter its regime. The second type of policy action system is characterised by a composite nature. It connects with other actors in order to expand the diversity of ideas and goals in the process. This results in a debate that questions the scope, subsequently taking into account more than one aspect of the physical system. Consequently, research is also aimed at exploring options rather than simply finding the means to a given end.

Fourth, while the classification into singular and composite policy action systems may suggest a stable dichotomy, empirically it has been observed that composite characteristics are encompassed within the singular policy action system but not always unlocked. Both systems consist of multiple actors, which creates the potential for more diversity. A more composite nature is also not the final state of a policy action system as it can convert (back) into singularity. Change or consolidation of regime is induced by actual unfavourable events or by the perceived imminent risk of such changes. While a change or consolidation may be a deliberate response to the selection pressures (that could stem from earlier decisions) it has also been observed that both types of systems have the capacity to reinforce their nature unintentionally. The singular policy action system is driven by its self-referential nature that reconfirms its workings while the composite policy action system is driven by further dissipation in an attempt to be comprehensive. Both methods have their advantages and disadvantages with regard to the selection pressures the policy action system is subjected to.

Fifth, when the first four points are combined, it appears that selections and selection pressures of coevolving systems have a reciprocal quality insofar as the degree of freedom of the policy action system is limited by events and developments outside the direct, perceivable and intended control of the actors within the system. Not only can the attractor basin containing the possible future states of the systems be compromised through adverse, unintended results and events, the nature of the policy action system can also change partly uncontrollably as a singular policy action system may not be aware of its singularity and a composite policy action system may not be able to keep its diversification under control.

Sixth, observing that the policy action system's degree of freedom is limited outside its intentional control, it still is able to have an impact on the physical system. The nature of the policy action system is important for the definition of the physical system's route through the attractor basin. Singular policy action systems have less of a chance of taking into account all the possible future attractors of the physical system than composite systems. However, composite systems are still subjected to the characteristics that are inherent in coevolution and their composite nature does not allow them to avoid the fact that unfavourable developments can take place – it can only reduce the probability of such developments. At the onset of both cases, the interaction between the two systems could be characterised as parasitism, with economic development compromising the estuarine characteristics. The further development in the case

of the Unterelbe saw that this economic development was in turn compromised by the physical developments, resulting in a change of coevolution towards interference. The Westerschelde case showed that the policy action system acknowledged the desirability of symbiotic coevolution but fell short in the implementation of its comprehensive plan. The actual interaction remained characterised as parasitism.

In terms of the motive of this research mentioned in Chapter 1 and at the start of this section, it seems that actors within the policy action system and the dynamics of the decision making process do have an influence over the physical system, but this influence is limited or distorted because of the six aspects described above. Policy-makers are subjected to selection pressures from the physical system and the societal environment as much as they can exert selective pressures on them. Coevolution between the systems is therefore a matter of reciprocal selection, with the results not being fully determined by intended selections made by policy-makers but rather, emerging from the entire complex process of reciprocal selections.

Chapter 9: The Gentle Art of Coevolution

9.1 Recapitulation

This book began with the empirical observation that the utilisation of physical systems such as estuaries and tidal rivers inevitably triggers a continuous pattern of actions and responses between the physical system and the social system utilising it. Decisions made in the past with unobserved, unintended and unfavourable consequences create situations that require considerable amounts of effort to be turned around. While decision making over physical systems is often understood as an anthropomorphic and unidirectional act, the argument made in Chapter 1 was that decision making on physical systems should be understood as a polycentric reciprocal act. The coevolutionary approach shows that decisions are made within the context of total interdependence that reduces the freedom to choose policy options. This perspective can help with understanding the complexity of managing and developing physical systems.

Complexity theory, as argued in Chapter 2, provides a systemic theoretical foundation that addresses the erratic nature of processes within and between systems. Such erratic processes are characterised by the occurrence of negative and positive feedback, punctuated change, hysteresis, path-dependency and lock-in. Coevolution is conceptualised as the process of reciprocal selection of attractors from the systems' attractor basins. Reciprocal selection is understood as feedback loops between systems and therefore bears the characteristics of complex processes, i.e. it is highly erratic. Decision making by humans plays an important role in the interactions between physical and social systems as it transforms desires and demands into concrete operations that alter the physical system. It also responds to the subsequent physical changes, hence becoming a part of the pattern of reciprocal selection. While this way of thinking is often understood conceptually, there is little empirical research of how day-to-day (political) decision making shapes or is shaped by coevolution. Longitudinal and continuous empirical research can help to fill this gap.

This study centres on two cases. The Unterelbe case study in Germany ran from 1996 to 2007 and the Westerschelde case in Belgium and the Netherlands ran from 1993 to 2007. The chronological presentations of the cases in Chapters 4 and 6 showed how, in both cases, the policy action system

decided to embark on a deepening operation despite societal protests, legal hurdles and uncertainty over the consequences of such an operation. Decision making on another deepening in the Unterelbe was accelerated because of a number of events. However, in the course of planning this deepening, the policy-makers were suddenly confronted with the unfavourable effects of decades of modifications to the physical system, as the deepening triggered a change in the tidal regime and with that, an unfavourable change in the transportation of sediments. Under pressure from these changes, the policy action system was forced to alter the process and content of the intended deepening operation and initiated the development of a long-term vision. It also started a mediation process in order to deal with societal unrest.

Such a major unfavourable physical change did not (yet) appear in the Westerschelde, but policy-makers were concerned enough about the state of the estuary to initiate a sequence of policy initiatives that led to the development of a comprehensive long-term vision and a more concrete development outline. This plan was drafted with the cooperation of many societal actors. However, once this plan was released, it appeared that societal resistance against nature development in the polders remained considerable, and this stalled the execution of the deepening. Consequently, the package deal began to disintegrate.

When the cases were analysed in Chapters 5 and 7 from the perspective of coevolution, they appeared to suggest that policy action systems attempt to select perceptibly and intentional but that the unforeseen and adverse effects of such decisions render selection blind. This pushed the policy-makers in the case studies into a reactive role and their freedom to choose the future state of the physical system was severely limited because of the situation that emerged. The disposition of the reciprocal selection meant that changes and responses were erratic by definition, appearing at other localities than expected, if they were expected at all. This kind of situation increases the complexity of managing and developing physical systems. Subsequent responses were therefore difficult to time, resulting in a cycle of a poor fit between change and response from policy-makers. The policy action systems responded through regime changes between singular and composite dispositions, with each disposition having particular advantages and disadvantages but most importantly, with each being partly unconsciously driven by self-referential or dissipative behaviour.

This book has focused on the central questions of how the management and development of physical systems can be understood as coevolution between physical systems and policy systems, how actors within these systems deal

empirically with the dynamics of coevolution in their decision making processes and which kinds of interactions between physical and policy systems promote a type of coevolution that is considered favourable to both systems. These questions can now be answered with the research findings.

The core of decision making in coevolving systems is reciprocal selection. While the purpose of decision making is to select perceptibly and intentionally, the cases showed that blind selection does also occur. The blind character of those selection pressures stems from the obscured complex causal relationships and the occurrence of responses in different locations, at different times and in different magnitudes than expected by the policy makers. Both perceptible and blind selection shape the attractor basin at a later stage, thus compromising the policy makers' freedom to select outside their control. This complicates the decision making process considerably, especially if the outcomes are unintended and adverse to what was originally planned.

