Navigating Climate Change Uncertainty:

Adaptive Governance of European Fisheries – a German Case Study

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Paul Müller

Hamburg, 31.03.2025 Paul Müller

Acknowledgments

One of the most important things I have learned from writing this dissertation is that research does not happen in isolation. Other people always make your research better by questioning assumptions, challenging ideas and offering support. I want to thank all those who did.

While there are too many people to name here, both inside and outside of academia, I want to highlight some who have really impacted my life over the last few years. I am lucky to have met amazing friends like Eva, Jihye and Alex, who were constant in their support and encouragement. I also met my incredible girlfriend Claudia, without whom I cannot imagine my life anymore.

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Words cannot express how grateful I am to have such amazing people in my life.

Abstract

Undeniably, European fisheries are greatly affected by climate change, with impacts extending beyond rising temperatures. However, climate change affects not only European fishing activities but also the institutional structures and processes that govern them. It is drastically increasing the speed at which marine social-ecological systems are changing and, consequently, calls into question the foundations of their governance. To date, the impact of climate change on European fisheries governance has received limited attention.

This dissertation analyzes and discusses the institutional impacts of climate change uncertainty on European fisheries governance, using brown shrimp fisheries as a case study of non-managed species in Europe. The interdisciplinary, mixed-methods research approach integrates qualitative social science analyses with quantitative natural science research on discard shrimp mortality. In doing so, the dissertation aims to bridge disciplinary gaps and foster a comprehensive understanding of Europe's marine social-ecological systems. Central to this approach is the integration of competing knowledge systems – scientific and practical – through semi-structured interviews and roundtable discussions with actors involved in fisheries. Using brown shrimp as a boundary object, the approach creates an integrated research paradigm and enables communication across knowledge systems and disciplines. The analyses presented in this dissertation, and the adaptive pathways that are developed, are primarily informed by Adaptive Governance Theory.

The research rationale follows a stepwise analytical logic, systematically exploring data through iterative stages and adopting a phased approach comprising theoretical, descriptive-analytical and inferential components. Following this line of thinking, the theoretical perspective informs the descriptive and inferential analyses by identifying variables of importance and the processes that connect them. The theoretical analysis examines the extent to which adaptive governance could facilitate climate change adaptability in EU fisheries governance, while the empirical analysis investigates constraints within the EU fisheries governance structure under climate change uncertainty – focusing on the self-management of the German brown shrimp fishery. The theoretical and the empirical analyses inform plausible European fisheries governance and German brown shrimp fishery adaptation options. The findings indicate that a nested, polycentric governance architecture is foundational to sustainable self-management in European fisheries.

Zusammenfassung

Europäische Fischereien sind im hohen Maße vom Klimawandel betroffen, wobei die Auswirkungen über steigende Temperaturen hinausgehen. Der Klimawandel beeinflusst jedoch nicht nur europäische Fischereiaktivitäten, sondern auch die institutionellen Strukturen und Prozesse, die diese steuern. Er beschleunigt den Wandel mariner sozial-ökologischer Systeme erheblich und stellt dadurch die Grundlagen ihrer Governance zunehmend infrage. Dennoch hat bislang der Einfluss des Klimawandels auf die Governance der europäischen Fischereien nur begrenzte Aufmerksamkeit erhalten.

Diese Dissertation analysiert und diskutiert die Auswirkungen des Klimawandels auf die Institutionen der europäischen Fischerei-Governance. Hierbei dient die Krabbenfischerei als Fallstudie. Die interdisziplinäre, mixed-methods Forschungsstrategie dieser Dissertation kombiniert qualitative sozialwissenschaftliche Analysen mit quantitativer naturwissenschaftlicher Forschung zur Sterblichkeit von Beifang-Krabben. Dabei wird bewusst ein multiperspektivischer Ansatz verfolgt mit dem Ziel, disziplinäre Lücken zu überbrücken und ein umfassendes Verständnis europäischer, mariner sozial-ökologischer Systeme zu entwickeln. Im Zentrum des Forschungsansatzes steht die Integration wissenschaftlichen und praktischen Wissens durch semistrukturierte Interviews und Roundtable-Diskussionen mit Fischereiakteuren. Die Nordseekrabbe fungiert hierbei als Boundary Object, das die Kommunikation zwischen Disziplinen und Wissenssystemen erleichtert und die Entwicklung eines integrierten Forschungsrahmens ermöglicht. Adaptive Governance Theory bildet den zentralen theoretischen Bezugsrahmen für die in dieser Dissertation vorgestellten Analysen und entwickelten Anpassungspfade.

Die Analyse folgt einer schrittweisen, iterativen Logik und ist in drei aufeinander aufbauende Phasen gegliedert: eine theoretische, eine deskriptiv-analytische und eine inferenziell-analytische Phase. Die theoretische Phase dient dabei als Orientierungsrahmen, indem sie zentrale Variablen und Prozesse identifiziert und so die empirischen Analysen strukturiert. Während der theoretische Teil untersucht, inwiefern die Adaptive Governance Theory die Anpassungsfähigkeit der EU-Fischereigovernance gegenüber dem Klimawandel erklären kann, konzentriert sich die empirische Analyse auf die Grenzen des bestehenden Governance-Systems. Im Mittelpunkt steht hierbei die Selbstverwaltung der deutschen Krabbenfischerei. Sowohl die theoretischen als auch die empirischen Analysen liefern Erkenntnisse zu Anpassungsoptionen der europäischen Fischerei-Governance und der deutschen Krabbenfischerei. Die Ergebnisse deuten darauf hin, dass eine verschachtelte, polyzentrische Governance-Architektur eine zentrale Voraussetzung für eine nachhaltige Selbstverwaltung in europäischen Fischereien ist.

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List of Abbreviations

AC	Advisory Council
CFP	Common Fisheries Policy
CMO	Common Organization of the Market
EMAF	European Maritime, Fisheries and Aquaculture Fund
EU	European Union
LPUE	Landings Per Unit Effort
MSC	Marine Stewardship Council
PO	Producer Organization
TFEU	Treaty on the Functioning of the European Union

1 Introduction

European fisheries are deeply impacted by direct and indirect Climate change effects (Beaugrand et al. 2022; Bastardie et al. 2022b; Dahlke et al. 2020; UNCTAD 2024). Climate change and human activities are intensifying pressures on the marine environment, causing shifts in primary productivity, food-web dynamics and species geographical distribution (Cooley et al. 2023). Continued ocean warming, acidification, and eutrophication are expected to further alter marine ecosystems considerably - affecting biodiversity, habitats, and fishing opportunities (Bastardie et al. 2022a; Payne et al. 2021). In the Greater North and Celtic Seas, for example, the proportion of warm-favoring species now makes up 64%, exceeding cold-favoring species since the late 1980s — a trend closely linked to rising sea surface temperatures (EEA 2024a). Apart from rising temperatures, climate change effects, such as increases in the frequency or force of extreme weather events, as well as sea level rise, can negatively impact fishing operations (Colburn et al. 2016). Climate change mitigation measures, such as offshore wind parks, also exert direct pressures by displacing fishers from traditional fishing grounds, potentially leading to a geographical concentration of fishing activities (van Hoey et al. 2021).

Climate change is, however, not only affecting European fishing activities but also impacting the institutional structure and processes that govern them (Harte et al. 2019). This dissertation analyzes and discusses the institutional impact of climate change on the European fisheries governance regime, focusing on non-managed species through the case study of the brown shrimp (*Crangon crangon*) fishery in the southern North Sea and explores and develops plausible adaptation pathways to climate change. An interdisciplinary mixed-methods research approach integrates qualitative social science analysis with a quantitative study on juvenile discard shrimp mortality rates. By using an interdisciplinary approach that combines qualitative and quantitative research, an integrative, multi-perspective paradigm is fostered that bridges disciplinary gaps and enables a comprehensive understanding by addressing not only what is happening but also how and why, in turn leading to the development of pathways for innovative adaptation options for European fisheries.

The following section introduces European fisheries governance as well as its relation to climate change before describing the brown shrimp fishery of the southern North Sea. I then outline and discuss the research questions, hypotheses, theoretical foundations, and methodological approach underpinning this dissertation. The section concludes with an overview of the dissertation's analytical structure.

1.1 Climate Change and European Fisheries Governance

Climate change is drastically increasing the speed with which social-ecological systems are changing and calls into question the institutional foundations that govern these systems (Paniagua and Rayamajhee 2024; Elrick-Barr et al. 2024). In a time when acute crises, such as COVID-19 and Russia's war on Ukraine, rapidly succeed one another and overlap with long-term, systemic threats such as climate change, the primary challenge is no longer merely managing crises but instead preserving the system's capacity to be governed on a permanent basis – shifting the focus from crisis management capacities to resilience. Resilience, in this context, is a concept that, much like governance, has recently attracted great popularity in both academia and politics—likely more due to its intuitive associative appeal than its conceptual precision. However, to preserve the system's ability to function on a permanent basis, conceptual and theoretical precision is needed. Therefore, this dissertation explores fisheries governance in Europe both theoretically and empirically, focusing on the government part of governance. Governance is understood as all formal and informal institutional arrangements in society that influence social transactions and actors' behavior and decision making (Nohlen and Schultze 2010). Government is the formal, through a constitution and a system of laws, defined dimension of a political system as well as the institutions of governing that are fitted to enforce political decisions (Nohlen and Schultze 2010). Both the accumulation of acute crises and the system-threatening problem of climate change make it necessary to ask: Is the current European fisheries governance system capable of delivering social as well as ecological sustainability amid the uncertainty of Climate Change?

The Common Fisheries Policy (CFP) is the legislative foundation of the European Union's (EU) fisheries governance (TFEU 2012). It is a highly integrated policy within the EU's governance framework, and through Article 3 of the Treaty on the Functioning of the European Union (TFEU), also known as the Treaty of Lisbon, one of the five exclusive competences of the EU. All other exclusive competences of the EU relate to market and monetary policy: the customs union, competition rules, monetary policy and common commercial policy (TFEU 2012). The CFP is a distributional policy, and its core purpose is the management of fish stocks under European jurisdiction. This distributional nature is also one of the reasons for the CFP's high degree of rigidity and inertia (Peñas Lado 2019; Peñas Lado 2016). Its rigidity results from the Member State's pursuit of national interests when allocating fishery resources rather than creating an EU wide sustainable fisheries management system. Any policy change with the aim of challenging the distribution of fishing rights that were established in 1983, commonly referred to as relative stability, has found opposition in much of the industry and in a significant number of the Member States (Peñas Lado 2019). However, other reforms, such as the introduction of Regional Advisory Councils or the establishment of the European Fisheries Control Agency, have been passed in

order to try to address shortcomings and adapt to changing circumstances. Major reforms to the CFP have been adopted roughly every ten years - in 1992, 2002 and 2013 (Verdins and Popescu 2025).
All of the CFP's rules, down to a very technical level, are written down in legislation – and are neither easy nor quick to modify. Interpretations of these rules are the exclusive right of the European Court of Justice and therefore only occur when it establishes new case law. However, the decadal reforms significantly change the policy foundation of European fisheries governance (Peñas Lado 2016; Peñas Lado 2019). Until the most recent reform in 2013, the CFP lacked clear and explicit fishery-specific objectives. The reform introduced three substantial policy changes (Peñas Lado 2019):

1. A clear objective of harvesting at **maximum sustainable yield** (MSY) by 2020;
2. the **landing obligation** and
3. an emphasis on **regionalization**.

The adoption of MSY provides, for the first time, a clear long-term management target with the provision of a timeframe to achieve that target. The landing obligation was introduced to minimize the problem of non-target species discards in European fisheries, while the emphasis on continued regionalization in decision making is based on the recognition of the diversity of fisheries and social-ecological contexts in Europe (Peñas Lado 2019).
The inter-reform periods, however, bring about changes in policy as well, as the example of MSY shows. These changes do not alter the legal basis of the CFP but generally stand in connection with the implementation of new and different approaches. The objective of maximum sustainable yield, for example, was introduced through a Commission Communication in 2006 (COM 2006) before being enshrined in the 2013 reform (CFP 2013). MSY was de facto being applied in the long-term management of stocks even before it was consolidated in legislation (Peñas Lado 2019). Against the backdrop of an upcoming reform of the CFP, the Commission's communications in this inter-reform period are therefore important and could be telling in terms of the reforms to come.
Policy reforms and management actions are, at least in theory, based on scientific advice from the International Council for the Exploration of the Seas (ICES) – an intergovernmental scientific network – and the Scientific, Technical and Economic Committee on Fisheries (STECF) as well as advice from the regional Advisory Councils (AC) on policy – as seen in Figure 1. ICES provides advice on the scientific total allowable catch (TAC) of stocks to the Commission based on biological information of stocks and the broader environment. The STECF, the Commission's independent scientific advisory committee, provides accompanying relevant socio-economic information regarding the scientific TAC to the Commission. The Commission then proposes a TAC to the Council of Ministers, which negotiates a TAC

to be distributed through the relative stability key to the Member States in the form of quotas (Schuch et al. 2021).

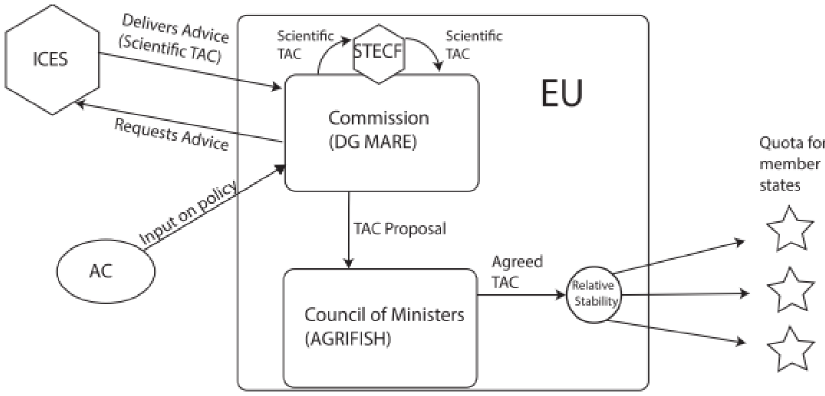

Figure 1: EU decision making system for quota setting in the European Union. Hexagons = scientific bodies, rectangles = political/administrative bodies, ellipse = stakeholder bodies, circle = institutional constraints and star = policy outcome. ICES = International Council for the exploration of the sea, STECF = Scientific, Technical and Economic Committee for Fisheries, AC = Advisory Council (Schuch et al. 2021, 2).

Climate change is challenging this system of fishing opportunity allocation (Bastardie et al. 2022a). It is leading to diverging scientific and management areas for stocks, therefore challenging the relative stability distributional key of the CFP. While a scientific area refers to the geographical distribution of a stock, a management area is based on biological as well as economic, administrative and political considerations. These political considerations result in constraints that are difficult and time consuming to resolve. Scientific areas can be adjusted without considering (as many) political factors compared to management areas - thus leading to differences in scientific and management areas (Schuch et al. 2021).

Fisheries management in the EU is based on different control systems, depending on the sea basin. In general, fishing management in the North-East Atlantic (FAO area 27) is done through quota (input) and in the Mediterranean and Black Sea (FAO area 37) through fishing effort (output) restrictions (Bellido et al. 2020). In- and output controls are in place for stocks that are often referred to as commercial species and are complemented by technical measures, such as gear selectivity requirements (Peñas Lado 2019).

The European Union (EU-27) reported catches of over 830 different marine species (Oceana 2012). The catch composition is heavily dominated by marine fish, accounting for 601 species (72%) - including 494 Osteichthyes and 107 Chondrichthyes. This is followed by mollusks with 88 species (10.6%) and crustaceans with 84 species (10.1%). While species from other taxonomic groups are also reported, they are significantly fewer and represent only a small fraction of the total number of species caught (Oceana 2012). Out of all declared species, only about 146 (18%) are managed - yet these species account for 69% of total catches. This indicates a tendency of the EU to focus management efforts on species that make up a significant portion of catch volumes. Among the main taxonomic groups, only fish (78%) and crustaceans (44%) have a high proportion of managed catches in terms of volume. However, the proportion of managed species within these groups remains low, at just 18% for fish and 13% for crustaceans (Oceana 2012). Consequently, a significant number of species that are not managed by quota or effort but only through technical restrictions, such as fishing gear or engine capacity limits. Often, these non-managed species have to date not played a significant economic role in the fishing industry or their stock status, species biology, and fishery characteristics are poorly understood or entirely unknown (Oceana 2012). Although the European governance system is officially based on precautionary principles (Fitzmaurice and Rosello 2020), it still mandates demonstration of unsustainable harvesting for non-managed species prior to the introduction of constitutional in- or output restrictions—a condition that the example of the brown shrimp will make evident (Steenbergen et al. 2017).