Empirically it appeared from the cases that policy action systems respond to the new situation by altering or not altering their selection patterns. A common response is to aim for singularity in process and content because the general perception is that this is functional in keeping the project under control. However, the cases showed that this does not remove the existing unfavourable selection pressures so this strategy can backfire. This forces the policy action system to alter its selection patterns from singularity to a more composite approach. It should be emphasised that these two types of approaches should not be seen as completely dichotomous. A change or consolidation of a certain state can be deliberate but also unintended as the singular policy action system can become strongly self-referential and the composite policy action system can become too dissipative to get anything done.

Consequently, the changes in the physical system and in the nature of the policy action system are partially outside the perceptible and intended control of policy-makers. While the singular type of policy action system is less likely to take into account the multidimensional character of the physical system, the composite type's increased likelihood of doing so provides no guarantee that blind and unfavourable developments will disappear. Therefore, based on the cases studied, no clear link can be established between the type of interaction and the occurrence of favourable or unfavourable effects. In fact, there are real constraints against approaches that could, theoretically speaking, change from interference or parasitism to symbiosis. The complexity of coevolution cannot disappear. This is discussed in more detail in this chapter.

Coming full circle, the empirical observation that physical systems behave differently from the steering incentives from the policy action system can be explained by the findings of this research that such incentives make up only one part of the reciprocal selection that drives the coevolution between systems. The purpose of this chapter is to understand the implications of the findings of this research for decision making on physical systems.

9.2 Surviving coevolution

It sometimes seems as if any research in the domain of public administration has an imperative to deliver recommendations that are designed to help practitioners in the field to deal with the issue at hand. This has lead to a plethora of guidelines, rules, focal points and numerous types of management strategies, each tailor-made to the situation investigated and sometimes even going beyond it. The most prominent of these are mentioned below.

Rooted in the environmental domain is adaptive management, which is based on the premise of flexibility in the face of erratic physical system developments (Goldsmith & Eggers, 2004). Adaptive management requires policy-makers to be receptive towards continuous feedback rather than warding off anything unfavourable. This is a sound strategy as shielding oneself from selection pressures rarely causes them to disappear. From this perspective, an evaluation of a given operation is therefore not carried out when the operation is concluded but rather, takes place during the operation and feeds the policy action system with information that allows it to change the operation depending on the new information. It should also take into account the time lag that is inherent to change in physical systems.

Adaptive management is an apt way of dealing with physical systems. At the same time, its possible downside is a lack of consistency and evaporation of potentially meaningful actions. Moreover, adaptive management sometimes seems to continue to rely on the unrealistic premise that human agents can overcome their lack of capacity to process information or the bounded rationality they are subjected to (e.g. Folke, Hahn, Olsson, & Norberg, 2005; Gerrits & Marks, 2007; Goldsmith & Eggers, 2004; Greiner, Young, McDonald, & Brooks, 2000; Rammel & Bergh, 2003; Teisman, 2005).

In contemporary literature on the management of physical systems such as rivers, estuaries and coastal zones, it is widely recognised that the involvement

of actors other than those traditionally belonging to the policy action system is necessary. Often described under the header of stakeholder involvement or public participation, it is understood that an enlargement of connections and composition can help to find attractors outside the inevitably narrow scope of the policy action system, to improve dealings with the inherent erratic complexity of the physical system, to understand the fact that the policy action system does not deterministically control the physical system, to overcome parasitism or interference because of resource conflict or depletion and to improve learning from feedback loops (e.g. Ast, 1998, 2000; Ast & Boot, 2003; Bell & Morse, 2004; Folke, 2006; Gerrits & Edelenbos, 2004; Greiner et al., 2000; Mostert, 2003; Noronha, 2004).

More research and knowledge can lead to a better understanding of the attractor basin (Allen & Strathern, 2003) but it is through interaction with others, including opponents, that this knowledge becomes truly meaningful (Buuren, 2006; Teisman, 2005). More information is not necessarily helpful but high diversity of information is (Bruijn, Ten Heuvelhof, & in 't Veld, 2002). This includes transparency of the motivations and actions of all actors involved. Again, there are also disadvantages such as low willingness to participate, considerable investments in terms of time and manpower and the risk of inconclusive discussions. Process management as proposed by Bruijn, Ten Heuvelhof and in 't Veld (2002) could help to overcome these potential advantages by appointing a change manager who is capable of protecting the progress of the process, gaining and keeping interests of actors and raising the costs of exiting the process.

These recommendations are a mere glimpse into a large body of knowledge that has been developed. Whatever shape they may come in, what they have in common is that they are sensible attempts to address the complexity of coevolution, even though it is not always presented as such. There is a problem, however. Regardless of all these recommendations, it continues to be extremely difficult to deal with the complexity of coevolution in real cases. Reality is such that even elaborate process architecture cannot avoid this complexity, as for example evidenced by the ProSes process in the Westerschelde case. Another new set of recommendations may add to this plethora of theories but is definitely not going to make complexity any simpler or easier to deal with.

Any (fixed) set of recommendations is an artificial attempt to control complexity (Koffijberg, 2007). Complexity will continue to be real, regardless of how many recommendations are thrown at it. It is therefore not a matter of developing yet another amalgamation of such recommendations. Instead,

it is essential to address the question as to why there is such a desire for recommendations in the domain of public administration and how, despite the widespread availability of such guidelines, policy action systems continue to have difficulties incorporating it in their decision making processes.

9.3.1 Craving simplicity

The observations of the cases have shown that policy-makers are naturally inclined towards a deterministic approach for decision making. However, this approach fails to incorporate the erratic behaviour of the physical system and the societal environment because responses are often different than those anticipated by the policy-makers. The same actors find it difficult to cope with the complexity that they are surrounded by as witnessed by the attempts, in both case studies, to maintain a closed scope and limited research and to move away from any information that was regarded to be interferential or white noise. This occurred even during the ProSes period in the Westerschelde case, as the selection patterns converted back to singularity during the closing stages as a way to reduce the complexity in order to draft a development outline. The main reasoning is that managing and developing an estuary is a technically complicated task that requires concentration rather than diffusion.

The argument put forward by Morçöl is that actors involved in political decision making processes have a natural tendency towards simplification. An evolutionary explanation for this is that simplified representations of reality are a way to cope with the massive and continuous complexity of the environment. After all, humans have a limited capacity to process information (Morçöl, 2003). Coincidentally, this idea was originally suggested by the same Ehrlich who suggested the concept of coevolution discussed in Chapter 3. Work by researchers who include Holland and Gell-Mann, both of whom have been mentioned earlier in this book, suggests that simple behavioural rules can help in coping with complexity but at the same time, these also build complexity. Such simple rules, schemata, images or routines are also known in the domain of public administration. They are known through archetypes such as the powerful leader, the uncompromised decision, the purposeful organisation, the fast decision making process, the fordist bureaucracy, etc.

This simplifying or order-seeking behaviour, as Teisman (2005) calls it, resonates throughout the cases in this book. An alternative secondary title for

this book could therefore be 'Why March is Right', referring to the work by James March on decision making (1994). Attempts to skip formal procedures, to keep operations as simple as possible, to exclude unwanted information and to keep opposing actors at a distance can all be regarded as measures that were implemented in order to feed a hunger for simplicity. This type of behaviour is not restricted to the case studies. as some have observed similar behaviour in other policy fields (cf. Gunsteren & Ruyven, 1995b). The desire for concrete recommendations that promise to deliver critical clues for dealing with complexity is also rooted in this type of thinking. After all, it promises to find and deal with the supposed control parameter of complexity. Complexity without the promises of simplicity does not sell well (Koffijberg, 2007).

Theoretically speaking, there are then two ways of arriving at the decision between adoption and adaptation when facing selection pressures: by reducing complexity or by absorbing complexity (Ashmos et al., 2000). Teisman argues that a case can be made in favour of simplicity when the object of governance is characterised by simplicity because of, for example, unchanging routines and regularity in developments. However, he states that such an approach falls short when the object or environment is characterised by complex dynamics. Conant and Ashby's law of requisite variety (1970, in Weick 1979) and Kickert's work in the context of public administration argue that the complexity within a policy action system must be at least as great as the environmental complexity it is attempting to regulate (Kickert, 1991b). Estuaries, tidal rivers, coastal zones, oceans and rivers are by definition complex adaptive systems and this is an indication that simplicity may not work, tempting though it may be.

Empirically, both cases showed that a singular regime driven by a desire for simplicity is not functional for escaping selection pressures. These selection pressures continued to exist regardless of all intentions and continued to haunt the policy-makers throughout the years. In the Unterelbe case it became clear that pressures that were ignored came back during the planning of the next deepening. This stalled the planning process. In the Westerschelde case simplification provoked a change of regime. However, while this was functional in designing a more comprehensive development outline for the estuary, the very act of drafting it inevitably implied simplification, i.e. discussions were concluded, research was finalised and the terms of the agreement were placed. This involved defining boundaries and with that, limiting further dissipation of debate and action. Subsequently, actors outside the policy action system felt alienated and declined the proposals, leading to the current stalemate.

The situation is such that simplicity through singularity fails to work in the context of complex developments, that composite decision making has the potential to be functional but that in practice it has real and legitimate limitations, and that temporal relapses into simplicity through singularity are inescapable. It is through simplicity that complexity remains manageable for humans. However, when the overwhelming complexity is simplified in order to understand it, something that will happen sooner or later, its true meaning is lost because breaking it up into parts and removing it from its contingency leads to further partial interpretation and explanation.

9.3.2 The inescapable reality of complexity

Such is the reality of complexity that any approach to it, simplistic or complex, singular or composite, adopting or adapting, does not reduce this complexity. While it remains sound to reflect the complexity of physical systems in the regime of the policy action system, this does not diminish the erratic behaviour of such systems and does not guarantee that all capriciousness will be understood. Above all, it does not remove the coevolutionary relationship between systems. Policy action systems remain dependent on the way the physical system and societal environment develop. Positive and negative feedback continue to exist and so do path-dependency, lock-in and punctuated change. Complexity remains complex. Regardless of the strategies or regimes deployed, human agents are still limited in their capacity to process information and are unable to respond adequately to feedback loops through their decision making processes (Diehl & Sterman, 1995; Morçöl, 2003). In fact, inadequate response to feedback loops is one of the reasons why perceptible selection becomes blind selection. Unexpected changes will continue to occur and actors will continue to be caught off guard in the face of complexity.

Many attempts to find an appropriate strategy to cope with complexity depend on a certain degree of stability. In some cases, it is assumed that a certain set of rules or tools provides a stable defence against the erratic world in which policy action systems have to operate. In other cases, recommendations are built on the explicit or implicit desire to achieve the right ideal stable state. Policies are examples par excellence of measures that are oriented towards achieving definite optimum and stable states (cf. Rammel & Bergh, 2003). The policy action system does what it perceives it needs to do in order to reach a certain favourable

stable state when this is different from the actual situation.

Even the most elaborate recommendations, if they exist, are poor guides if they are used for the purpose of creating stability. However, such a purpose is the core of (political) decision making, i.e. it is inherent to the process and therefore unavoidable. While complexity is real and unavoidable, so are the nature and constraints of (political) decision making. Some (conceptual) discussions on the management of physical systems seem to ignore this and blame policy-makers for the problems with physical systems. While this research indeed shows that decisions can backfire severely, policy-makers cannot be blamed for being human in their desire for simplicity. In addition, the recommendations that could supposedly change situations of parasitism or interference could lead to ostensible adverse effects.

For example, adaptive management that aims for the opposite of stability has adverse consequences. It could be argued that in both case studies there were many moments where the policy action system seized the opportunity, i.e. showed adaptive behaviour in the face of changing circumstances in order to protect itself from disturbing fluctuations. This confirms the observation that in the domain of political decision making, perceived threats are not always met with increased but unproductive stability but rather with change (Kickert, 1991a). Still, the cases showed that it is very difficult to change from situations of parasitism or interference to symbiosis, despite or perhaps even because of adaptive management. While adaptive management might look like a good idea from a purely theoretical perspective, in practice it is more nuanced because the conflicts continue to exist. Craving for recommendations that aim for optimums, stability or change or that assume that boundary judgments and bounded rationality can be overcome is understandable but deceptive. Coming up with new methods or rules may be useful for the sake of conceptual branding but not for the empirical practices analysed in this book.

9.4.1 Building on the premise of complexity

The argument in this chapter is not a nihilistic one. If the world is imperfect because continuous complexity hinders improvement, the starting point for understanding the implications of this research should be that imperfect world. This does not imply that all hope is lost. Rather, it means that patterns of expectations regarding these implications should be different. Instead of 'fixing'

complexity, e.g. through the use of a checklist or a number of steps to be taken or a guidebook to be followed, one should aim to incorporate complexity into decision making – as argued before.

Empirically, all respondents proved to be aware of the complexity they were in and each response to this complexity was legitimate from the perspective of the respondent in that time and place. It is therefore besides the point to reprimand them for making decisions that backfired later on. However, there are a number of dimensions that can be addressed during the decision making process on physical systems. Van Gunsteren and Van Ruyven (1995) indicate that the proper response to complexity in political decision making consists of three dimensions: acceptance of complexity, a wider notion of knowledge and research and an understanding of governmental steering as a selection system. These three dimensions are extended and modified in this book in order to tailor them to the type of decision making analysed here. Decision making over surprising physical systems should therefore address the following three mutually connected dimensions: reciprocity in decision making, system resilience and, finally, the anxiety for complexity. These are discussed in the following sections.