The Scientific, Technical and Economic Committee on Fisheries reports that the EU's annual average catch between 2017 and 2019 in the North Sea, Eastern Channel, Western Channel, Irish Sea, Celtic Sea, and West of Scotland was 1 585 474,316 tons (Table 1).

Table 1: Landings weight (kg) annual average (2017-2019) in in the North Sea, Eastern Channel, Western Channel, Irish Sea, Celtic Sea, and West of Scotland by country (adapted from STECF 2022, 203)

Country	All spp.	Quota spp.	Hybrid spp.	Non-quota spp.
Belgium	21,973,367	12,112,004	3,535,192	6,326,171
Denmark	604,837,848	201,063,117	344,961,836	58,812,895
France	276,219,078	128,223,999	7,442,957	140,552,121
Germany	132,095,934	108,131,553	11,326,700	12,637,680
Ireland	162,472,465	131,854,432	13,258,797	17,359,236
Netherlands	293,397,961	227,501,503	12,820,976	53,057,482
Poland	15,525,276	15,311,347	-	213,929
Portugal	66,022	65,992	-	30
Spain	25,863,263	23,302,402	451,860	2,109,002
Sweden	53,041,101	21,556,831	31,431,174	53,097
Total EU-27	**1,585,474,316**	**869,123,179**	**425,229,493**	**291,121,644**
United Kingdom	600,491,855	460,387,105	14,383,173	125,721,576
Total	**2,185,966,171**	**1,329,510,285**	**439,612,666**	**416,843,220**

Of this total catch, an average of 869 123 tons consisted of quota species, while 425 229 tons were hybrid-quota species. The annual average catch in this time frame of non-quota species was 291 121 tons (STECF 2022). The annual average landing value in the same area was €1757 million. Of this total, an average of €902 million came from quota species, €316 million from hybrid-quota species, and €539.2 million from non-quota species (STECF 2022). In the study area, France is the country most reliant on landings from non-quota species, accounting for 51% of the total catch by weight (140.6 thousand tons out of 276 thousand tons) and 48% of the total landings value (€263.3 million out of €546 million). It is followed by Germany, with 35% of landings value and 10% of weight from non-quota species; the Netherlands, with 31% in value and 18% in weight; and Ireland, with 27% in value and 11% in weight (STECF 2022).

EU landings of non-quota species in the study area support approximately 1,538 vessel-equivalents, employing about 4,155 people (3,027 full time equivalents) and producing 291.1 thousand tons of fish and shellfish. These landings are valued at €539.2 million, generating €315.7 million in gross value added and €112.9 million in operating profits. The Scientific, Technical and Economic Committee on Fisheries concludes that "*without these non-quota species landings, the EU would lose a significant portion of its fishing sector, undermining its ability to maintain current economic performance levels*" (STECF 2022, 212). While the impact of climate change for managed species is becoming more of a research focus (Bastardie et al. 2022a; Predragovic et al. 2023; Sailley et al. 2025), this is less so for non-managed species like the brown shrimp, with all the potential consequences that this brings to the fisheries that depend on those resources.

This dissertation uses the brown shrimp fishery as a focal case study to explore the complex interplay between climate change, non-managed species, and the adaptive capacity of the existing governance regime within the European Union.

1.2 From the Greater North Sea Region to the Wadden Sea

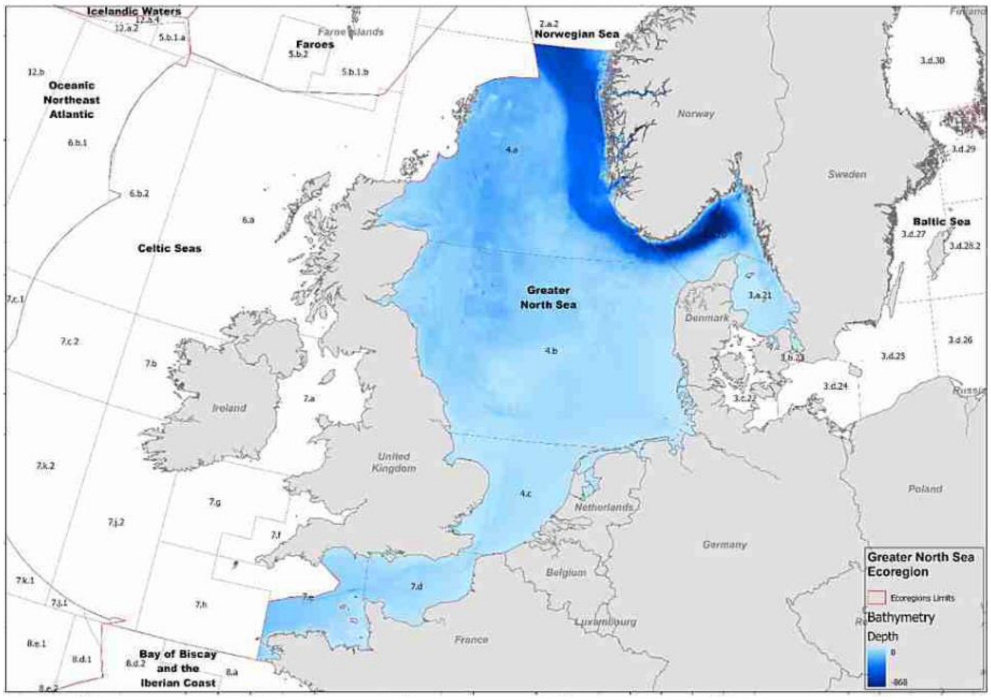

Figure 2:Greater North Sea ecoregion including ICES statistical rectangles (ICES 2022, 2)

Climate change, along with mitigation efforts such as the expansion of offshore wind parks, is profoundly shaping the Greater North Sea region. In 2023, the North Sea recorded a sea surface temperature of 11.9°C at Helgoland Reede, the highest on record (AWI 2024). Offshore wind capacity has also grown rapidly: by the end of 2021, it stood at 22.5 GW, with projections reaching 120 GW by 2030 and 300 GW by 2050 (Hereon 2025). At the same time, EU as well as national biodiversity and conservation initiatives—often framed as "green" politics and policies—are becoming increasingly influential across the region (EU Action Plan 2023). Together, these developments place significant pressure on fisheries and are therefore central to understanding how climate change affects the European fisheries governance system.

The Greater North Sea ecoregion (Figure 2) encompasses the North Sea, English Channel, Skagerrak, and Kattegat (ICES 2022). It is a relatively shallow marine area situated on the European continental shelf, with the exception of the Norwegian Trench, which runs parallel to Norway's coastline.

Pelagic species, mainly herring (*Clupea harengus)* and mackerel (*Scombridae*), constitute a substantial share of the region's commercial fish landings. Additionally, landings of benthic and demersal finfish species are also substantial, such as haddock (*Melanogrammus aeglefinus),* sandeel *(Ammodytes tobianus),* cod (*Gadus morhua) and* flatfish species (*Pleuronectoideo*) and. Around 6600 vessels from nine nations operate in the Greater North Sea, with the largest numbers coming from the UK, Norway, Denmark, the Netherlands, and France. Landings in the greater North Sea peaked in the early 1970s and have since declined drastically (ICES 2022).

Total landings in the region ranged between 2 and 3 million tons in the 1950s, then increased to 3–4 million tons from the late 1960s to the mid-1990s. This increase was driven by high catches of pelagic species, such as mackerel and herring, as well as demersal species like cod and haddock. After 1995, total landings declined, reaching a low of 1.4 million tons in 2012. This decrease was primarily due to overfishing and reduced productivity of key stocks like cod and herring - alongside efforts to reduce fishing mortality to more sustainable levels after 2000 (ICES 2022). Since 2003, pelagic fisheries using trawls and purse seines have contributed the largest share of total landings, followed by demersal and benthic fisheries. However, these figures include only species for which ICES provides advice, excluding several important stocks such as scallop (*Pectinidae)*, European lobster (*Homarus gammaru*s), blue mussel (*Mytilus edulis*), and, notably within the context of this dissertation, the brown shrimp (ICES 2022).

Although the brown shrimp's distributional range is from the White Sea to the coast of Morocco, and into the Baltic as well as the Mediterranean and Black Sea, the high biomass and geological features only allow for a significant fishery in the southern North Sea - specifically the Wadden Sea (Campos 2009). The Wadden Sea (Figure 3) is the world's largest continuous system of intertidal sand and mudflats and a UNESCO natural world heritage site (UNESCO 2025).

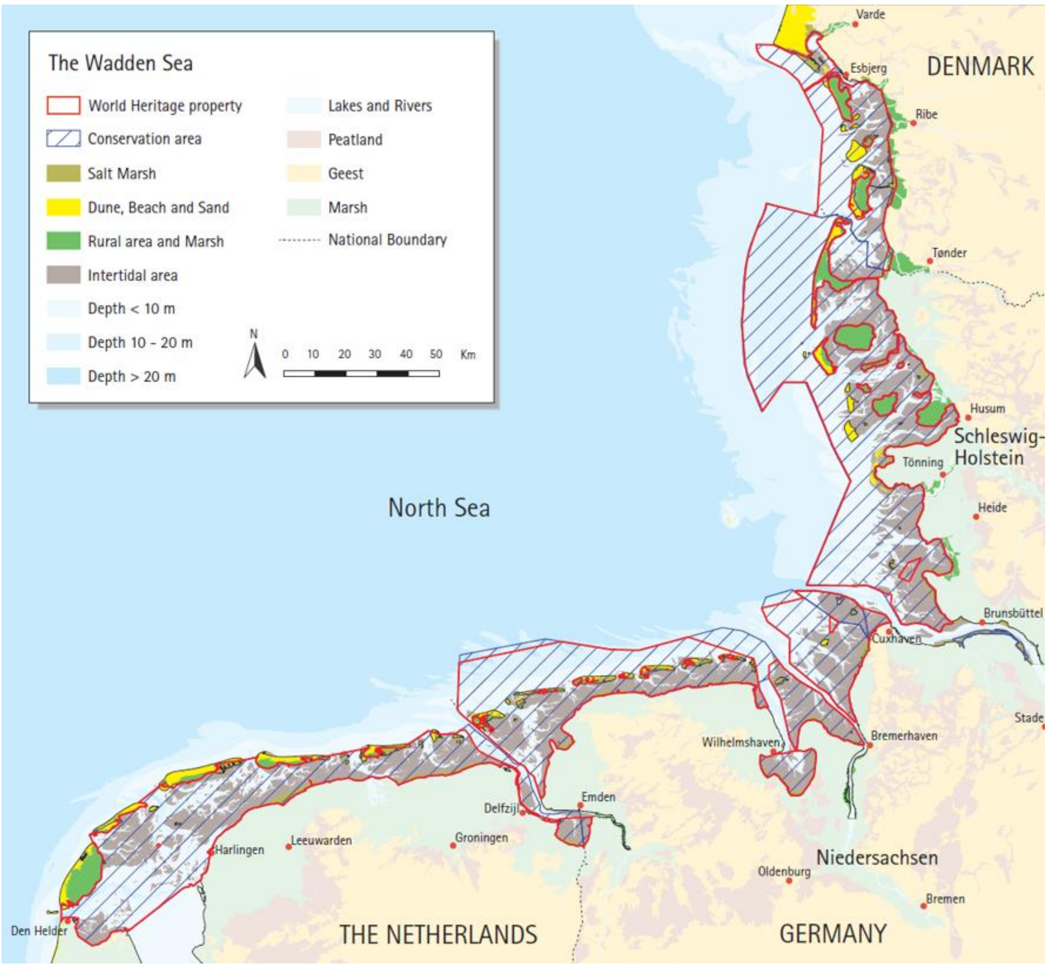

Figure 3: The Wadden Sea including political, cultural and ecological descriptors, © Common Wadden Sea Secretariat

It spans the Dutch Wadden Sea Conservation Area, the German Wadden Sea National Parks of Lower Saxony, Hamburg and Schleswig-Holstein, and most of Denmark's Wadden Sea maritime conservation area. This expansive, temperate coastal wetland is shaped by complex interactions between physical and biological forces, creating a diverse range of transitional habitats. These include tidal channels, sandy shoals, seagrass meadows, mussel beds, sandbars, mudflats, salt marshes, estuaries, as well as beaches and dunes on various islands. The region supports a wide variety of plant and animal life, including marine mammals such as the harbor seal, grey seal, and harbor porpoise (UNESCO 2025).

Geographically speaking, the Wadden Sea can be divided into three regions. In the southern Wadden Sea, twelve major barrier islands, situated 5 to 15 km off the mainland, protect the tidal zone from waves driven mainly by northwesterly and northerly winds. In this region, sediment deposition from the sea does not fully offset rising sea levels, causing the islands to gradually migrate east or northward (this process is, however, stopped by human intervention). In the central Wadden Sea, tidal ranges often exceed three meters. This region features four estuaries, resulting in lower and more variable salinity compared to the other regions. Unlike the southern and northern sections, this part lacks a seaward chain of barrier islands. Here, sediment import appears to keep pace with sea-level rise. In the northern Wadden Sea, eight islands and elevated sandbars form a protective barrier 5 to 25 km off the mainland, shielding the area from waves generated by prevailing westerly winds. In most places, sediment supply falls short of counteracting sea-level rise, except for an oversupply between the islands of Rømø and Fanø. Scattered throughout the tidal zone are several marsh islands and holms, remnants of a once-extensive marshland. In the far north, Pleistocene cliffs directly meet the sea (WSWH 2025).

Hydrologically, the Wadden Sea consists of 39 distinct tidal basins, each characterized by salt marshes, tidal flats, tidal gullies, barrier islands, and ebb-tidal deltas. These tidal basins are closely linked to the barrier islands and elevated sandbars. Between them, tidal currents are concentrated, carving out deep inlets that produce strong water flows. Behind the barrier islands, these inlets typically branch into major tidal channels, which then divide into progressively smaller tidal creeks and runnels, forming a recurring fractal pattern (WSWH 2025).

Climate change has diverse effects on the biodiversity of the Wadden Sea, ranging from species geographical distribution to mortality rates and recruitment. Increases in temperature — including heatwaves in 2018, 2019, and 2022 — as well as rising sea levels and changes in precipitation patterns, such as cloudbursts, droughts and wind patterns, including summer storms, are the main climate change effects in the Wadden Sea (Philippart et al. 2024; WSWH 2025). These shifts, along with changes in sediment and water dynamics, have intensified pressures on the Wadden Sea ecosystem, which is already heavily impacted by human activities such as fisheries, eutrophication, and mining. Wadden Sea species are currently experiencing changes in their geographical distribution (primarily shifting northward), the timing of lifecycle events (mostly occurring earlier), and their recruitment and survival rates. These changes have led to broader ecological consequences, including changes in biodiversity (e.g. northern bivalves being replaced by southern species), disruptions of food webs (mismatches between prey and predators) and alterations in ecosystem functionality such as a decline in nursery habitats for juvenile fish. Elevated water temperatures can enhance the recruitment success of certain species, such as the invasive jellyfish (*Mnemiopsis leidyi*) while reducing that of others (Philippart et al. 2024). Brown shrimp recruitment, for example, is likely negatively influenced by a mismatch in hatching time between shrimp larvae and the plankton that they feed on (Saborowski and Hünerlage 2022). As a keystone species, such a mismatch has the potential for major repercussions both ecologically and for inshore fisheries.

Brown shrimp are particularly interesting within the context of climate change, both from a biological as well as a governance perspective. Much of the fishery occurs within the UNESCO World Heritage property and conservation areas, and in some cases, almost exclusively (Örey et al. 2025). As a non-managed fishery, there are no quotas or fishing effort restrictions in place at the constitutional level, only technical restrictions set by the EU. In- and output controls only apply within the self-management plan of the fishery, yet climate change is increasingly undermining this capacity for self-regulation. By altering ecological and economic conditions, climate change, in combination with the current governance system, incentivizes over-exploitation through various feedback mechanisms (see Chapter 9).