9.4.2 Decision making as reciprocal selection

Flood has argued that dealing with complexity is like working with the unknowable (1999). A natural response to this is to increase research efforts in order to understand the object of steering, in this case the physical system. Such research adds to an understanding of the physical system but at the same time, this does not always lead to clearer clues for sound operations. For example, the monitoring report in the Unterelbe case could have shown changes in sediment transportation and tidal regime if it was not rushed out, i.e. it could have added meaningful information. On the other hand, the timely preliminary monitoring report in the Westerschelde case provided more information but no clear operational instructions for what the subsequent deepening operation should be like. The paradox of increasing research and decreasing understanding cannot be solved within the unknowable world (Flood, 1999; Gunsteren & Ruyven, 1995a; Teisman, 2005). However, some of the unpleasant surprises that take place during decision making processes can become less surprising if the reciprocal nature of decision making is understood.

Decision making is seldom a well-structured process and this

observation has resulted in a number of theories on models of decision making that take into account the erratic nature of such processes. Kalders refers to them as reconstruction models, which he defines as attempts to present a realistic reconstruction of decision making processes (Kalders, 1998). The approach presented in this book is one such attempt in the quest to approach the erratic reality of decision making over highly complex physical systems as closely as possible. Instead of measuring the progression of the process through time in terms of steps, phases, episodes, rounds or connections between streams, decision making as a coevolutionary process is understood as defining a route through the attractor basin that is driven by a mix of perceptible and blind reciprocal selection.

Often, decision making and real world changes are assumed to be tightly connected. From the cases in this book, it appears that changes that matter in terms of selection pressure are often loosely coupled or even seemingly detached from the actual policy decisions while they are important for defining the route through the attractor basin. It is not the decision itself that acts as an analytical demarcation but systems' shifts from one attractor to the next one in the attractor basin because that is when selection pressures change and become real. Focusing solely on the decision artificially structures the analysis of processes. This does not render the decisions themselves irrelevant, but rather, implies that the decision itself does not fully explain the way in which the process develops.

Looking back at the cases in this book, there are many occasions during which the systems shift regardless of the intended and perceptible selection of the policy action system. Such shifts can occur in the physical system, the policy action system or the societal environment. The change in the tidal regime in the Unterelbe case, the ideas and proposals of PAET and societal resistance in both cases, to name a few examples, are system shifts that are of major importance for the trajectory through the attractor basin even though they are not started by an intentional policy decision targeted at those changes. The relationship between decisions and change still exists but changes occur from a complex amalgamation of decisions that can appear to be mutually disconnected. Intentional and perceptible selection by the policy action system is only one of the many factors for change.

Sometimes a decision can make a desired change, e.g. when the decision to deepen results in a deeper estuary, as shown in both cases. Sometimes a decision can trigger unwanted change, e.g. when the decision to deepen leads to a deeper Unterelbe and to unfavourable sediment transportation. At other

times a decision does not lead to any change, e.g. when the decision to alter the regime regarding the Westerschelde results in years of collaborative planning after which no real change in actors' attitude and subsequent action occurred. The ensuing trajectory through the attractor basin is therefore not the sum of all intended and perceptible selections but the entire complex of both this and blind and unintended selection. This perspective reduces the importance of the policy-maker in deciding over the trajectory.

The analysis of decision making in this book abandons the anthropocentric perspective and places decision making within an explicit relationship with the contingency because it includes an analysis of the chain of selections and responses that influence the physical system and societal environment and that in turn, also influence the policy action system. Changes or perceived changes in the stable states of systems are much more decisive for the trajectory than policy decisions. Thus, an arrangement in time does not depend on decisions but on a change in stable states and subsequently a change in selection pressures.

Because of the complex causation inherent in changes to physical systems, the mix of perceptible and blind reciprocal selection is indistinct, i.e. in practice it is almost impossible to disentangle the exact causation. This obviously hinders policy-makers. Moreover, since the reciprocal selections in the attractor basin constitute feedback loops between systems, this introduces the erratic nature of the elements of processes into decision making. Change can appear unexpectedly because its locality is influenced by positive and negative feedback, path-dependency and lock-in, i.e. it is punctuated in an irregular fashion.

If the process of decision making is not explained by focusing on the decision but by focusing on change, it is imperative that any analysis of decision making should consider the feedback loops that cause unexpected change. Their unexpected character may in the eye of the beholder but this does not mean that causality does not exist. This includes an analysis of the physical system and the societal environment. However, while backward mapping of the trajectory through the attractor basin can explain the (erratic) course of decision making, it does not hold much predictive power. As such, it does fit with the group of reconstruction models suggested by Kalders (1998). It also resembles configuration theory (cf. Twist & Termeer, 1991), except that the coevolutionary approach suggested in this book goes beyond the concept of mutual interaction to include the reciprocal nature and perceptible and blind selection to the analysis of polycentric decision making.

Understanding decision making as reciprocal selection does not reduce the unpleasantness of some surprises but it can be helpful in making a shift from blind to perceptible selection. Note that this does not coincide with a change from unintended to intended selection. However, empirically the anthropocentric perspective drives many steering activities with the physical system. Ongoing analysis of the complexity of the physical system will not improve the quality of the decision making if it is not understood that the decision making process has complex and erratic characteristics similar to the physical system.

9.4.3 Resilience and turbulence

The idea that decision making on physical systems is driven by reciprocal selection consequently means that there is a relationship between selection, diversity and systems' resilience against turbulence. The relationship between selection patterns and diversity, discussed in Chapter 3, was evident throughout the case studies. Diversity in connections, composition, scope and research led to distinctively different approaches towards the management and development of the estuaries. At the same time, it should be admitted that these plans had not (yet) been implemented when the case studies were concluded. Yet it could be observed that events that disturbed the course of the process, from the perspective of the policy action system, occurred during periods of singularity.

Van Gunsteren and Van Ruyven (1995) argue that increased diversity in policy-making increases a system's ability to cope with turbulence. This is also the argument put forward by Bruijn, Ten Heuvelhof and in 't Veld in their book in process management (2002). The authors consider a broad repertoire as an appropriate response to the multidimensional world, with its pleasant and unpleasant surprises. While singularity may promise the smoothest way of operating during periods of turbulence, it may not address crucial aspects of the physical system in operations. Still, creating diversity in composite decision making does not necessarily mean that surprises will not occur; it only means that an appropriate response is more likely to be available when the moment arises. The policy action system's ability to build resilience lies with its capacity to create diversity and to select from this diversity. Greater diversity could help to improve the response to turbulence to avoid a relapse into parasitism or interference (cf. Folke, 2006; Folke et al., 2005; Gunsteren, 2003, 2006; Holling & Melle, 1996).

The perhaps counterintuitive core idea for building resilience is that resistance should be faced instead of avoided. Since it is a human reflex to revert to simplicity when facing complexity and to choose the course of least resistance, it is rather difficult to live up to the above principle. It is nevertheless necessary because resistance will not diminish if it is avoided (Bruijn, Ten Heuvelhof, in 't Veld, 2002). The case studies showed that resistance that remained unaddressed during the decision making process returned to haunt policy-makers later. In the Unterelbe case, for example, the opposition was able to gain more momentum instead of less as time went on. The minimal and partly late inclusion of agricultural organisations and land owners in the ProSes process in the Westerschelde case is one of the reasons that the package deal began to fall apart.

As stated by Van Gunsteren (2006), it can be considered dangerous to strive for complete and constant unity. Self-referential behaviour is to a certain degree unavoidable but when it turns into a reflex against complexity, it should be avoided. Besides, there is no such thing as the final state of a system as systems continue to evolve. The idea of the big push - the grand operation or design that will make the crucial change to the desired state - a desire often observed in the environmental sector - falls into the category of simplistic decision making. The idea that simplicity is the best defence against the diversity and capriciousness of the environment is one source of the problems that actors experience. Such decisions are not disentangled from physical changes, but are instead a part of the unfavourable consequences of diversity and capriciousness that one may wish to avoid.

It is therefore up to the policy action system to promote resilience through the creation of diversity in order to capture as much of the attractor basin as possible. This diversity is created through composite decision making, with extended connections and composition, with exploratory research next to exploitative research and with as much orientation on the process as on the contents, with a wide scope next to and connected with the narrow one of project-oriented decision making in the case of concrete operations (cf. Bruijn, Ten Heuvelhof, & in 't Veld, 2002).

9.4.4 Complexity and anxiety

Despite the conceptual separation between complexity and difficulty discussed in Chapter 2, the daily experience of respondents in this research is that complexity

and difficulty are one and the same concept. Understanding decision making as reciprocal selection, creating diversity and incorporating resistance are aspects that could overwhelm actors. They feel that managing and developing physical systems is difficult already when done in a singular fashion. Adding elements for the sake of resilience seemingly increases the difficulties that the actors are already dealing with. At the same time, it is clear from the case studies that a singular operation is not faster or less difficult to complete than a composite one. The difficulties lie in the fact that surprising events continue to occur and that people can become victims of their own decisions. This continues to happen regardless of the type of decision making chosen.

There are two faces of fear in the management and development of physical systems. The first is the fear of environmental risks such as the risk of flooding. Such fears were observed in both cases. Because this type of fear and risk perception is already addressed elsewhere (e.g. Ellen, Gerrits, & Slob, 2007), the focus here is on the second type, i.e. the personal experience of the complexity in process and content of decision making. The paradoxical situation is that at the personal level, complexity is instinctively met with singularity (March, 1994; Morçöl, 2003) whereas many have pointed out that a better response would be to engage in connections with others (cf. Panzar, Hazy, McKelvey, & Schwandt, 2007; Teisman, 2005), i.e. not to relapse into singularity.

The task at hand, which is fundamental to the two other dimensions discussed in the previous sections, is for people to overcome their anxiety for complexity. This fear seems to be a strong driver in the course of decision making but is not easily overcome. Telling people to stop worrying does not reduce their concerns. As such, it is not easily addressable. However, the aspect of fear in political decision making when facing complexity is something that deserves more research. It seems to be fundamental to resistance against change inherent to the world of policy making and could be a powerful variable for explaining how and why policy processes progress through time.

9.5 Final remarks

In conclusion, there are three dimensions to decision making that are able to respond to surprises from erratic environments. First, the reciprocal character of decision making should be understood. It does not reduce the probability of unfavourable responses but can help to reduce the blindness of certain

selections. Second, the policy action system can increase its resilience against such unfavourable events by enlarging its connections, composition, research and scope. While there are real constraints to this, it could still help to respond in a way that is non-destructive for either the policy action system itself or its environment. At the root of these two dimensions lies the third, namely that the instinctive desire to avoid complexity should be suppressed as far as possible. These three dimensions constitute a cognitive attitude rather than a list of recommendations that can be implemented. It is by no means a quick fix for complexity but, at best, a mental preparation that could render the surprises a little less surprising.

Coevolution is an ongoing process and decision making is never concluded. Perhaps the underlying message of this book is that an advanced understanding of real, empirical complexity of coevolution between physical systems and social systems is crucial in order to have a full appreciation of the situation of total interdependence. Such interdependence extends to the policy-maker and the researcher – including the one writing this book. There is no road to 'solve' or diminish complexity but sophisticated analysis can help to develop one's feeling for complexity. Hopefully, this book can be helpful in this. The art is in the understanding.

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Appendix 1: Data case Unterelbe

Respondents case Unterelbe:

Klaus Baumgart	Rettet die Elbe	08-06-2006
Michael Bergemann	ARGE-Elbe	07-06-2006
Manfred Braasch	BUND Hamburg	14-11-2006*
Günther Eichweber	B.anstalt Wasserbau und Schifffahrt	06-06-2006
Tobias Ernst	NABU Hamburg	13-11-2006*
Ulrich Ferk	Hamburg Port Authority	14-11-2006
Ulrich Foerstner	TU Hamburg Harburg	08-06-2006
Andreas Giesenberg	B. für Stadtentwicklung und Umwelt	15-11-2006*
Harro Heyer	Bundesanstalt für Wasserbau	09-06-2006
Susanne Heise	TU Hamburg Harburg	08-05-2006
Susanne Heise	TU Hamburg Harburg	08-06-2006
Andreas Kellner	B. für Stadtentwicklung und Umwelt	13-11-2006*
Uwe Köhler	Hamburg Hafen und Logistik AG	15-11-2006*
Jörg Maerkt	Handelskammer Hamburg	14-11-2006*
Jörg Oellerich	Hamburg Port Authority	07-06-2006*
Heinrich Reincke	Senat Hamburg	07-06-2006*
Heinrich Reincke	Senat Hamburg	16-11-2006
Mareike Schaerffer	TU Hamburg Harburg	13-11-2007*
Friedrich Tönjes	Landkreis Stade	23-01-2007
Walter Zuckerer	B. für Stadtentwicklung und Umwelt	15-11-2006*

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Appendix 2: Data Case Westerschelde

Respondents case Westerschelde:

Leen van de Berg	Secretariaat Benelux	22-02-2005*
Jan Blomme	Havenbedrijf Antwerpen	26-10-2004*
Peter Bollenbakker	Rijkswaterstaat Directie Zeeland	15-01-2004*
Peter Bollenbakker	Rijkswaterstaat Directie Zeeland	21-10-2004*
Jos Claessens	ProSes	09-10-2003*
Jon Coossen	ProSes	03-10-2003*
Jon Coossen	ProSes	08-12-2004*
Susanne Hulscher	Universiteit Twente	04-10-2004
Harry van Huut	ProSes	09-10-2003*
Claire Jeuken	WL Delft Hydraulics	22-01-2004*
Claire Jeuken	WL Delft Hydraulics	08-10-2004*
Vincent Klap	Zeeuwse Milieufederatie	25-11-2003*
Bart Kornman	Rijksinstituut voor Kust en Zee	25-11-2003*
Thijs Kramer	Provincie Zeeland	22-08-2005
Gert-Jan Liek	Rijksinstituut voor Kust en Zee	21-10-2004*
Youri Meerschaut	WL Borgerhout	21-11-2003*
Sander Meijerink	Radboud Universiteit Nijmegen	19-08-2005*
Marieke van Nood	ProSes	03-10-2003*
Bianca Peters	Rijksinstituut voor Kust en Zee	22-10-2004*
Jean Jaques Peters	Port of Antwerp Expert Team	16-01-2004*
Jean Jaques Peters	Port of Antwerp Expert Team	17-08-2004*
Tom Pieters	Bureau Getijdenwateren	15-01-2004*
Yves Plancke	Havenbedrijf Antwerpen	29-10-2004*
Adrie Provoost	Waterschap Zeeuwse Eilanden	18-08-2005
Carel de Villeneuve	Ministerie van Verkeer en Waterstaat	22-04-2005*