1.3 The Brown Shrimp Fishery

Figure 4: Brown Shrimp Cutter , Photo by Stephan Sprinz, CC BY 4.0, Wikimedia Commons, adapted

The brown shrimp is a non-managed, keystone species in the social-ecological system of the Wadden Sea. Due to its high abundance and biomass, it plays a critical role in the coastal ecology of the Wadden Sea as well as an important economic role in its inshore fisheries (STECF 2023). Brown shrimp are a major predator of in- and epifauna in the intertidal areas, controlling bivalve and plaice recruitment and serve as an important food source for gadoids and other fish (Saathoff 2023).

The brown shrimp fishery is an inshore fishery. Commercial inshore fisheries refer to fishing activities conducted for profit within coastal or nearshore areas, typically within the 12 nautical miles zone. These fisheries often use small to medium-sized vessels and various fishing methods such as nets, traps, or hand lines. They are an essential part of local economies, providing seafood, employment, and supporting small-scale fishing communities (Seafish 2019).

In 2024, there were 175 brown shrimp licenses in Germany. Each cutter typically measures between 16 and 19 meters in length. These vessels usually operate in waters up to 20 meters deep and employ a drum-sieve system for on-board sorting. Crews usually consist of a captain, responsible for navigation and strategic decision-making, and a deckhand who performs the majority of manual work. Unlike many other inshore fisheries that conduct daily operations, brown shrimp trips can extend for up to three days, with their duration largely determined by the captain's strategy and prevailing weather conditions. During these periods, the captain and deckhand work, live, and sleep in the limited space available on the cutter (COFAD 2020, personal communications).

 

Figure 5: Beams of a brown shrimp cutter (left) and drum sieve for catch sorting (right), Photos by the author.

The fishing gear used in the brown shrimp fishery, the beam trawl, has undergone relatively few changes over the past century. Modern gear consists of an eight- to ten-meter beam that keeps the trawl net open, with each cutter deploying two beam trawls, one on each side. Beam shoes attached at both ends allow the gear to slide over the seabed, while a chain of hard rubber rollers spans the space between them (Figure 5, left). As the gear is towed, the rollers bounce along the seafloor, generating pressure waves that disturb benthic shrimp and drive them upward into the net. The cod-end then collects shrimp together with bycatch and debris. Trawling typically lasts two to three hours, after which the net is hauled on board using winches and emptied into a catch funnel. From there, the catch is conveyed to a drum-sieve system (Figure 5, right), where two interlocking rotating drums with different mesh sizes separate marketable shrimp from undersized shrimp and bycatch such as small fish and crabs. Undersized shrimp and bycatch are immediately discharged overboard. Marketable shrimp are cooked in seawater on board, and any remaining small fish or crustaceans are removed manually. The processed shrimp are stored in the vessel's refrigerated hold below deck until landing (COFAD 2020).

The brown shrimp fishery is one of the most valuable fisheries in the North Sea as well as its largest crustacean fishery (STECF 2023; ICES 2022) and has been Marine Stewardship Council (MSC) sustainability certified since 2017 (Chapter 6). The self-management plan that is the basis for the MSC certification and imposes de facto the only restrictions relating to fishing effort and harvesting quantities (MSC 2023). However, starting in 2016, the fishery has experienced a drop in landings from on average about 35 000t to about 25 000t – a decrease of about 25% as seen in Figure 6 (ICES 2025). The landings per unit effort (LPUE) exhibit similar trends across most countries. After reaching peak values in 2018, LPUEs have declined for the Dutch, German, and Danish fleets and now lie at the lower end of historical ranges. In 2023, annual LPUE (kg per horsepower-days at sea) was recorded at 1.5 for the Netherlands, 1.8 for Germany, and 2.9 for Denmark (ICES 2023), with the Dutch fleet reporting its lowest value in the ICES time series (ICES 2025).German landings in 2023 were generally below the 10-year running average, particularly from May to June, which was accompanied by a similar pattern in the fishing effort (ICES 2025).

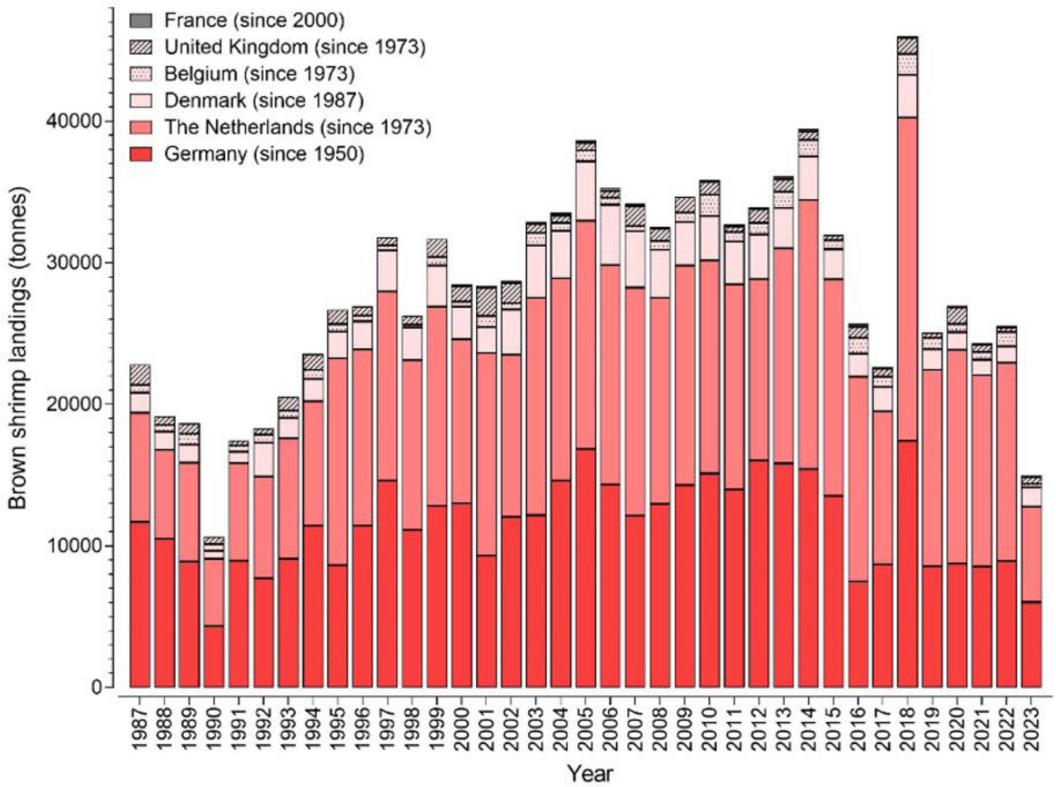

Figure 6: Brown shrimp landings by France, the United Kingdom, Belgium, Denmark, The Netherlands and Germany from 1987 to 2023 (ICES 2025, 5)

While there is no way of knowing whether landings will increase, continue to fall, or plateau at the present level, the current trend has the tell-tale signs of a coming fishery collapse with the abrupt decline in landings corresponding with an increased fishing effort (Möllmann et al. 2021). This makes the fishery an empirically and theoretically important case within the broader discussion of self-managed common-pool resources in Europe, which are marked by high excludability challenges - rivalrous subtraction where one user's harvest diminishes availability for others (Ostrom 1990; Hardin 1968; Quinn et al. 2007). While the long-term trajectory of brown shrimp landings remains uncertain, a recent analyses reveal escalating risks in this fishery: from 2009–2018, effort rose by 12% across Danish, Dutch, and German fleets while landings fell 9%, driving significant declines in landings per unit effort, especially in early-season fisheries across sub-regions—a classic indicator of uncontrolled effort creep and potential local recruitment overfishing (Parmentier et al. 2019; Respondek et al. 2014, 2022).

1.4 Theory, Hypotheses and Methodology

Adaptive Governance Theory (Dietz et al. 2003) is used as the theoretical foundation of this dissertation. As a combinatory, institutionalist theory, it highlights the self-management capacities of communities and the feedback mechanisms between the self-management level and higher levels of governance - such as the European Union (Chaffin et al. 2014). In the brown shrimp fishery, feedback mechanisms between lower and higher governance levels are especially relevant as all in- and output controls are implemented through a Marine Stewardship Council's self-management plan, with only certain technical restrictions coming from the EU or its Member States. From a theoretical standpoint, this issue is significant in three key respects:

- First, targeting a non-managed species, the fishery offers an instructive case for examining common-pool resource dynamics within the European fisheries governance framework.
- Second, it provides an opportunity to analyze how a self-managed fishery operates within what is effectively a quasi non-management regime at the constitutional level.
- Third, the fishery spans Germany, the Netherlands, and Denmark, requiring fishers to adhere to a common self-management plan while simultaneously complying with differing national regulatory frameworks. This mismatch generates an uneven playing field across the fleets.

This dissertation aims to understand the systemic problems and resulting failures of the multi-layered governance system that shapes the policy, polity and politics of the European fishery governance structure, focusing on inshore, non-managed fisheries through the case study of the German brown shrimp fishery. Central to the research approach is the integration of competing knowledge systems – scientific and practical knowledge – of diverse actors. I aim to identify and analyze the processes and institutional arrangements that fishers themselves regard as particularly problematic within the current fisheries governance framework in Germany. Local knowledge can serve to complement scientific knowledge in developing adaptation scenarios (Thornton and Scheer 2012; Rathwell et al. 2015). By analytically integrating both the multi-layered political structure that determines fisheries governance in Germany and the practical knowledge of fishers, I will develop plausible adaptation options for the fisheries governance structure within the context of Climate Change uncertainty.

Together, these research foci generate three interconnected research questions that address (1) the theoretical dimension, (2) the empirical analysis of the EU governance system using the brown shrimp fishery as a case study, and (3) governance adaptation under the uncertainties posed by climate change:

(Q1) To what extent could Adaptive Governance Theory facilitate climate change adaptability in EU fisheries governance?

This first research question focuses on the applicability and compatibility of Adaptive Governance Theory in EU fisheries governance, particularly in the context of climate change. Three hypotheses are central to addressing this question:

(H1) Adaptive Governance Theory needs to go beyond a normative concept in its implementation in order for the EU to engage with climate change uncertainties and adapt at scale.

(H2) Adaptive Governance needs to entail an incremental change in fisheries political governance rather than just a change in knowledge acquisition about fisheries – an important theoretical move from epistemology to ontology.

(H3) Adaptive Governance enables climate change adaptation through iterative learning and implementation processes at both lower and higher levels of governance.

(Q2) What are the constraints of the EU's fisheries governance structure under climate conditions?

The second research question addresses the empirical component of the dissertation, namely the analysis of the EU fisheries governance structure within the context of climate change uncertainty. This part examines the multi-level European fisheries governance system by analyzing the European, Member State, and self-management levels. Using the brown shrimp fishery as a case study, it explores the system's adaptive capacity, its institutional path dependencies and its ability to support socially and ecologically sustainable fisheries. As with the first research question, three hypotheses have been developed:

(H4) The multi-level European fisheries governance system is not designed to deal with uncertainty – that is to be flexible and adapt to new conditions. It therefore produces unsustainable fisheries.

(H5) The multi-level European political governance system is designed with the large-scale commodification of fisheries resources at its core, which favors and consequently produces large-scale compared to small-scale fishing operations.

(H6) Non-managed species, such as brown shrimp, incentivize overcapacity through unregulated harvesting quantities which, when combined with limited biological information and climate-change uncertainty, threaten both ecological and social units within marine social-ecological systems in the EU.

(Q3) How should governance structures be adapted to climate change uncertainty to enable the social and ecological sustainability of the German inshore brown shrimp fishery?

The third research question builds on the findings of the empirical analysis of the EU's fisheries governance system with the aim of developing plausible adaptation options. No hypotheses guided this stage of the research. Instead, it relies on an inductive approach in which insights from the theoretical and empirical analyses directly shape the proposed adaptation options.

This dissertation follows a process ontological (Mancilla García et al. 2020; Hertz and Mancilla Garcia 2021), beyond harvesting approach (Basurto et al. 2020) in its empirical analysis. From a process ontological perspective, reality is fundamentally made up of processes rather than static entities. It emphasizes change, interaction, and becoming over static substances. Applying this lens, fishing is framed not merely as a discrete act of harvesting but all the processes that make harvesting possible (Hertz and Mancilla Garcia 2021). This perspective is grounded in a social-ecological research logic (Hertz and García 2019), for which an interdisciplinary mixed-methods approach was adopted that employs the brown shrimp as a boundary object (Star and Griesemer 1989). Using the brown shrimp as a boundary object not only helped bridge disciplinary divides and foster the development of an integrated research paradigm but also facilitated communication across the distinct knowledge systems of researchers and fishers.

To answer the research questions and test the hypotheses, both qualitative social science research on climate change perception and system functions of the brown shrimp fishery, as well as quantitative biological research on the mortality rate of discard brown shrimp in commercial fisheries, were integrated. With this interdisciplinary approach, a multi-perspective conceptual framework allows for a comprehensive analysis and understanding by addressing not just the observable patterns, but also the mechanisms and reasons underlying them.

To understand local perspectives and practices, semi-structured interviews were done with actors involved in brown shrimp fisheries – politicians, administrative staff and fishers. The interviews with fishers were conducted online, in-person and as on-board interviews and were indispensable for integrating competing knowledge systems – scientific and practitioner knowledge. A key piece in the methodological framework of this dissertation was the qualitative, mobile method of on-board interviews. Conducted during commercial fishing trips, these interviews provided direct access to the fishers' lifeworld. While on-board, research on the immediate mortality of discarded shrimp was carried out, generating novel insights from both social and natural science perspectives.

1.5 The Dissertation's Analytic Structure

This dissertation is structured by four distinct parts (Figure 7). Part 1 develops this dissertation's theoretical foundation, discussing to what extent Adaptive Governance Theory could facilitate climate change adaptability in EU fisheries governance (Chapter 2). Part 2 builds the research methodology upon the theoretical framework established in Part 1 and situates it within the context of the main empirical analysis (Chapter 3). Part 3 analyzes the constraints of the EU's fisheries governance system amid climate change uncertainty, focusing on the German brown shrimp fishery (Chapter 4-9). Part 4 draws on the theoretical framework and the empirical analyses to discuss adaptation options for European fisheries governance, with a continued focus on the German brown shrimp fishery (chapter 10).

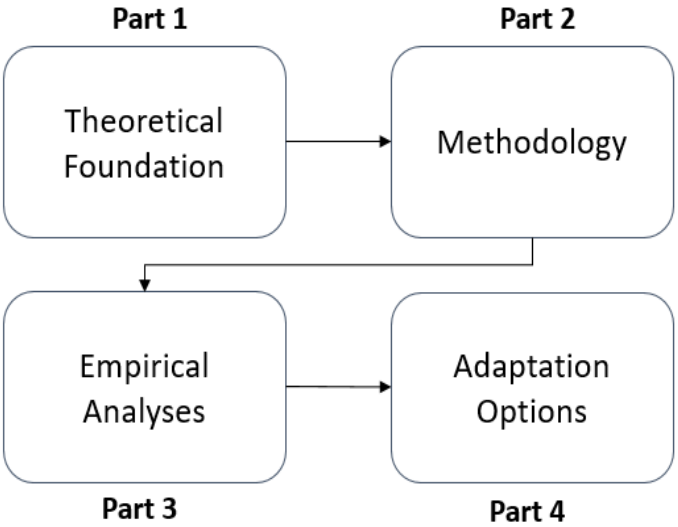

Figure 7: Part 1-4 of the overall structure of this dissertation

This dissertation's research rationale follows a stepwise analytical logic through the systematic exploration of data in iterative stages, which is helpful in developing complex understandings from qualitative data while maintaining a precise analytical framework (Tjora 2018; Ratan et al. 2019). This assists in managing the complex datasets of the interdisciplinary and mixed-method research approach applied here. A three-step phased approach is followed:

1. **Theoretical,**
2. **Descriptive analytical and**
3. **Inferential**

This approach mirrors practices that help to address complex adaptive systems challenges, such as fisheries (Ratan et al. 2019; Biggs 2021a). Following this research rationale, the theoretical perspective informs the descriptive and inferential analyses by identifying variables of importance and the processes that interconnect them. The descriptive analysis, in turn, establishes the empirical foundation for subsequent inferential analyses. This deliberate, stepwise approach offers the advantage of fostering a robust theoretical grounding before the empirical exploration, in which descriptive analyses explore and contextualize data in advance of the inferential analysis.