** Interviews together with dr. Arwin van Buuren*

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Appendix 3: List of translations and abbreviations

APA	Havenbedrijf Antwerpen *Antwerpen Port Authority*
AMINAL	Administratie Milieu- Natuur- Land- en Waterbeheer *Administration Environment, Nature, Land and Watermanagement*
ARGE-Elbe	Arbeitsgemeinshaft für die Reinhaltung der Elbe *Association for Maintaining the Ecology of the Elbe*
AWZ	Administratie Waterwegen en Zeewezen *Administration Waterways and Maritime Affairs*
BAW	Bundesanstalt für Wasserbau *Federal Waterways and Engineering Research Institute*
BOWS	Bestuurlijk Overleg Westerschelde *Administrative Consultation Westerschelde*
BSU	Behörde für Stadtentwicklung und Umwelt *Department for City Development and Environment*
BUND	Bund für Umwelt und Naturschutz Deutschland *Association for the Protection of Environment and Nature*
BWA	Behörde für Wirtschaft und Arbeit *Department for Economy and Labour*
CDU	Christlich Demokratische Union Deutschlands *Christian Democratic Party*
CPB	Centraal Planbureau *Central Planning Bureau*
EIA	Environmental Impact Assessment *Environmental Impact Assessment*
GAL	Bündnis90/Die Grünen *Association90/Green Party*
HHLA	Hamburg Haven und Logistik AG *Hamburg Port and Logistics*
HPA	Hamburg Port Authorities *Hamburg Port Authorities*
IKSE	Internationale Kommission zum Schutz der Elbe *International Commission for the Protection of the Elbe*
ISL	Instituts für Seewirtschaft und Logistik *Institute of Shipping Economics and Logistics*
LTV 2030	Lange Termijn Visie 2030 *Long Term Vision 2030*
NABU	Naturschutzbund *Association for Environmental Protection*

OAP	Overleg Adviserende Partijen *Consultation Advising Actors*
OS 2010	Ontwikkelingsschets Schelde-estuarium 2010 *Development Outline Scheldt Estuary 2010*
PAET	Port of Antwerp Expert Team *Port of Antwerp Expert Team*
ProSes	Projectdirectie Ontwikkelingsschets Schelde-estuarium *Project Directorate (for the) development (of a) development outline (for the) Schelde estuary*
RIKZ	Rijksinstituut voor Kust en Zee *National Institute for Coastal and Marine Management*
RWS	Rijkswaterstaat *Waterway and Shipping Administration*
(S)CBA	(Strategic) Cost-Benefit Analysis *(Strategic) Cost-Benefit Analysis*
SMD	Schiffsmeldedienstes Hamburg *Department for Shipping Data*
SPD	Sozialdemokratische Partei Deutschlands *Social Democratic Party Germany*
TUHH	Technische Universität Hamburg Harburg *Technical University Hamburg Harburg*
V&W	Ministerie van Verkeer en Waterstaat *Ministry of Transport, Public Works and Water Management*
VITO	Vlaamse Instelling voor Technologisch Onderzoek *Flemish Institute for Technological Research*
WSD-Nord	Wasser- und Schiffahrtsdirektion Nord *Water and Shipping Administration Nord*
ZLTO	Zuidelijke Land- en Tuinbouworganisatie *Southern Association for Agriculture and Horticulture*
ZMF	Zeeuwse Milieufederatie *Environmental Federation Zeeland*

Samenvatting

Zeehavens zijn voor hun voortbestaan afhankelijk van hun maritieme toegang, de verbinding tussen de haven en de open zee. In veel gevallen is dat een eenvoudig kanaal, of ligt de haven direct aan de kust zodat geen extra verbinding nodig is. Er zijn echter ook havens die verder landinwaarts liggen en waarbij de maritieme toegang niet vanzelfsprekend is. Voorbeelden hiervan zijn Hamburg en Antwerpen. Tussen deze havens en de zee bevindt zich grote overgangsgebieden, estuaria. Een estuarium is een halfomsloten kustwater waar het getij van de zee vrij spel heeft en waar het zoete water van de rivier en zoute water van de zee mengen. Bij elke verandering in het tij stromen water en sediment door het estuarium en dat maakt dat de morfologie van de bedding dynamisch is. Estuaria worden ook beschouwd als ecologisch belangrijke maar fragiele gebieden.

Deze dynamische karakteristieken van estuaria verhouden zich slecht met de eis van efficiënte maritieme toegang tot de haven. Een eenvoudige, gefixeerde navigeerbare route is lastig te realiseren in een dynamisch rivierbed. Bovendien kennen estuaria een beperkte diepte en omdat schepen steeds groter worden willen havenautoriteiten graag de vaarweg verder uitdiepen. Dit is een gecompliceerde taak. Het verder uitdiepen van de vaarweg heeft deels onbekende gevolgen voor de morfologische dynamiek en voor de ecologie van het estuarium. Zolang de gevolgen onder controle zijn hoeft dit niet problematisch te zijn. Maar wat als de havenautoriteiten hun grip op de gevolgen verliezen? Wat als de negatieve gevolgen groter zijn dan de opbrengsten van een diepere vaarweg?

De doelstelling van dit promotieonderzoek is te begrijpen wat het effect is van beleidsbesluiten en de daaropvolgende fysieke ingrepen op estuaria en wat deze gevolgen vervolgens betekenen voor de ruimte die beleidsmakers hebben om nieuwe besluiten te nemen. Er wordt een nadrukkelijke verbinding gemaakt tussen de dynamiek van besluitvorming en de fysieke dynamiek van de estuaria. Deze focus op samenhang vereist een systemische aanpak. Het proces waarbij fysieke systemen en beleidssystemen door de tijd heen veranderen vanwege de invloed die zij op elkaar uitoefenen wordt aangeduid met de term ‘co-evolutie’ en dit begrip staat centraal in het onderzoek. De hoofdvraag van het onderzoek luidt:

Hoe kan het beheren en ontwikkelen van fysieke systemen worden begrepen in termen van co-evolutie tussen fysieke systemen en beleidssystemen, hoe gaan actoren in de bestudeerde casus om met de dynamiek van co-evolutie in besluitvorming en welke vormen van interactie tussen de systemen bevorderd een vorm van co-evolutie die gunstige effecten voortbrengt?

Om deze vraag te beantwoorden moeten een aantal stappen genomen worden. De eerste stap is een theoretische, namelijk het begrijpen van de ontwikkeling van fysieke en beleidssystemen als systemische veranderingen. De theoretische fundering van dit onderzoek wordt gezocht in complexiteitstheorie. Complexiteitstheorie is één van de verschillende typen systemische theorieën. De oorsprong van complexiteitstheorie ligt in de natuurwetenschappen maar sinds de jaren ’80 van de vorige eeuw wint het ook aan populariteit in de sociale wetenschappen. Vanuit dit perspectief wordt de complexe causaliteit van samenhangende ontwikkelingen expliciet gemaakt en onderzocht.

Meer in het bijzonder kan vanuit dit theoretische vertrektpunt worden begrepen dat systemen door de tijd heen worden gekenmerkt door het simultaan optreden van zowel stabiliteit als grillige veranderingen. In dit boek wordt een onderscheid gemaakt tussen elementen van structuur en elementen van proces. De elementen van structuur beschrijven de samenstellende delen van systemen, de elementen van proces beschrijven de mechanismen die stabiliteit en verandering veroorzaken. Vanuit deze benadering is co-evolutie is een element van proces dat er voor zorgt dat de aard en werking van systemen veranderd.

Het begrip co-evolutie is geworteld in de evolutionaire biologie. Het begrip werd oorspronkelijk gebruikt om te beschrijven dat een bepaalde soort zich niet alleen aanpast aan de omgeving maar dat deze aanpassing wederzijds is, oftewel dat de omgeving zich aanpast aan deze bepaalde soort. De landbouweconoom Richard Norgaard nam dit idee van wederkerigheid over en gebruikte het om inzicht te krijgen in de interactie tussen fysieke systemen en sociale systemen. In dit onderzoek wordt het principe van co-evolutie verder gespecificeerd om het hanteerbaar te maken voor het analyseren van besluitvorming. In besluitvormingsprocessen houden mensen zich bezig met het vormgeven van een gewenste toekomst. Daarbij trachten zij te begrijpen wat de huidige situatie is en hoe zij vervolgens naar deze situatie moeten handelen om die gewenste toekomst te creeëren. Zij selecteren als het ware een toekomstige staat van het fysieke systeem.

Hoewel dit het vertrekpunt is voor het beheren en ontwikkelen van estuaria laten praktijkvoorbeelden zien dat elke ingreep van beleidsmakers ook onvoorziene en soms zelfs ongewenste effecten met zich meebrengt. Doordat zowel fysieke als sociale systemen worden gekenmerkt door complexe causaliteit lijken die onvoorziene effecten het product van toeval. Vaak zijn ze echter te herleiden tot besluiten die in het verleden zijn gemaakt. Deze onvoorziene gevolgen zijn echter net zo definiërend voor de toekomstige staten als de zichtbare en intentionele handelingen van besluitnemers. Co-evolutie is de selectie van toekomstige staten van systemen door middel van zowel zichtbare en intentionele selectie als blinde selectie. Beleidsmakers die proberen het fysieke systeem te veranderen selecteren de toekomstige staat van dat systeem maar door blinde selectie kan het resultaat anders zijn dan verwacht. De nieuw fysieke situatie bepaalt echter de verdere mogelijkheden voor beleidsmakers, oftewel: de selectie van toekomstige staten is wederkerig. Dat is in essentie co-evolutie in besluitvorming.

De tweede stap die moet worden gezet is het bepalen van hoe deze processen kunnen worden onderzocht. Het probleem met systemische theorieën is dat systemen in de sociale wereld niet zonder meer kunnen worden vastgesteld. Mensen ontwikkelen door interpretaties beelden van wat een systeem is en uit welke elementen het bestaat. Om te begrijpen hoe beleidsmakers omgaan met de druk van co-evoluerende systemen moet worden begrepen hoe zij voor zichzelf een beeld vormen van wat systemen zijn en hoe zij daar vervolgens naar handelen. Daarbij is van belang te begrijpen dat mensen een beperkte hoeveelheid informatie kunnen hanteren en dat zij in de praktijk dus impliciet en expliciet bezig zijn met het selecteren van informatie wanneer zij een beeld van het systeem trachten te vormen. Er worden vier verschillende manieren om informatie te selecteren onderscheiden: connecties en compositie (uitspraken over de verbindingen en samenstelling van systemen) en scope en onderzoek (uitspraken over wat wel en niet wordt beschouwd als een opgave bij het beheren en ontwikkelen van estuaria). Op basis van de geselecteerde informatie wordt een beeld gevormd dat vervolgens de basis vormt voor een besluit.

Het onderzoek naar co-evolutie moet gericht zijn op het vermogen van mensen beelden te vormen van systemen en er naar te handelen. Daarnaast is het van belang te begrijpen dat de keten van acties en reacties tussen systemen pas goed zichtbaar kan worden in lange tijdreeksen. Het onderzoek is dan ook longitudinaal. Data wordt verkregen middels interviews en documentonderzoek. Triangulatie van bronnen helpt om tot een intersubjectieve reconstructie van

besluitvorming te komen.

Met deze theoretische achtergrond en uitgangspunten voor onderzoek kan de derde stap worden genomen, namelijk het analyseren van empirische casus. Twee casus komen uitgebreid aan bod in dit boek. De eerste casus is de Unterelbe, het gedeelte van de Elbe tussen Hamburg en de Noordzee. Deze casus beslaat de periode 1996 – 2007. Op zoek naar uitbreiding van de capaciteit van de haven besluiten de havenautoriteiten en de Hamburgse overheid om de Unterelbe verder te verdiepen zodat grote schepen onafhankelijke van het getij de haven kunnen binnenlopen. De onderhandelingen over deze verdieping verlopen stroef omdat de omliggende federale staten Niedersachsen en Schleswig-Holstein slechts met tegenzin meewerken. Bovendien is er veel protest van milieuorganisaties, vissers en mensen die langs de dijken. Zij vrezen dat een verdieping de ecologie en veiligheid van het gebied zal aantasten.

De Unterelbe wordt verdiept in 1999. Kort na de verdieping beginnen de havenautoriteiten en Hamburg een nieuw verdiepingsplan te ontwikkelen. Bij het ontwikkelen van dit plan baseren zij zich op de resultaten van het monitoringsprogramma van de voorgaande verdieping. Omdat er haast is met het verder verdiepen van de Unterelbe wordt het monitoringsrapport vervroegd uitgebracht. De gegevens laten zien dat de gevolgen van de vorige verdieping niet heel anders waren dan destijds verwacht. Het planningsproces wordt daarom voortgezet.

Echter, kort nadat het monitoringsrapport is uitgebracht vindt een grote verandering in het sedimenttransport plaats. De hoeveelheid sedimenten die in de havenbekkens accumuleert verdubbelt in hoog tempo. Dat is problematisch want Hamburg heeft nauwelijks mogelijkheden om deze grote hoeveelheid bagger kwijt te raken. Zeker na de moeizame onderhandelingen met Niedersachsen en Schleswig-Holstein zijn de mogelijkheden beperkt. Er lijkt een sterk verband te bestaan tussen de reeksen ingrepen in het fysieke systeem in het verleden, inclusief de vorige verdieping, en deze plotselinge verandering in het sedimenttransport. Ondertussen moet de planning van de nieuwe verdieping doorgaan terwijl de maatschappelijke protesten in vergelijking met vorige keer heviger zijn.

De Westerschelde casus beslaat de periode 1993 – 2007. De Westerschelde is een estuarium op Nederlands grondgebied dat maritieme toegang biedt tot de haven van Antwerpen in Vlaanderen. Net zoals in de casus Unterelbe bestaat hier bij de havenautoriteiten het verlangen het estuarium te verdiepen. In 1993 wordt België een federale staat waardoor Antwerpen, Vlaanderen en Nederland in staat zijn om, nu Wallonië geen onderhandelingspartner meer is, de onderhandelingen

die al decennia voortduren vlot te trekken. De Nederlandse staat beseft dat het tijd wordt om goed nabuurschap te tonen en forceert toestemming om de Westerschelde te verdiepen.