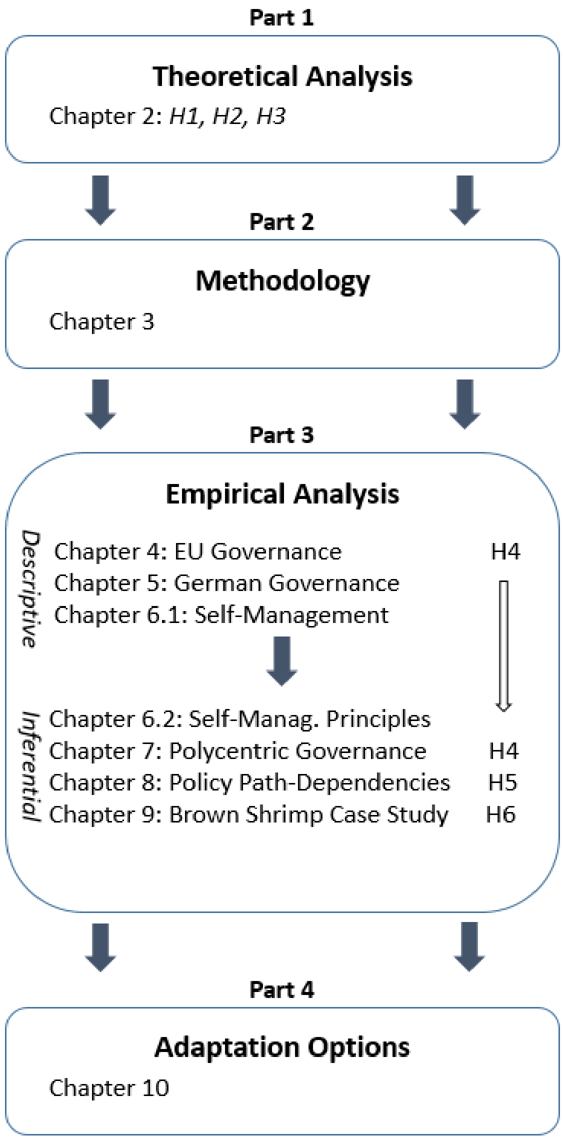

Figure 8: The analytical structure of this dissertation in detail for each of its four structural parts.

First, I will establish my ontological, epistemological and theoretical perspective (Figure 8) through a theoretical analysis of Adaptive Governance Theory. In this step, I develop my research ontology and establish a detailed understanding of Adaptive Governance principles, which subsequently inform the research epistemology and methodology. Building on this theoretical foundation, this dissertation is empirically structured by three governance levels: The European Union, the German and the self-management level and focuses on the interconnections and feedback processes between them, emphasizing structure but prioritizing processes (Chapter 1.4). Subsequently, through a descriptive analysis, I develop a detailed and contextualized understanding of the multi-level European fisheries governance system. This descriptive foundation provides the basis for the inferential analysis of both the EU governance system and the governance of the brown shrimp fishery. I employ a phased hypothesis-testing approach, which allows descriptive analysis to first identify plausible relationships before inferential analyses test the hypotheses (Ratan et al. 2019; Castleden et al. 2012).

Chapter 2 develops the theoretical foundation of this dissertation through an analysis of Adaptive Governance Theory. By providing a detailed understanding of Adaptive Governance principles and their ontological foundations, I show that Adaptive Governance Theory needs to go beyond a normative concept if the EU wants to productively engage with climate change uncertainties and adapt at scale (H1). Such progress is only possible if the importance of integrating diverse knowledge systems is fully recognized. Adapting at scale, however, requires transforming not only how knowledge is produced but also how fisheries are perceived and conceptualized—shifting from an epistemological focus to an ontological one through a beyond-harvesting perspective (H2). A central element of this shift involves recognizing the different levels of governance and the interconnections and feedback processes among them—namely the European Union, the German national level, and the self-organizational level (H3).

Out of the interplay between research ontology and Adaptive Governance Theory, Chapter 3 develops the methods and methodology used. The complex adaptive systems understanding and theoretical perspective developed in Chapter 2 informs the mixed methods research methodology, combining qualitative and quantitative methods in an interdisciplinary approach (Chapter 1.4). An emphasis is put on interdisciplinary integration as well as the integration of different knowledge systems. Therefore, document analysis, interview study, round table discussions and logistic regression analysis of discard shrimp mortality are done in a coherent, integrated methodological framework. The document analysis provides the foundation for the qualitative interview study and round table discussions. These, in turn, enable the integration of scientific and practical knowledge systems, while the logistic regression analysis allows for an interdisciplinary integration.

Chapters 4 to 7 analyze the constraints of the multi-level European fisheries governance system under climate change uncertainty. In a first step, I evaluate whether the EU's fisheries governance is not designed to deal with uncertainty by being flexible and able to adapt to new conditions, therefore producing unsustainable fisheries (H4). Based on the phased hypothesis testing approach, the hypothesis is split into two parts and tested in sequence. In the first part, a descriptive analysis is done to test if fisheries governance is rigid at the European, German and at the self-management level as theoretically informed by Adaptive Governance Theory (Chapter 4-6.1). In the second part, I evaluate if the EU's rigid governance system in fact produces unsustainable fisheries. Drawing on the theoretical principles developed in Chapter 2, the sustainability of the German brown shrimp fishery is examined at the self-management level, alongside an assessment of the role of polycentricity in its sustainability and, more broadly, the contribution of polycentric governance structures to the sustainability of EU fisheries as a whole (Chapters 6.2–7).

In Chapter 4, a descriptive analysis of the flexibility of the EU fisheries governance system is done using the political dimensions policy, polity and politics as analytical tools to develop an extensive, contextualized understanding of European fisheries governance. A closer look will be taken at the conception of the CFP, the latest reform as well as inter-reform periods, how a future CFP might look like and how it is negotiated. Fisheries Governance rigidity in the EU will then be set in context to climate change uncertainty. Chapter 5 continues with a descriptive analysis of fisheries governance in Germany in general and the brown shrimp fisheries management in particular, highlighting a lack of German objectives or fishery governance strategies. The self-management, as the third relevant governance level, is discussed in detail in Chapter 6.1 - with a focus on the MSC self-management plan and the role producer organizations play. Based on this, Chapter 6.2 does an inferential analysis of the brown shrimp fishery's self-management plan, using Ostrom's best practice design principles for sustainable community self-management of common pool resources. Chapter 7 advances an inferential empirical analysis on the influence of multiple, nested and interdependent decision-making centers (polycentricity) on the sustainability of fisheries at the European level in general and the German brown shrimp fishery in particular - discussing the importance of feedback processes and constitutional level rule integration.

Chapter 8 discusses the role and emergence of a large-scale exploitation logic within the European fisheries system - from the EU through to the Member States and the self-management level. It focuses on path-dependencies of the large-scale exploitation logic foundational to the European fisheries (H5). The chapter examines the degree to which European multi-level governance systematically prioritizes the large-scale commodification of fisheries resources by favoring large-scale over small-scale fishing operations through access to fishing opportunities and subsidies. Chapter 9 analyzes the threat of a collapse of the German brown shrimp fishery based on the descriptive and inferential analyses done in Chapters 4 to 8. This chapter moves from a retrospective analytical approach to a prospective analysis using the Social-Ecological Action Situation Framework (Schlüter et al. 2019). The action situations used to develop a system's understanding and build inferential connections are theoretically informed by Adaptive Governance Theory's focus on governance levels, the inclusion of different knowledge systems and interdisciplinary research informed by a social-ecological systems approach.

Based on the analyses from Chapter 4-7, 8 and 9, Chapter 10 develops plausible adaptation options within the context of climate change using a resilience approach to fisheries. Chapter 11 summarizes the results within the broader context of climate change adaptation options developed in Chapter 10. It critically reflects on the theory, methodology and empirical analyses of this dissertation, highlighting advantages as well as its limitations. Finally, an outlook aims at depicting a research pathway for developing climate smart inshore fisheries on the German North Sea coast.

2 Adaptive Governance Theory: a Stepwise Exploration

Adaptive Governance theory (Dietz et al. 2003) is a combinatory theory, which focuses on the evolution of institutions, both formal and informal, for the sustainable use and management of resources such as common pool natural resources. It recognizes the interconnectedness of ecological and social processes across various levels and scales by integrating concepts, principles and elements from different theories with the aim to develop a general theoretical and analytic structure for the management of common pool resources. Its conceptual building blocks include complex adaptive systems thinking, Polycentricity Theory, Collective Action Theory as well as the concepts of resilience and social-ecological systems thinking. Adaptive Governance Theory is thus iterative and learning-based, founded on an inclusive process of governance. It frames institutional arrangements that are to evolve to meet the needs of communities in a changing social or bio-physical environment (Partelow et al. 2020; Hatfield-Dodds et al. 2007; Chaffin et al. 2016; Chaffin et al. 2014; Datta and Chaffin 2022). Adaptive Governance Theory has a broad scope, which makes it applicable across various fields to explain a wide range of phenomena and has no one agreed-upon definition. Despite their differences, most definitions converge in recognizing social-ecological systems as complex adaptive systems, emphasizing the interlinked and co-evolving relationships between ecological and social subsystems. Common to most versions of Adaptive Governance Theory are diverse and polycentric institutions, the collaboration of diverse actors, the integration of multiple knowledge systems, as well as social learning processes and continuous feedback mechanisms (Chaffin et al. 2014; Cosens et al. 2017; Huitema et al. 2009). Against this background, I developed the following research question:

(Q1) To what extent could Adaptive Governance Theory facilitate climate change adaptability in EU fisheries governance?

Based on a document analysis (Chapter 3.2) of both the theoretical and empirical literature, I have identified three issues that I consider as central for EU fisheries to adapt to climate change induced societal and bio-physical changes: (1) Adaptive Governance Theory needs to be implemented with theoretical depth and precision, (2) there needs to be a change in how fisheries governance is thought of and (3) sustainable fisheries need feedback mechanisms between lower and higher levels of governance. While these aspects are not the only changes required, they appear to be the most urgent for ensuring the effective functioning of European fisheries governance under climate change, leading to the following hypotheses:

H1: Adaptive Governance Theory needs to go beyond a normative concept in its implementation in order for the EU to engage Climate Change uncertainties and adapt at scale.

H2: Adaptive Governance Theory needs to entail an incremental change in fisheries political governance rather than just a change in knowledge acquisition about fisheries – an important move from epistemology to ontology.

H3: Adaptive Governance enables Climate Change adaptation through iterative learning and implementation processes at both lower and higher levels of governance.

The document analysis demonstrates that the literature regularly neglects to make the theoretical assumptions underlying Adaptive Governance Theory explicit. This gap is problematic, as the integration of multiple theories requires deliberate clarification of their underlying premises and interrelations. In the following sections, the theoretical presumptions and foundations of Adaptive Governance Theory will be critically explored and analyzed. I will explore its potential and shortcomings while also trying to move beyond its use as a normative concept. When exploring the need for a systemic change of EU fisheries governance in the face of climate change uncertainty, it is important to highlight that feedback between lower and higher levels of governance is indispensable and in the case of non-managed species, such as the brown shrimp, currently missing.

In the literature, Adaptive Governance Theory is often used as something more akin to an approach, concept or framework than a theory (Chaffin et al. 2014), likely, in my opinion, due to its intuitive appeal. This, however, is not a unique characteristic of the scientific discourse on Adaptive Governance Theory. Many researchers often employ terms such as concepts, frameworks, theories and models almost interchangeably (McGinnis and Ostrom 2014), neglecting the importance of precise differentiation for advancing empirical and theoretical work. Therefore, a brief clarification of these terms is necessary before proceeding to the analysis of Adaptive Governance Theory.

Frameworks are meta-theoretical tools that provide a common language for relationships at multiple levels and scales in the social world. Ostrom's Social-Ecological Systems framework (Ostrom 2007), for example, represents an attempt to identify critical relationships and basic working parts among critical elements within social-ecological systems. Researchers specify a framework's basic elements through the development of theories. *Theories* are conceptual deliberations and assumptions that are used and needed to understand and analyze phenomena, explain processes and reflect on possible outcomes (McGinnis and Ostrom 2014). Multiple theories are usually compatible with and can be tested within any framework. For example, several social and ecological theories are compatible with the SES-framework - such as game theory, social choice theory or the theory of natural selection. A *model*, furthermore, is a representation of a theory that makes specific and precise assumptions about how a certain issue might manifest under specific circumstances in a particular setting (Ostrom 2010; McGinnis and Ostrom 2014). A *concept,* on the other hand, is a theoretically informed mental construct that represents a principle that is used to classify, structure and explain observations, phenomena and relationships. Ideally, they are meant to be generalizable and applicable across different contexts. Concepts are the iterative building blocks for the construction of theories and tentative tools for thinking about and analyzing complex systems (Margolis and Laurence 2023).

Reducing Adaptive Governance Theory to an approach or an unspecified concept consequently diminishes its analytical and empirical capacity and applicability. To apply the theory of Adaptive Governance, it is important to talk about its history and theoretical building blocks. This chapter builds the overarching systems understanding that guides this research is going to be established, which includes defining the underlying assumptions about reality (ontology) and knowledge production (epistemology) (Hertz and García 2019). The approach is grounded in complexity thinking (Thiel and Moser 2019) and a resilience approach as well as social-ecological systems understanding (Folke 2006) (Chapter 2.1). The historical development of Adaptive Governance Theory is examined and its theoretical principles discussed (Chapter 2.2). Then, a beyond harvesting rational to fisheries governance is going to be developed (Chapter 2.3) and Ostrom's Collective Action (Ostrom 1990) as well as Polycentricity Theory (Carlisle and Gruby 2019) further introduced (Chapter 2.4). Building on this foundation, I develop a theoretically grounded institutionalist approach to guide the empirical analysis and methodological design. This enables a broader examination of multi-level European fisheries governance.

2.1 Complex Systems: Developing a Research Ontology

Complex system theories try to explain how patterns of collective behavior emerge out of relationships between components of a system. This collective behavior defines the properties of the "whole system" and, through interaction among elements, forms relationships with its surrounding environment (Carmichael et al. 2019; Thiel et al. 2019). In this dissertation, complexity thinking is used to gain new insights and perspectives rather than directly applying complexity theories as a research object. Complex systems thinking is thus conceived as and used both as a meta-theory and a methodology. As a meta-theory, it provides a theoretical foundation for studying social-ecological systems by informing the researcher how to conceptualize and analyze the system under study. Framed as a methodology, it supplies the conceptual and practical frame of the methods used to study and analyze social-ecological systems in an empirical setting.

To date, although widely used in the scientific community, not one distinct, unambiguous, agreed upon theory of complexity exists (Carmichael et al. 2019). However, within the field of complexity thinking and theories, two main strands can be distinguished. Structural complexity focuses on the constitution of the system, while behavioral complexity – like the name suggests – on its behavior. Structural complexity exists when a system is comprised of distinct parts and interactions, while behaviorally complex systems are not by necessity made up of large numbers of elements and relationships between them (Egner et al. 2008). The notion of complex behavior does not necessarily mean a so-called complicated structure. A double pendulum is an example of a very simple physical system that exhibits behavioral complexity. It consists of two pendulums, A and B, which are attached to each other. On their own, each pendulum is a simple mechanical system, but joined together, the double pendulum exhibits complex behavior that is nonlinear, sensitive to initial conditions and unpredictable as the pendulums influence each other. The question that we must ask is: How can something simple give rise to something complex? (Ratter 2012)

As the question implies, system behavior cannot be understood solely by examining the properties of individual elements. It emerges from the interactions among those elements. Simple systems can exhibit complex behavior – see the double pendulum. However, structurally complex systems may show complex behavior too, through the interaction of elements of the systems. In dynamic systems, the elements, or agents, are supposed to interact with each other in a non-linear manner. Complex behavior can emerge as the result of non-linear interactions while surprising system properties can materialize when sub-processes interact to form a larger system (Ratter 2012). Fundamental to behavioral complexity is the recognition that within a complex system non-linear behavior simply is irreducible: It, thus, considers the processes between the elements of a system as well as the properties and qualities of the system at large. Complex systems are unpredictable due to their non-linear and dynamic character. They are characterized by self-organization, which ensures their continuation. However, internal feedback processes and adaptation to a system's environment can change the structure of the system and, therefore, its identity. It is also important to recognize that a system's present characteristics can only be understood in light of its historical development, as path dependencies emerge from these past trajectories. The structural reorganization of a system does thus not stem from a single cause, but is the result of micro-scale interdependencies and emerging relations that - together - give rise to major changes, such as the disappearance of system structures and order (Egner et al. 2008; Ratter 2006).