De verdieping wordt uitgevoerd in 1997. Zowel Nederland als Vlaanderen vinden dat de onderhandelingen over deze verdieping te lang hebben geduurd en dat het tijd wordt om meer samen te werken op het gebied van onderzoek en het beheren en ontwikkelen van de Westerschelde. Met dat doel worden verschillende fora opgericht waarbij ruimte ontstaat om nieuwe ideeën over het beheren en ontwikkelen van estuaria voor te stellen. Dit mondt uit in een lange-termijnvisie en afspraken over de toekomstige ontwikkeling van de Westerschelde. Deze afspraken leiden vervolgens tot de oprichting van een bilaterale projectorganisatie die tot taak heeft de lange-termijnvisie om te zetten in een concrete ontwikkelingsschets.

Onder veel betrokkenen bestaat het besef dat onvoorziene en ongewenste fysieke ontwikkelingen, zoals in het geval van de Unterelbe, kunnen optreden wanneer de verkeerde keuzes worden gemaakt. Er wordt daarom ook veel geïnvesteerd in het onderzoeken van de staat van het fysieke systeem, in het bijzonder naar het risico dat het meergeulensysteem van de Westerschelde kantelt.

Velen denken dat het niet mogelijk is om zo kort na de vorige verdieping een nieuwe verdiepingsoperatie uit te voeren zonder negatieve fysieke gevolgen. Deze dominante visie komt onder druk te staan door een alternatieve visie waarbij een verdieping zou kunnen worden gekoppeld aan morfologisch herstel van het estuarium. Het moment dat de projectorganisatie haar ontwikkelingsschets moet opleveren valt samen met de eerste testresultaten van een in-situ test waarbij deze alternatieve visie getest is. Hoewel de test zeer lokaal is in plaats en tijd zorgt het voor een snelle kanteling in de politieke besluitvorming omdat het ogenschijnlijk een uitweg biedt uit de conflicterende eisen. Echter, bij de uitvoering van de ontwikkelingsschets stuiten de plannen weer op veel maatschappelijk verzet.

Op basis van de analyse van de casus kunnen, als vierde stap, conclusies worden getrokken. Besluitvorming in co-evoluerende systemen wordt begrepen in zes aspecten. Ten eerste blijkt dat beleidsmakers sterk leunen op de gedachte dat zij in staat zijn het fysieke systeem intentioneel en zichtbaar vorm te geven terwijl de praktijk laat zien dat blinde selectie constant optreedt. De situatie die dan ontstaat bepaalt de verdere mogelijkheden voor beleidsmakers. Het sturend vermogen van beleidsmakers moet daarom sterk worden gerelativeerd – zij worden in een reactieve rol gedrukt.

Ten tweede blijkt dat de relatie tussen ingreep en gevolg in fysieke systemen grillig is. Sommige gevolgen verschijnen zoals verwacht maar andere gevolgen blijven uit of verschijnen op een andere tijd en plaats dan voorzien. Dit draag sterk bij aan de onzekerheid waarmee beleidsmakers geconfronteerd worden. Fysieke veranderingen kunnen daarom onbedoeld, onbegrepen en onverwacht zijn.

Ten derde blijk dat beleidsmakers op twee verschillende manieren reageren op de nieuw onstane situatie. Het eerste type reactie houdt in dat zij trachten de complexiteit van het probleem onder controle te houden door versterkte vereenvoudiging van de besluitvorming. Dat betekent dat connecties en compositie van de besluitvorming worden teruggebracht tot de kerngroep van besluitnemers en dat scope en onderzoek van het project worden beperkt om doelgerichtheid te bewaren. De motivatie van deze vereenvoudiging van de besluitvorming is dat nieuwe situatie zo ingewikkeld is dat alle factoren die als ruis worden ervaren moeten worden buitengesloten. Alle aanwezige middelen moeten worden ingezet om de kern van het probleem aan te pakken.

Echter, deze opvatting wordt onhoudbaar wanneer de druk van buiten niet verdwijnt door vereenvoudiging maar juist toeneemt. Het buitensluiten van andere actoren en het vernauwen van de scope leidt er niet toe dat deze actoren verdwijnen of dat het probleem uit minder deelaspecten is gaan bestaan. In dat geval is een verandering van regime zichtbaar. Het tweede type response op de nieuwe situatie wordt dan ook gekenmerkt door het aangaan van nieuwe verbindingen met andere actoren. Dit leidt vervolgens tot een herijking van de scope en het bijbehorende onderzoek. Het onderzoek wordt meer gericht op het exploreren van mogelijkheden dan op het onderbouwen van een beslissing die al genomen is.

Ten vierde: de indeling in enkelvoudige en meervoudige besluitvorming suggereert in de eerste instantie een dichotomie. Er is echter geen dichotomie omdat meervoudige besluitvorming besloten ligt in enkelvoudige besluitvorming maar lang niet altijd wordt geactiveerd. Verandering of consolidatie van een bepaald type besluitvorming komt voort uit druk vanuit de omgeving of de dreiging van die druk. En hoewel deze response intentioneel kan zijn laat de analyse ook zien dat beide typen het vermogen hebben zichzelf onbedoeld te versterken. Enkelvoudige besluitvorming blijft enkelvoudig omdat men niet meer ziet dat het niet productief is. Immers, de informatieselectie sluit alternatieve visies uit. Meervoudige besluitvorming daarentegen heeft het gevaar dat het constant uitdijt in een poging alle aspecten en actoren te bevatten.

Ten vijfde, wanneer alle voorgaande punten worden samengenomen blijkt dat de vrijheid van besluitvorming in co-evoluerende systemen wordt beperkt door het wederkerig karakter van co-evolutie. Dit komt voort uit de gebeurtenissen en veranderingen die buiten de directe, zichtbare en intentionele controle van beleidsmakers plaatsvinden. Niet alleen kunnen onvoorziene en ongewenste veranderingen zorgen voor situaties die beleidsmakers in een reactieve rol drukken, ook de verandering van de aard van besluitvorming tussen enkelvoudigheid en meervoudigheid is deels ontroleerbaar.

Tenslotte, hoewel de sturingsmogelijkheden van beleidsmakers dus in veel opzichten sterk beperkt zijn hebben hun beslissingen nog steeds een impact op het fysieke systeem. Het type besluitvorming is daarbij nog steeds van belang. Hoewel het niet mogelijk is de complexiteit van co-evolutie te verminderen en hoewel onvoorziene en ongewenste effecten nog steeds kunnen optreden lijkt het er op dat meervoudige besluitvorming beleidsmakers beter in staat stelt een completer beeld te vormen van alle dimensies van het fysieke systeem waardoor het onverwachte iets minder onverwacht wordt. De fijnzinnige kunst van co-evolutie is dan ook het begrijpen van de ontwikkeling van fysieke systemen als een co-evolutionaire proces.

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