The emphasis in research on complex systems lies on emergence, on becoming. Necessary for the study of such systems is therefore a shift to non-linear thinking. Linear or deterministic thinking is not going to help understand the development and interactions of system elements, and it cannot assist in understanding emerging patterns of system behavior. Non-linear thinking, on the contrary, provides the conceptual foundation for understanding how patterns are formed, due to repeated and local interactions between elements, and how these patterns change over time. Interactions and the effect

of these interactions are significant within this context, as systems do not exist in an equilibrium: changing relationships of elements are therefore of significant relevance (Ratter 2012).
Stable states, in contrast, can occur abruptly and disappear quickly within a dynamic system. Dynamic systems alternate between pattern and non-pattern phases, in which stability is a transitory period of equilibrium. Qualitative transformations of these systems can occur without external stimuli as the result of internal feedback processes (Thiel et al. 2019). An example of such internal feedback processes are positive feedback loops in fisheries. A complex systems approach ,therefore, lends critical analytical insight into the nature of qualitative transformations of social-ecological systems, e.g. the cod fishery off the coast of Newfoundland (Schlüter et al. 2019). Surprise is an inherent feature of a complex system, and it should be accepted as such. Emergent structures are not the result of a single event or rule but rather system level patterns. An important field for the application of complexity thinking is the analysis of human-nature relationships or interactions (Ratter 2012). These are conceived of as non-linear, dynamic and interact to form intertwined social-ecological systems.
Closely connected to complex systems thinking is the resilience approach (Folke 2016; Folke et al. 2005). While complex systems thinking provides a framework for understanding systems as interconnected and dynamic, the resilience approach focuses on how systems absorb and deal with disruptions. It has been applied across a wide range of contexts and academic disciplines, leading to diverse interpretations, concepts and definitions (Haider et al. 2021; Lorenz 2013; Berkes 2017). In ecology, resilience refers, for example, to the capacity of an ecosystem or a species to withstand and recover from disturbances (Holling 1973), whereas in social system contexts, resilience encompasses the ability of individuals, communities, and institutions to cope with, reorganize, and renew themselves in response to an emerging change (Cinner and Barnes 2019). The Intergovernmental Panel on Climate Change (IPCC) integrates the ecological and social perspectives into a social-ecological systems framework by defining resilience as a "*system's capacity to anticipate and reduce, cope with, and respond to and recover from external disruptions*" (Mason et al. 2022, 524), thereby highlighting the "intertwindness" of our social and natural worlds. Recognizing that a society-nature dichotomy hinders the building of resilience capacities, the concept of resilience of social-ecological systems is based on both the environment's capacity to resist, recover, and adapt to disturbances as well as the capacity of people, groups and institutions to prepare for, manage, and adapt to emerging changes (Folke 2016). A resilience approach thus focuses on dynamic feedback loops between human and natural systems, which can generate trade-offs and synergies across system components and over different temporal and spatial scales (Folke 2016). In fisheries, temporal scales and the resulting trade-offs play an important role. Harvesting a fishery resource below a capacity threshold in the short-term results in lower profits in the near-term but will likely provide higher ones in the long-term (Peñas Lado

2019). These different temporal scales in fisheries necessitate trade-offs and "*[…] attention […] be paid to the potential disconnects between what science tells us is necessary for a healthy ecological system, what society wants from that ecosystem, and perhaps more importantly, what is politically feasible. The resilience literature outlines the objectives of a system of AG [Adaptive Governance]—to reach and maintain a desired state for coupled SESs, but who and what sets of values determine the desired state, in both ecological and social terms?*" (Chaffin et al. 2014, 5). A resilience approach consequently requires addressing key questions about these trade-offs: resilience of what, resilience to what, and resilience for whom (Mason et al. 2022).

A resilience perspective on social-ecological systems offers the opportunity to analyze and understand how ecosystems behave, are structured and in turn, how people associated with those ecosystems behave and are organized. There is an emphasize on "managing by change" rather than in reaction to disruptions also recognizing the key role that individuals and small groups play (Folke 2016). This view stands in stark contrast to an equilibrium centered approach that seeks to control the variability of resources such as fish. Equilibrium centered strategies are good at solving resource problems in the short term, such as declining yields. However, controlling a resource that often fluctuates can lead to changes in variables that work at different spatial and temporal scales, like nutrient flows. It creates land- and seascapes that are spatially homogenized and vulnerable to disruptions that previously would have been able to be absorbed. Multi-stable ecosystem behaviors arise from the interplay between spatial and temporal scales, resulting in recovery pathways that are distinct to systems affected by disturbances and spatial variability. However, the complexity of a system and unanticipated effects make it difficult, if not impossible, to predict recovery trajectories (Haider et al. 2021; Folke 2016; Mason et al. 2022). In social-ecological systems that are resilient, disruptions can create space and opportunity for development and innovation, while even small disruptions can have dramatic social and ecological consequences in vulnerable systems. The prevailing view in both research and society used to be that the natural environment was infinitely resilient and stable: If human stressors were to be removed, nature would self-repair (Folke 2016). However, this static equilibrium understanding provides little to no insight into systems that are transient in behavior and not near equilibrium, as tipping points in marine ecosystems show (Möllmann et al. 2021).

This dissertation posits that effective fisheries governance hinges on fostering renewal, re-organization, and regeneration rather than merely pursuing recovery, leading to a conceptual preference for resilience over efficiency (Cleaver and Whaley 2018). Therefore, this dissertation will discuss the resilience of the German brown shrimp fishery within the wider EU's fisheries governance system and within the context of Climate Change driven disturbances as part of its empirical analysis in Chapter 9.

2.1.1 Complex Adaptive Systems

Complex Adaptive Systems are a subcategory of complex systems. They are dynamic systems composed of interconnected and interdependent agents that adapt and evolve in response to interactions with each other and their environment. As a special instance of complex systems, adaptive capacities and components are especially recognized in them (Carmichael et al. 2019). There are six foundational features of complex adaptive systems. These can be divided into features related to processes of a system and those related to its structure (Preiser 2018):

1. Complex adaptive systems are constituted relationally;
2. are radically open;
3. context dependent;
4. self-organizing and adaptive;
5. dynamic;
6. and experience complex causalities.

That complex adaptive systems are constituted relationally, are radically open and context dependent, are structural features while self-organization, adaptability, dynamic capacity and complex causality are behavior related features (Preiser 2018; Levin et al. 2013). Rather than being defined by the constituent components, complex adaptive systems are defined by the interactions and processes of their components. Process-dependent interactions distributed on different scales result in networks of interactive relations, which is the foundation for the process ontology developed in Chapter 2.5. Every system is made up of subsystems and part of a wider array of systems. Through interactions, effects are generated across scales and domains defining a contextualized identity and function of complex adaptive systems. Complex adaptive systems are self-organizing and adaptive in that they hold the ability to adjust behavior based on and as a response to changes in their environment. The behavioral patterns of a complex adaptive system are, thus, the result of non-linear dynamic processes, meaning that non-linear feedback loops and small changes can have significant effects on system wide re-organization. Systems cannot be understood through information relating to its constituent parts as their interaction contributes to newly emerging phenomena (Preiser et al. 2018).

The six organizing principles provide a foundation for conceptualizing a research ontology based on complex adaptive systems. Here, research ontology refers to the conceptual framework that defines the nature of reality and existence within a research study. It addresses fundamental questions about what entities exist in the field of study and how they relate to each other (Hertz and García 2019). Complex adaptive systems are challenging the traditional Newtonian view in which the universe is well-ordered deterministic system by granting ontological significance to relationships and emergent, nonlinear processes. In this view of complexity, emergent properties and behavioral patterns are real but inseparable from the agents or components that generate them (Preiser 2018) . A complexity-centered ontology therefore acknowledges both the functional and relational interdependence between a system's structurally integrated parts and its broader environment. Complex adaptive systems experience feedback loops among multiple scales that allow the self-organization of the system and properties to evolve through the interplay between adaptive responses of its components, the emergent qualities of the entire system, and the environment in which they operate. Multilevel interactions—bottom-up, top-down, and across spatial and temporal scales—together shape the structure and behavioral patterns of complex adaptive systems as they unfold over space and time (Levin et al. 2013; Preiser et al. 2018).

The theoretical and conceptual consequence of a complexity-centered ontology is as follows: Framing and understanding society and the environment, in which we live, as intertwined results in breaking open the society-nature dichotomy that we are habituated to (Latour 2011). It lets us recognize our world as consisting of social-ecological systems (Becker 2012). Social-ecological Systems are complex adaptive systems that offer the opportunity for further theoretical insight, heuristics and empirical understanding. All of which are crucial in responding and adapting to the challenges of the Anthropocene: from biodiversity loss to world hunger and Climate Change (Reiser 2018). This complex adaptive systems ontology rejects reductionism, emphasizing instead relational dynamics, iterative learning, and the coexistence of multiple ontological states within the same system. It frames systems as processes rather than static entities, where human and ecological components continuously co-evolve (Beunen and van Assche 2021; Haider et al. 2021). In the context of European fisheries, this means recognizing that stocks, marine ecosystems, and fishing communities are interdependent, shaped by feedback loops and environmental variability, while also being dependent on governance systems. Fisheries systems are nonlinear as well as multiscalar, affected by policies, market demands and Climate Change - influencing both resource availability and human behavior. In the following chapters, we will continue to expand this dissertation’s complex-centered ontology while simultaneously and iteratively developing Adaptive Governance Theory.

2.2 Moving Beyond a Normative Concept

Adaptive Governance Theory is fundamentally rooted in a complexity-centered ontology that recognizes social-ecological systems as interconnected, dynamic and therefore inherently unpredictable. It explicitly acknowledges that societal and ecological challenges arise from emergent properties of complex adaptive systems, which cannot be reduced to individual components. This contrasts with traditional governance's linear causal assumptions, cascading impacts across scales, path- and context-dependencies as well as adaptation (Duit and Galaz 2008). However, Adaptive Governance Theory is often used more akin to a concept or approach than a theory, likely due to its intuitive appeal. The document analysis has shown that its theoretical principles are often used without explicit definitions and, consequently, a missing understanding of their precise meanings. Without explicit definitions of its principles and a precise understanding of its building blocks, a meaningful operationalization and implementation appears to be problematic if not impossible – meaning that without a meaningful operationalization and implementation, climate resilient fisheries in the EU are unlikely:

(H1) Adaptive Governance Theory needs to go beyond a normative concept in its implementation in order for the EU to engage climate change uncertainties and adapt at scale.

To gain a deeper understanding of Adaptive Governance Theory that goes beyond a mere use of it as a normative concept, it is necessary to look at its origins and historical development within the space of Environmental Governance. Figure 9 (Partelow et al. 2020, 11), shows the historical development of environmental governance theories and corresponding concepts in the natural sciences, economics, political science and sociology since the 1960's, and enables us to trace the development and emergence of Adaptive Governance Theory.

Since the 2000's, combinatory environmental governance theories that cross disciplinary boundaries have emerged, each with a different focus – such as Environmentality, Interactive Governance or Adaptive Governance. Central to the development of Adaptive Governance Theory are the resilience approach and the social-ecological system's understanding (highlighted in blue in Figure 9). Most Adaptive Governance literature is squarely situated in resilience scholarship. Governing social-ecological systems from a resilience perspective fundamentally impacts the institution's governing direction and outcome expectations. Instead of limiting change, the role of institutions is to manage and shape the ability of a system to cope with and adapt to change as well as to enable further change to happen (Chaffin et al. 2014). The most emblematic shift in thinking about what constitutes a successful social-ecological system is probably the prioritization of resilience as opposed to efficiency as an outcome, an important aspect that will be discussed in detail in Chapter 9 and Chapter 10 (Cleaver and Whaley 2018).

Adaptive Governance Theory has its origins in both the natural and the social sciences. As shown in Figure 9, in the social sciences Polycentricity Theory (political science) of the 1970's and Elinor Ostrom's Collective Action Theory (economics/political science) of the 1990's are the most important theoretical foundations. Ostrom's work on governing the commons is itself greatly influenced by her husband's (Vincent Ostrom) seminal work on polycentric governance structures in metropolitan areas. From the natural sciences, Buzz Holling's ecological systems theory (biology) represents the conceptual foundation for Adaptive Governance Theory. From this synthesis of ecological systems theory and Elinor Ostrom's work on polycentric, self-organizational commons governance, Adaptive Governance Theory emerged (Figure 9) (Partelow et al. 2020).

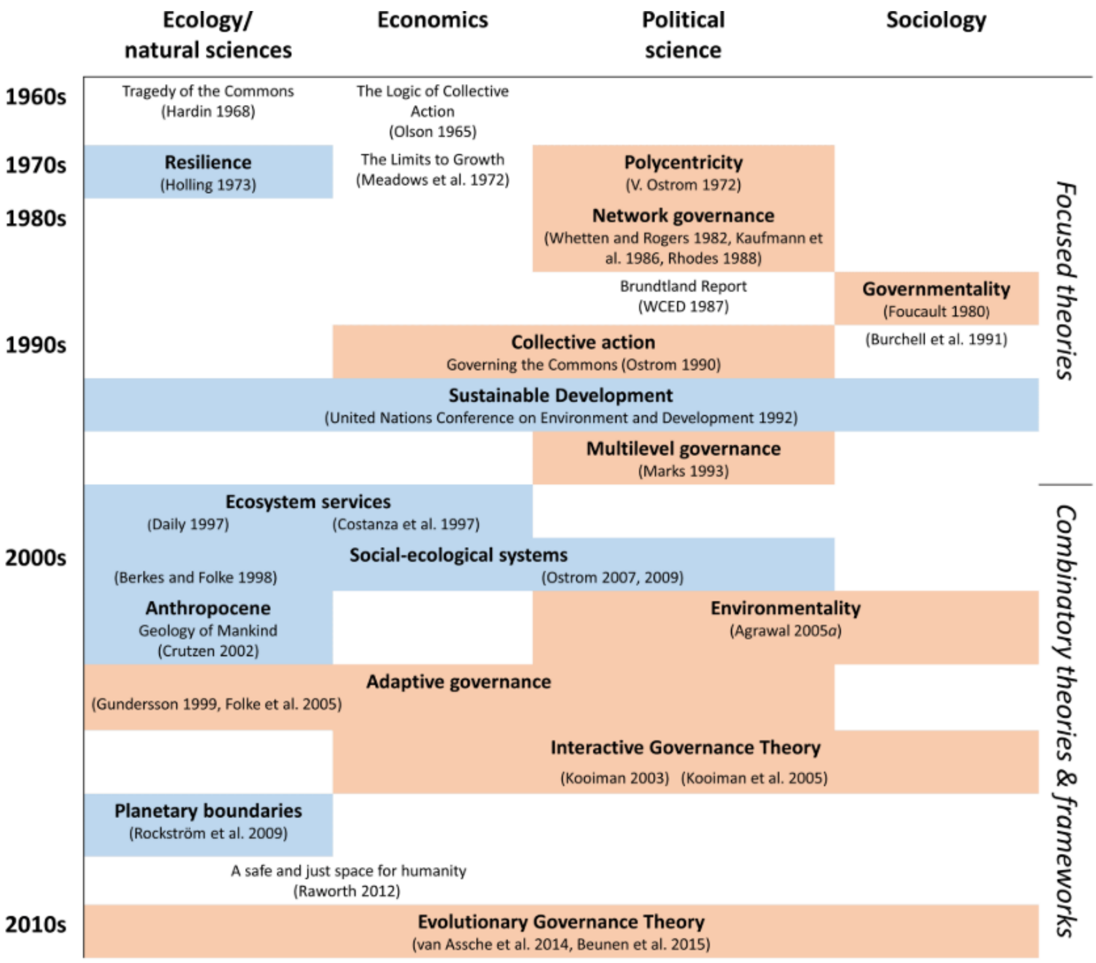

Figure 9: The evolution of environmental governance theories and their disciplinary affiliations. Theories are depicted in orange while concepts are in blue (Partelow 2020, 11).

Holling and colleagues introduced the concept of adaptive management in the late 1970's as a critique of science-based expert management of natural resources, as it did not grant enough attention to the uncertainty and complexity of ecosystems. They developed an alternative in which natural resource management was set up to be a series of experiments to improve both the outcome and the managers' understanding of the ecosystem. Over time, this led to a more general theory of ecosystem dynamics and regime phases, as well as interdependent social-ecological systems. This systems approach intersected with Ostrom's work on the social dynamics of natural resource management (Ostrom 1990; Ostrom 2005). Her research focused on traditional institutional arrangements of intensively managed resources, challenging the presumption that the tragedy of the commons could be best resolved through externally imposed expert management and identified principles or conditions that best enable adaptive governance and management (Hatfield-Dodds et al. 2007). This wariness of externally imposed expert knowledge is also present in Adaptive Governance Theory. The critique of centralized expert management does not imply that resource management should be entirely decentralized or done by non-experts. It rather advocates the position between the polar opposites of centralized, uniform, biophysical expert management and the notion of a sort of romantic agrarianism informed by tradition – it promotes the "messy" middle ground (Hatfield-Dodds et al. 2007; Partelow et al. 2020; Chaffin et al. 2014).

Adaptive Governance always stands in relation to the broader environment. Local processes are shaped by larger scale and, in the end, global scale processes that affect the dynamics of these social-ecological systems. Decisions made affect ecosystems and people far away (Liu et al. 2007). This means that simple solutions do not exist for governing complex social-ecological systems. There are no optimal, one-size-fits-all, blueprint solutions for common-pool resources (Ostrom 2008), which is why a central assumption of Adaptive Governance Theory is that governance decisions are regarded as experiments (Hatfield-Dodds et al. 2007).

A static understanding of fisheries systems, in the tradition of Gordon's open-access model, has incorrectly led to the recommendation of three idealized institutional types in the past. These "optimal" solutions developed by policy analysts are private property, government ownership or community control. While there are instances where transitions between institutional management models have produced short-term gains in efficiency, these cases diverge markedly from the overly simplified "optimal" blueprint solutions advocated by some researchers. Neither government ownership, private property nor community management is sufficient to guarantee the sustainable use of resources (Ostrom 2008; Ostrom 2005). Imposing "institutional mono-cropping" by implementing uniform institutional blueprints is not a long-term sustainable solution. Instead, institutional diversity is a key element in designing a sustainable governance system for the use of common-pool resources (Ostrom 2005; Ostrom 2012). In fisheries, institutions of private property, such as individual transferable quota (ITQ) systems, are frequently seen as optimal solutions. There are notable examples where an ITQ system has been a success story and averted the collapse of a fishery, although that success was not immediate and additionally based on various ex-post adjustments. Most countries rely on multiple institutional arrangements instead of simple ITQ systems, such as Denmark (Schuch et al. 2021). In the EU, various forms of private property, state ownership and community management exist (Carpenter und Kleinjans 2019).

2.2.1 Adaptive Governance Theory Principles

The principles of Adaptive Governance Theory aim to ensure and shape the sustainable use of common-pool resources in social-ecological systems with a focus on resilience rather than the efficiency of those systems. In the following, I will start to develop my theoretical perspective on Adaptive Governance Theory, relying on Datta and Chaffin's (2022) literature review of Adaptive Governance. I use their eight principles of Adaptive Governance as a theoretical starting point and will contrast, compare and analyze the components that are linked to its theoretical building blocks - Polycentricity Theory as well as Ostrom's Collective Action Theory:

1. Nested polycentricity
2. Inclusive participation
3. Interweaving knowledge types
4. internal and external rule enforcement
5. internal conflict resolution mechanisms.
6. Clear boundaries
7. Social-ecological fit
8. Adaptive Management

Nested polycentricity describes the decision-making authority of multiple nested centers in natural resource use, while the principle of *inclusive participation* invites diverse actors to participate meaningfully in the development of the rules governing the system. This means that not only are diverse types of actors involved in developing those rules, but also their types of knowledge as expressed in the principle of *interweaving of knowledge types*. This process is supposed to interweave local ecological, practitioners' and science-based knowledge(s) and follows an inter- but also transdisciplinary approach. Important are also forms of *internal and external rule enforcement* and *internal conflict resolution* mechanisms. The social-environmental challenge faced needs to have clear boundaries, meaning that the political, institutional, ecological and jurisdictional boundaries are well defined. The challenges need to have the right *social-ecological fit,* while formal and informal institutions need to possess the appropriate bio-geographic scale. The last principle, Adaptive Management, represents the practical implementation of Adaptive Governance Theory. As an iterative and uncertainty-embracing approach, it promotes learning through experimentation. It operates through a structured cycle of setting goals, monitoring outcomes, and adjusting objectives, thereby generating new goals over successive iterations (Datta and Chaffin 2022).

Adaptive Management is the key element in the process of operationalizing Adaptive Governance. Although it will not be specifically addressed in this work, it is still important to distinguish Adaptive Management and Adaptive Governance at this point, as both are at times used interchangeably (Datta and Chaffin 2022). Adaptive Co-Management, as one form of Adaptive Management, is a flexible community-based approach for resource management specific to a place and situation, supported by various organizations at different levels (Folke 2016; Hamelin et al. 2024). It is dependent on the collaboration of diverse actors at different levels – from local users to municipalities, regional and national organizations as well as international bodies (Datta and Chaffin 2022). While the objective of adaptive management consists in understanding ecosystem dynamics and conveying knowledge into management organizations, adaptive governance focuses on a multi-objective[1] reality in conflicts between diverse actors. Adaptive Governance is the frame in which governance decisions are made, making a distinction between the two important (Folke et al. 2005).

The principles of nested polycentricity, Inclusive participation, internal and external rule enforcement, internal conflict resolution mechanisms and clear boundaries have their origins in Ostrom's classic work "Governing the Commons: The Evolution of Institutions for Collective Action" (Ostrom 1990), for which she won the Nobel Prize in 2009. As primary theoretical contributions, it is unsurprising that Polycentricity and Collective Action Theory principles are pivotal parts of Adaptive Governance Theory. In their pioneering article on Adaptive Governance, Thomas Dietz, Elinor Ostrom and Paul Stern (2003) identified three principles of Adaptive Governance that are particularly relevant for achieving a sustainable use of common-pool resources - all of which can be found in "Governing the Commons" (Ostrom 1990). First, all actors – scientists, resource users and the interested public – should be involved in an informed discussion on the rules of the commons. This *analytic deliberation*, as they call it, builds trust, develops social capital, and lays the groundwork for conflict resolution. Dietz et al. (2003) highlight that institutions must be *nested in layers*, complex and redundant. Simple, optimal solutions that rely on one-level, centralized control or the market alone have proven not to work. Finally, a governance structure should be based on *institutional diversity*, which has its foundation in a number of decision rules that change incentives, monitor use, induce compliance and increase information (Dietz et al. 2003) .

[1] Multi-objectivity in governance refers to the explicit recognition and systematic management of multiple, often competing objectives within policy-making and institutional design, acknowledging that governance challenges require balancing diverse priorities across different scales and actor groups

Of central importance to both Datta und Chaffin (2022) and Dietz et al. (2003) are the principles of inclusive participation (analytic deliberation) and (nested) polycentricity. Institutional diversity is not explicitly mentioned in Datta und Chaffin's (2022) review, however, one can argue that it is implicitly embedded within Ostrom's principles of commons governance, where institutional diversity constitutes a foundational element (to be elaborated in Chapter 2.4). However, I am of the opinion that it is important to explicitly highlight institutional diversity as a guiding principle within Adaptive Governance Theory. Without such explicit theoretical precision, the framework loses much of its empirical applicability, potentially hindering the EU's governance system from adapting to climate change in an ecologically and socially sustainable manner.

The explicit principles of Adaptive Governance Theory that go beyond Polycentricity and Collective Action Theory are adaptive management (principle 8) and interweaving knowledge types (principle 3) (Datta and Chaffin 2022). As already discussed, adaptive management is not further explored. However, the principle of interweaving knowledge types takes on a significant role in the theoretical conceptualization of this dissertation.

2.2.2 Interweaving Knowledge Types

I argue that for an in-depth understanding of regional as well as local Climate Change adaptation solutions, as is the case in the brown shrimp fishery, local social-ecological and practical knowledge inclusion is necessary. Combining different knowledge systems enhances the capacity to deal with uncertainty in complex adaptive systems (Folke 2016). Local actors that interact with and whose livelihood is dependent on ecosystem resources have an intimate knowledge of ecosystem dynamics and the associated management practices (Folke et al. 2005). In particular, local communities have historically recognized that coexisting with gradual and rapid change is necessary, leading them to develop formal or informal institutions that have a knowledge base on how to respond to environmental impacts. This allows disturbances to enter at smaller scales, thereby precluding large-scale collapse. These practices are the result of local experiences with crises, change and the realization that not all outcomes can be anticipated. These crises, whether perceived or real, can trigger knowledge generation and learning processes (Folke et al. 2005; Folke 2016; Ostrom 2008; Ostrom 2005), but what are the processes that lead to them?

Michael Polanyi's concept of tacit knowledge (Polanyi 2009) is a crucial component in understanding environmentally oriented decision-making by way of feedback relations between mental models and human-environment relations. A starting point for understanding the concept of tacit knowledge is

Polanyi's simple notion that humans can know more than they can tell. In its most simple and intuitive form, this concept represents acts of physical motion. Polanyi (2015, 51) argues that *"a skilful performance is achieved by the observance of a set of rules which are not known as such to the person following them*". For him, there is no reason to fundamentally distinguish between practical and theoretical knowledge. Polanyi interprets practical knowledge as the basis for all explicit knowledge. To him, completely explicit knowledge is unthinkable as he sees the body as the instrument through which we gain all our internal and external knowledge, intellectual or practical. For example, most fishers are not going to be aware of all the forces that enable their boats to maneuver or the electronic systems that make them function. The point being that one cannot separate practical from intellectual knowledge. Within the context of integrating different knowledge types into decision making processes of a governance system, Polanyi's approach provides food for thought. Is there a need to change how knowledge is generated, our epistemology?

Practical knowledge plays an important role if we want to understand our system of study. Rather than just looking at knowledge acquisition from an individual's point of view, in this dissertation, the concept of tacit knowledge is applied to the brown shrimp fisheries by integrating scientific (explicit) and local social-ecological (practical) knowledge. The aim is to gain a deeper understanding of the brown shrimp social-ecological fisheries system and for this to be achieved, we need to include practical and scientific knowledge. Therefore, integrating practical knowledge is not only necessary for a refined understanding of the system, but also of importance to realize adaptation options in a rapidly and unpredictably changing world. But why is Polanyi's tacit knowledge relevant both from an individual and a system's perspective?

From an individual perspective, our actions within or towards social-ecological systems are not solely determined by explicit rules. Rules are internalized or embodied into practice, only then can they become intuitive. This has fundamental consequences for environmental policy (Kaaronen 2018). If we follow Polanyi and assume that practical and intellectual knowledge are both fundamentally ingrained in the tacit domain, then "*any feat of environmental behavior is not fundamentally rooted in rational explicit knowledge of nature, but rather in our tacit belief frameworks and embodied experience in relation to nature*" (Kaaronen 2018, 23). The way we ascribe meaning to the environment is the result of frameworks that we have internalized and to which we are habituated. The way we dwell in and experience the world tends to be a projection of our conceptual worldview that undergoes permanent change. Similar to the example of a fisher who is not fully aware of the tacit knowledge of steering her ship, a person is not going to be explicitly aware of the tacit metaphysical framework from which she attaches meaning within and towards a social-ecological system. Our environmental actions are grounded in the fairly static tacit metaphysical framework which we, through culture, ecology and a set of rules, have embodied and attach meanings to the world. Therefore, our belief frameworks manifest our actions towards nature and the environment while we simultaneously dwell in them (Kaaronen 2018).

The impact of failing to integrate practical, local social-ecological knowledge is therefore twofold. First, from an individual's perspective, perception strongly influences how environmental policies are implemented and adhered to. Secondly, from a system's perspective, without the inclusion of practical knowledge, we simply fail to build a comprehensive policy portfolio that acknowledges and is aware of the potential local impact of proposed policies. An example of such a failure is the EU Commission's "EU Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries". By not integrating fisher's practical knowledge, the EU action plan failed from an individual as well as a social-ecological systems perspective to establish a sustainable fishery policy. In Germany, the plan led to widespread outrage in the industry and a demonstration by brown shrimp fishers in February and March of 2023 (personal attendance). A ban of mobile bottom trawling in MPAs would have meant an end to the German brown shrimp fishery, as a majority of inshore fishing ground landings stem from within the national parks of Schleswig-Holstein or Lower Saxony (Örey et al. 2025). It would most likely have led to a collapse of the entire fishery and the entire brown shrimp supply chain along the German coast. The bottom trawling ban would be a broader and structural change that would also include and affect communities and wholesalers. The top-down approach, seemingly based on just explicit knowledge, shows at best a simplistic and naïve view of fishing and marine ecologies [2]. This example shows that the integration of different knowledge types is necessary in developing a sustainable policy, but also that the inclusion of diverse actors and knowledge systems needs to be based on a bottom-up rather than a top-down approach if they are to be successful.

2.3 Moving from Epistemology to Ontology

Local social-ecological knowledge inclusion needs to come, as we have seen in the previous chapter, with a change in the way the governance system functions, and not just as a simple addition to the way knowledge about fisheries is produced. Michael Polanyi proposes that embodied and purely mental modes of knowing are interconnected at a fundamental level and that there is no truly explicit knowledge (Polanyi 2009; Polanyi 2015). Following this, Kaaronen (2018) merges insights from

[2] A more detailed analysis of the EU action plan can be found in Chapter 8.3.

Polanyi's epistemology with process ontology to form a framework for environmental policy development.

(H2*) Adaptive Governance implementation needs to entail incremental change in fisheries political governance rather than just a change in knowledge acquisition of fisheries – a move from epistemology to ontology*.

Following a relational complex adaptive systems approach (Chapter 2.1.1), process philosophy "*emphasizes the ontological primacy of process over substance*" (Kaaronen 2018, 183) and takes on the current bifurcation of nature that is predominantly a result of the substance-based metaphysical framework of western philosophy. Reordering these priorities allows process ontology to serve as a framework for rethinking and reconstructing the human–nature divide, which significantly shapes governance strategies for sustainability under accelerating environmental change.

In process philosophy, no ontological distinction between subject, object or predicate is made, or as Kaaronen (2018: 9) puts it: "*nature, it follows, is an integrated whole of emergent processes*". In most of the West, humans currently distinguish and separate the environment into biological, physical, chemical, cultural or psychological aspects. Process ontology aligns particularly well with social-ecological systems research, as it conceptualizes change as the constitutive characteristic of all systems of reality. Actors are not ontologically separated from their environment nor from their actions. Indeed, substance-based philosophy neglects - or at least downplays - the role of agency, understood as the capacity to act or to manifest action, even though substance itself becomes meaningless in the absence of action (Hertz and Mancilla Garcia 2021; Kaaronen 2018). Therefore, if entities only appear to be real when they interact, why do we still emphasize their separateness?

For "processists" such as Rescher (1996) or Whitehead (1969), it is thus better to describe things as what they *do* and not what they *are*. The difference between subject and object is in degree rather than in kind, meaning that knowledge for processists remains fundamentally incomplete, as reality is always in a process of becoming, while static descriptions remain imperfect and only heuristically useful. However, processists agree to work with this incompleteness pragmatically. Process philosophy does not denounce substance, it rather reconceptualizes stable things *"as static 'stability waves' in a dynamic 'sea of process'"* (Kaaronen 2018, 190). Rather than discarding of substance altogether, processists reduce its ontological status to a pragmatic one. Instead of a change in explicit language, it is an adjustment to how one relates to the world (Kaaronen 2018).

Substance ontologies, on the other hand, give priority to stability and equilibrium thinking over change (Hertz et al. 2020). A substance perspective makes it hard to imagine social-ecological systems because it conceives SESs as social and ecological entities that exist before producing social and ecological outcomes together (Hertz et al. 2020). Social-ecological and cognitive systems are, in western thinking, understood as ontologically separated. To achieve a sustainable transition, there needs to be a change in both macro and micro (cognitive) systems – something that is all too often forgotten (Kaaronen 2018). Process Philosophy has its strength in its intrinsic dynamism, enabling an application and interpretation in either its ontological (strong) or epistemic (weak) form. At the very least, process philosophy can be conceived as an epistemic tool for rethinking the basic assumptions that our unsustainable culture is based on (Kaaronen 2018).

In fisheries, the focus on harvesting exemplifies a substance ontology. Fishing policy puts emphasis on harvesting much more than pre- or post-harvesting activities, although harvesting represents only one aspect that determines fishers' choices (Arton et al. 2024). A *beyond harvesting approach* would offer the opportunity to see that fishing includes pre- and post-harvesting activities such as negotiations with wholesalers, accounting work or meal preparations (Basurto et al. 2020). Modeling by Arton et al. (2024) has shown that fisher's goals determine the effect that a policy has, highlighting the importance of a beyond harvesting approach as not all goals are related to harvesting quantities. A policy may trigger or prevent a tragedy of the commons, therefore showing the need to understand fisher's perceptions and to engage them. Only by changing the conceptual framework in which fishers' dwell can their goals be changed. But apart from these aspects, a beyond harvesting approach opens-up a different perspective, understanding and framing of the respective social-ecological system.

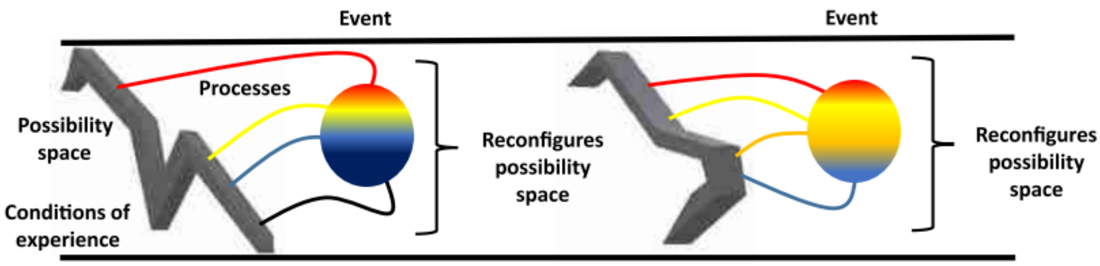

Figure 10: Being as a sequence of events - being is conceptualized as a temporally unfolding sequence of events, each emerging from a possibility space that is conditioned by historically and situationally specific conditions of experience. Within this possibility space, multiple processes originating from different realms interact, but only some are realized in any given event. The realization of an event is therefore contingent upon both the configuration of the possibility space and the perspective of the experiencing being. Once realized, events feed back into and reconfigure the conditions of experience and the possibility space itself, thereby shaping future processes and event trajectories (Hertz et al., 2020, 6).

A process ontological, theoretical dissection of a beyond harvesting approach is imperative for this inherently different understanding of social-ecological systems. Within systems, the interaction of processes with other processes give rise to "events" (Figure 10).While processes and events are essentially understood as the same thing, events differ as they are experienced by a being (Hertz et al. 2020). Entities or beings are in this context conceived as a sequence of events or, as Hertz et al. (2020) put it, "*entities exist over a sequence of events that are brought about by recurrent processes*" (Hertz et al. 2020, 332). Therefore, entities are understood as a combination of events and exist within possibility spaces. Within these spaces, potential processes exist that can enter an event. Any conceivable event exists within these possibility spaces of ever-changing process possibilities and its preceding events (Figure 10).

To understand a possibility space, the history of an event matters. Being in this context means the continuous unfolding of events in concert with perpetually changing possibility spaces. Fishing constitutes such an event, as it encompasses a set of processes experienced by humans. Multiple processes—ranging from stock dynamics and fuel prices to the dynamics of the family unit—converge to produce what is ultimately recognized as the event of fishing. Taking a beyond harvesting perspective, a process-based approach to fishing yields fundamentally different results compared to conceiving of fishing as harvesting. Framing fishing as harvesting results in different possibility spaces and inherently different conditions of experience. Consequently, policy proposals are more prone to fall short of ecological and social sustainability targets if they misinterpret or overlook fishers' actual goals and motivations. As shown by Arton et al. (2024), such misjudgments can severely constrain a policy's sustainability potential and may catalyze a tragedy of the commons. Therefore, an ontological approach and perspective need to be taken when it comes to designing policy. This means that institutional and policy frameworks must move beyond static system conceptions and instead recognize the non-linear, dynamic, and self-organizing nature of social-ecological systems, along with their multiple spatial and temporal scales. Institutional design processes need to be understood as experiments with parts that is, rules, of the current system. Policy design is the search for a combination of rules that work effectively in a particular setting, while policy changes are experiments that are based on informed expectations of outcomes[3].

2.4 Moving between Lower and Higher Levels of Governance

After having analyzed the Adaptive Governance Theory principle of diverse types of knowledge, further establishing this dissertation's research ontology and epistemology, this chapter focuses on the role of Ostrom's Collective Action Theory and Polycentricity Theory – highlighting the centrality of feedback processes at and between lower and higher levels of governance.

(H3) Adaptive Governance enables Climate Change adaptation through iterative learning, feedback and implementation processes at lower and higher levels of governance.

[3] In much of the literature, the term *experiment* is used in a largely colloquial sense rather than being grounded in theory. What is described as experimentation typically reflects processes shaped by informed expectations and path dependency. Moreover, policy-making—at least within democratic systems of the European Union—takes place within institutionalized systems of checks and balances, which limit the extent to which individual actors can advance policy ideas without reference to existing constitutional, political, or policy frameworks.

In the next two subchapters, I will first discuss the theoretical contributions of Elinor Ostrom's Collective Action Theory (Ostrom 2005) and Polycentricity Theory (McGinnis 2016) to Adaptive Governance Theory. Drawing on Collective Action Theory, I will focus on the lower levels of governance and their self-management capacity. The focus for higher levels of governance will be Polycentricity Theory and the empirical evidence with regard to its role in the governance of common-pool resources, as an institutional design principle that connects higher and lower levels of governance. The sharp distinction that is made between the two theories, their influence and their interconnections, is done for analytical purposes and is an artificial one. Ostrom's Collective Action Theory has been greatly influenced by Polycentricity Theory, as shown in Chapter 2.2.1, and therefore the theories fold into one another.

2.4.1 Collective Action Theory

Elinor Ostrom, in her work on sustainable and community-based management of common pool resource systems, describes eight institutional design principles (Ostrom 1990). She used the term "design principles" not to imply that resource users had these principles in mind when developing systems with long lasting resource extraction schemes, but that they characterize institutional regularities that are present in them (Ostrom 2010). An analysis of over 100 case studies revealed that in roughly two-thirds of the cases, successful—i.e., robust—resource regimes were characterized by the presence of most of Ostrom's design principles, whereas failed regimes generally were not (Ostrom 2010). These design principles [4] "*describe the broad structural similarities among those self-organized systems that have been able to adapt and learn so as to be robust to the many social, economic, and ecological disturbances that occur over time*" (Ostrom 2005, 21). She advocates for rules that fit the bio-physical and social realities of the social-ecological system at hand (Ostrom 2005). These best so-called practices are (Ostrom 2010):

1A. **User Boundaries**: Well-defined and locally acknowledged boundaries distinguish between legitimate users and non-users.

1B. **Resource Boundaries**: Clear demarcations separate a specific common-pool resource from the broader social-ecological system.

2A. **Congruence with Local Conditions**: Rules for resource use and management align with the unique social and environmental context of the locality.

[4] Rather than using the term design principles, as Ostrom noted herself, they may be better called "best practices" of sustainable, community-based management of common pool resources (Ostrom 2010).

2B. **Appropriation and Provision**: Rules governing resource use match those governing resource replenishment; the sharing of costs corresponds to the sharing of benefits.

3. **Collective Choice Arrangements**: Most individuals affected by a resource regime have the authority to participate in the formulation and adjustment of its regulations.

4A. **Monitoring Users**: Accountable individuals or user representatives oversee the levels of resource use and provision.

4B. **Monitoring the Resource**: Accountable individuals or user representatives monitor the condition and health of the resource.

5. **Graduated Sanctions**: Penalties for rule violations begin mildly but escalate for repeated infractions.

6. **Conflict Resolution Mechanisms**: Swift, cost-effective mechanisms are in place at the local level to resolve disputes among users or with authorities.

While design principles 1 through 6 relate to lower levels of governance, namely self-organization, principles 7 and 8 target higher levels of governance.

7. **Minimal Recognition of Rights**: The government acknowledges the rights of local users to establish their own governance rules.

8. **Nested Enterprises**: Governance structures operate across multiple nested layers when a common-pool resource is intricately linked to a broader social-ecological system.

Ostrom opens up new perspectives by distinguishing between lower and higher levels of governance (Ostrom 1990). Three levels of governance should be distinguished: the operational and collective action level (lower levels) as well as the constitutional level (higher level). On the operational level, design principles affect the practical choices that actors, either individuals or representatives of groups, can make. At the collective choice level, rules determine which norms and strategies are available to specific actors at the operational level and how they can be changed. At the constitutional level, regulations determine how rules at lower levels can be changed and who is empowered to do so (McGinnis and Ostrom 2014). Figure 11 shows, using the example of the brown shrimp fishery, the different roles that actors occupy, placing them at the constitutional, collective action or operational level.

Ostrom's design principles one to six are part of the lower levels of governance and are congruent with the adaptive governance principles inclusive participation, social-ecological fit, clear boundaries, internal and external enforcement and internal conflict resolution mechanism (Chapter 2.2.1). I equate the adaptive governance principle "social-ecological fit" with Ostrom's second principle "congruence with local conditions" (2A) and "Appropriation and Provision" (2B). The differences between them are semantic rather than substantive. The six lower level governance principles (Ostrom 2010) will be used to analyze and examine the self-management capacities of the German brown shrimp fleet with regard to climate change adaptation and sustainability (Chapter 6.2), as they offer the possibility of a more detailed analysis compared to the ones commonly described in Adaptive Governance Theory.

Ostrom's "minimal recognition of rights" and "nested enterprises" on the other hand, target higher levels of governance, such as the Member State or EU level. While Ostrom's (2010) "nested enterprises" and Adaptive Governance's "nested polycentricity" (Datta and Chaffin 2022) are qualitatively the same, a principle equivalent to Ostrom's "minimal recognition of rights" is not explicitly mentioned in Adaptive Governance Theory. She goes further than commonly is explicated in Adaptive Governance Theory by postulating that the government needs to acknowledge the right of local users to establish their own governance rules (design principle 7). It could be argued, however, that a minimal recognition of rights is implied in Adaptive Governance Theory's principles within the principle of nested polycentricity, further discussed in the next section.

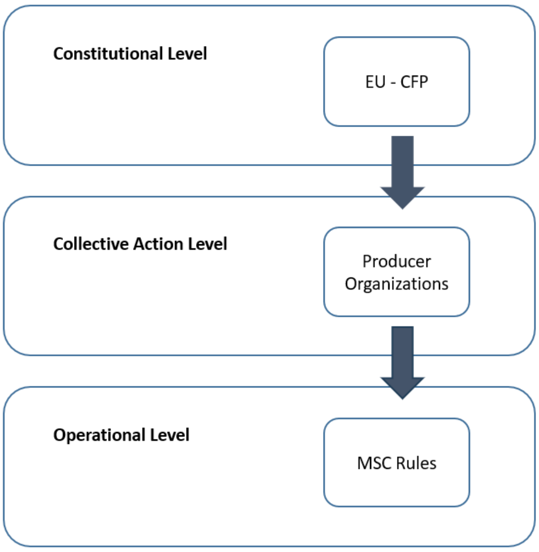

Figure 11: The different governance levels (constitutional, collection action & operational) in the brown shrimp fishery (adapted from Steenbergen 2017)

2.4.2 Polycentricity Theory

A significant gap exists in the understanding of whether, why, and how polycentric governance impacts the long-term capacity of policy actors to address collective action problems (Baldwin et al. 2023). This dissertation addresses this gap and tries to close it by adopting a long-term and process-based perspective. The focus will be on feedback mechanisms between lower and higher levels of governance, while taking into account specific ecological and institutional contexts.

The concept of polycentricity traces its roots back to Polanyi (1951), who introduced it as the idea of self-organization within systems – scientific, political and economic. It describes multiple independent decision centers that operate autonomously yet remain interdependent. The was first applied in the realm of political systems in 1961. Vincent Ostrom, Charles Tiebout, and Robert Warren (OTW) coined the term "polycentric political system" to describe a form of metropolitan governance characterized by multiple, overlapping, autonomous, yet interconnected decision-making centers (Ostrom et al. 1961):

““Polycentric” connotes many centers of decision making that are formally independent of each other. Whether they actually function independently, or instead constitute an interdependent system of relations, is an empirical question in particular cases. To the extent that they take each other into account in competitive relationships, enter into various contractual and cooperative undertakings or have recourse to central mechanisms to resolve conflicts, the various political jurisdictions in a metropolitan area may function in a coherent manner with consistent and predictable patterns of interacting behavior. To the extent that this is so, they may be said to function as a “system.” (Ostrom et al. 1961, 831)

Baldwin et al. (2023) provide a thorough and up-to-date literature review on polycentric governance by doing a systematic review of 179 empirical, peer-reviewed articles. They both provide empirical support for positive and negative features that are theorized to be part of polycentric governance and identify shortcomings in the literature. Their analytical distinction between processes and structure brings Polycentricity in line with the previously outlined process ontological approach (Chapter 2.3) and connects both aspects.

The bulk of research on polycentric governance (PG) has primarily focused on its operational aspects, such as its structure and processes, and the interactions between them. These studies often evaluate how polycentric structures and processes influence the overall performance of the governance system (Baldwin et al. 2023). However, many of these studies overlook the specific social-ecological and institutional contexts within which a polycentric governance system is situated. Most research adopts a short-term perspective, offering only a glimpse into the performance of polycentric governance systems, disregarding the evolution of a system and consequently its outcomes. Additionally, there has been limited exploration of feedback mechanisms that could instigate evolution and adaptation within polycentric governance systems. Consequently, a significant gap exists in the understanding of whether, why, and how polycentric governance impacts the long-term capacity of policy actors to address collective action problems (Baldwin et al. 2023).

Many scholars view polycentric governance as normatively desirable, considering it a solution to governance systems that grant insufficient influence to local communities in matters affecting them (Marshall 2009; Andersson and Ostrom 2008). PG's perceived normative desirability attracts a diverse range of researchers. This has also led to the development of several case studies that assume rather than empirically examine whether PG will yield favorable outcomes (Baldwin et al. 2023). Furthermore, many studies lack adequate contextual information to facilitate systematic comparison across cases.

Consequently, a substantial body of research exists on polycentric governance that is characterized by high internal validity, but that offers limited generalizable insights into why polycentric governance succeeds in some instances while failing in others, which makes definitional clarity of core attributes of polycentric governance so important (Baldwin et al. 2023).

Drawing on Ostrom, Tiebout and Warren's definition, Carlisle and Gruby (2019) define Polycentric Governance as: *"(1) many autonomous units formally independent of one another, (2) choosing to act in ways that take account of others, (3) through processes of cooperation, competition, conflict, and conflict resolution*." Stephan et al. (2019) add on to Ostrom, Tiebout and Warren's original definition and identify eight dimensions which Baldwin et al. (2023) re-organize into three categories (Table 2): dynamic processes, structural characteristics and outcomes.

Table 2: the eight characteristics of polycentric governance grouped into three characteristics – structural characteristics, dynamic processes and outcomes (adapted from Baldwin 2023, 4)

Structural Characteristics ➡	Dynamic Processes ➡	Outcomes
• Multiple decision centers • That are autonomous • With overlapping authority • Operating within a set of overarching institutions	• Multiple processes of mutual adjustment between decision centers • Low entry and exist cost for decision centers	• Emergent patterns of behavior, interactions and outcomes • Emergent and effective coordination throughout the system as a whole

The majority of polycentric governance definitions, however, predominantly revolve around structural and process-oriented elements. The structural attributes of polycentric governance are readily observable, making them a convenient focus for analysts in case identification and empirical analysis. These characteristics encompass the extent to which polycentric governance grants authority and autonomy to local decision centers for self-governance. Additionally, they illuminate the ways in which local self-governance may be either supported, undermined, or influenced by decision centers operating at higher levels of governance (Baldwin et al. 2023). Polycentric governance, however, cannot be solely defined by structural relationships as a functional polycentric system necessitates decision centers that take each other into account through various interrelating processes — competitive, cooperative, conflictual, and hierarchical (Baldwin et al. 2023).

The interplay between structure and process gives rise to outputs and outcomes (Table 2). While any case of polycentric governance generates numerous outputs and outcomes, identifying which ones are most significant to study can be challenging. Scholars have taken various approaches to conceptualizing "outcomes" in polycentric governance. This is mirrored in early studies that focused on its potential to enhance citizens' satisfaction with service delivery (Ostrom et al. 1961). As polycentric governance evolved in the realm of natural resource governance, it was theorized to promote long-term sustainable use of resources (Andersson and Ostrom 2008) or adaptive capacity (Pahl-Wostl 2009; Pahl-Wostl et al. 2012). It is crucial to recognize that polycentric governance systems are woven into their respective social-ecological contexts - significantly influencing their form, processes and consequently outcome. These contextual factors also play a role in shaping how analysts define the performance of an outcome, as the effectiveness of PG systems is often evaluated in terms of their collective capacity to address intricate collective action problems (Baldwin et al. 2023). Within the context of this dissertation, it is the ability to deliver effective coordination throughout the EU fisheries system and results in emergent sustainable outcomes. But what leads to effective coordination?

Polycentric governance structures have been shown to improve climate change related challenges if effective coordination mechanisms exist (Pahl-Wostl et al. 2012). Without these coordinating mechanisms, which depend on information exchange through feedback, polycentric structures are not adaptive. This highlights the importance that feedback mechanisms within and between the different governance levels (constitutional, collective choice and operational level) play (Baldwin et al. 2023). The outcomes of interactions at different governance levels (constitutional, collective choice and operational level) are connected through and dependent on feedback loops (McGinnis and Ostrom 2014).

These feedback mechanisms between the constitutional, collective choice and operational level of governance are depicted in Figure 12. Changes at lower levels of governance, e.g., operational choice level, require changes to higher levels of governance, e.g., collective choice level.

Sustainable self-organization relies on multiple feedback mechanisms functioning across various hierarchical levels and only through this interplay self-management emerges. These mechanisms create a circular system that integrates governors and the governed, operating through decentralized decision centers - polycentric structures. These structures foster checks and balances, as well as experimentation and learning, enabling the discovery of rules at different levels that support and enhance effective self-governance. Thus, the interplay of feedback mechanisms within a multi-level hierarchy provides the foundation for functioning self-governance (Lewis and Aligica 2024), indicating that without a well-designed system at the constitutional level, self-governance is likely impossible in the long run. An example that illustrates the importance of feedback loops are two lobster fisheries in North America. Barnett and Anderies (2014) analyzed and compared the change in the lobster fishery in Maine and Nova Scotia and found that in Maine, a stronger feedback mechanism within the system existed. Fishers were able to change and modify the rules based on outcomes, while in Nova Scotia, this feedback mechanism was weaker and the fishery declined over time.

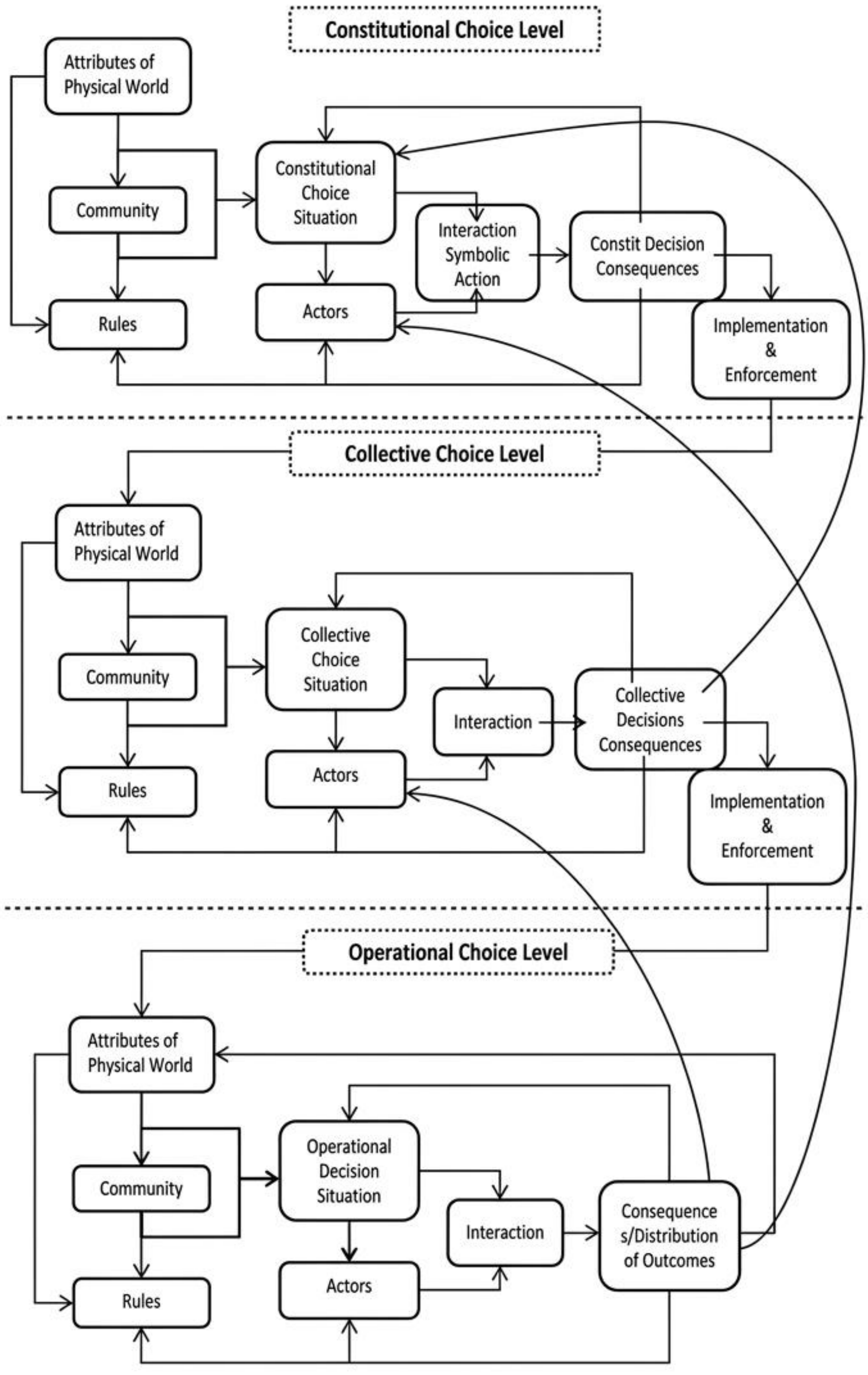

Figure 12: The interconnections and feedback processes between the constitutional level, the collective choice level and the operational level (Lewis and Aligica 2024, 14).

How an outcome is evaluated also greatly depends on whether a short- or long-term evaluation approach is taken. There are few studies that take a longitudinal approach to outcome evaluation, despite a heavy theoretical emphasis on improved governance through iterative learning. However, the process of learning over time is often not examined empirically with limited attention paid towards long-term feedback processes that influence the way in which the system changes over time (Baldwin et al. 2023). Outcomes are often measured as a single moment in time when a longitudinal, pattern over time approach would theoretically and empirically make more sense. Therefore, this dissertation adopts a pattern-over-time approach in analyzing the Common Fisheries Policy and the brown shrimp fishery.

Directly related to, and part of the feedback mechanism at an individual level, are the resource users and their perception of an outcome in a social-ecological system. Actors who are affected by an outcome have the ability to foster change in and of the system. Their perception of and perspective on the outcome has the potential to have a significant influence on the system and influences how governance rules are adhered to (Barnett und Anderies 2014). Therefore, I include fisher's perception of climate change and the brown shrimp fishery in my analysis as part of my *beyond harvesting approach,* both theoretically and methodologically. Specifically integrating the resource user's perspective on system processes changes the behavior of the resource user within the system and can ,by extension, influence the outcome. In this case study, the sustainability of the brown shrimp fishery in the Wadden Sea.

2.5 Theoretical Integration

This dissertation is grounded in process ontology founded on social-ecological systems understanding, resilience thinking, and complex adaptive systems understanding that frame reality as dynamic, interconnected, and emergent and in which human and ecological components continuously co-evolve. In the context of fisheries, this means recognizing that fish populations, marine ecosystems, and fishing communities are interdependent and shaped by feedback loops, environmental variability, and governance structures. A purely reductionist perspective is rejected, acknowledging that fisheries systems are multiscale and nonlinear, with factors like climate change influencing both resource availability and human behavior. From an epistemological standpoint, knowledge about these systems is inherently situated, context-dependent, and partial, favoring a mixed-methods approach in both quantitative models to detect patterns (e.g. stock assessments) and qualitative insights to capture human agency, adaptation options, and institutional dynamics. Essential for understanding fisheries resilience are therefore both objective system properties, such as predator-prey relationships and subjective human interpretations, such as climate change perception. Knowledge production must therefore include and emphasize a bottom-up actor participation.

Following Polanyi (Polanyi 2009; Polanyi 2015), the inclusion of practical knowledge on an individual and system level is necessary for understanding complex adaptive systems such as the European fisheries. The impact of failing to integrate practical, local social-ecological knowledge is therefore twofold. First, from an individual's perspective, perception strongly influences how environmental policies are implemented and adhered to. Secondly, from a system's perspective, without the inclusion of practical knowledge, we simply fail to build a comprehensive policy portfolio that acknowledges and is aware of the potential local impact of proposed policies. Combining insights from Polanyi's epistemology and process ontology holds the potential to form a framework for environmental policy development and shows that not just a change in knowledge acquisition is needed, but a conceptual and structural change in the rationale of fisheries governance. A beyond harvesting approach based on a process ontological, complex adaptive systems understanding yields such a change. In this approach, not only the harvesting of stocks is considered relevant, but also other factors that impact the lifeworld of fishers - such as political and social issues.

This dissertation distinguishes, based on Ostrom (2010), three tier 2 governance levels: the constitutional, collective action and operational level. Ostrom's Collective Action Theory highlights the ability of communities to sustainably harvest common pool resources through self-management, rejecting sole reliance on external expert management (Ostrom 1990). However, institutional diversity, interconnectivity and feedback mechanisms between governance levels are also highlighted, noting that without adequate rules at higher levels of governance sustainable resource use is unlikely. Therefore, making nested polycentricity, consequently, a necessary part of a governance system.

For these reasons, the analytic focus of this dissertation is the self-management (collective action and operational level) and the Member State as well as the EU level (constitutional level), their respective roles and the feedback mechanism between them. This categorization is the common thread and logic that runs through the chapters of this dissertation.

In the descriptive analysis of Chapters 4 and 5, the role of the constitutional level actors, the EU and Germany, is described and analyzed within the context of climate change. In Chapter 6, a descriptive analysis of the self-management (collective action and operational level) of the brown shrimp fishery is done, after which an inference analysis using Ostrom's design principles is conducted, testing the sustainability of the brown shrimp fishery governance system. Chapter 7 analyzes the role of feedback mechanisms in the sustainability of a fishery from a longitudinal perspective. First, Polycentricity Theory is used to examine the EU fishery sector as a whole before examining the brown shrimp fishery. Following this, the role of feedback mechanisms between higher and lower levels of governance is discussed for the brown shrimp fishery and the impact on its future. While Chapters 4 through 7 focus on the structural characteristics of the European fisheries governance system, Chapter 8 examines the underlying fisheries rationale within the EU, adopting a path-dependency approach. The focus of the chapter lies on the role of path-dependency at the constitutional level as well as at the self-governance level for the brown shrimp fishery. These empirical analyses, descriptive and inferential, together inform the risk assessment of a fishery collapse for the brown shrimp fishery in Chapter 9. The prospective analysis in Chapter 9 is done using the Social-Ecological Action Situation Framework. The framework analyzes emergent phenomena based on an integrative social-ecological approach using so-called action situations, which can be either ecological, social or social-ecological (Chapter 3.1) - understood as an interaction context defined by human and non-human participants and the rules governing their interactions. The action situations developed in the analysis were based on an interdisciplinary, integrated theoretical understanding of Adaptive Governance Theory with a focus on the inclusion of different governance levels (EU, Germany and self-management), research on discard shrimp mortality rates, local social-ecological knowledge of fishers and the system's understanding developed in Chapters 4 through 8.

I have shown that Adaptive Governance Theory principles can significantly impact the adaptive capacity of the EU's fisheries governance to climate change based on the following reasoning: Adaptive Governance Theory principles must extend beyond a purely normative to a theoretical framework to be effectively implemented, enabling the EU to address climate change uncertainties and adapt on a large scale (H1). Rather than treating Adaptive Governance as an intuitive normative concept, a precise theoretical foundation is essential, particularly an understanding of its core principles. A key aspect of this theory is its critique of centralized expert management, which underscores the need to integrate diverse forms of knowledge. Drawing on Polanyi, incorporating practical knowledge at both individual and systemic levels is crucial for the EU to develop sustainable fisheries. Furthermore, the implementation of Adaptive Governance Theory requires more than just changes in how fisheries knowledge is acquired—it necessitates incremental shifts in political governance structures (H2). This transition moves beyond epistemological concerns to an ontological reconfiguration of governance. Simply adding local social-ecological knowledge to the existing system is insufficient. Instead, governance structures must be reconceptualized and reformed to accommodate and operationalize this knowledge. By integrating Polanyi's perspectives on epistemology with process ontology, a more robust framework for environmental policy can emerge—one that emphasizes not just knowledge acquisition but also structural and conceptual shifts in fisheries governance. Adopting a process-oriented, complex adaptive systems perspective on fisheries governance holds the potential to foster this necessary transformation. Additionally, Adaptive Governance Theory, through its principles, can also contribute to facilitating climate change adaptation by enabling iterative learning, feedback loops, and multi-level implementation processes (H3). Effective governance of common pool resources relies on feedback mechanisms both within and across different levels of governance. Polycentricity theory and Ostrom's Collective Action Theory, which add institutional insights to Adaptive Governance Theory, emphasize the importance of continuous learning and adaptive implementation across governance scales. Without structured feedback loops and regulatory interventions at the constitutional level, the sustainable management of currently unmanaged fisheries in the EU is unlikely to succeed.

Therefore, based on my theoretical analysis, I recognize the following elements of Adaptive Governance Theory as constitutive (Ostrom 2010; Datta and Chaffin 2022; Ostrom 2008; Ostrom 2005):

1A. **User Boundaries**: Well-defined and locally acknowledged boundaries distinguish between legitimate users and non-users.

1B. **Resource Boundaries**: Clear demarcations separate a specific common-pool resource from the broader social-ecological system.

2A. **Congruence with Local Conditions**: Rules for resource use and management align with the unique social and environmental context of the locality.

2B. **Appropriation and Provision**: Rules governing resource use match those governing resource replenishment; the sharing of costs corresponds to the sharing of benefits.

3. **Collective Choice Arrangements**: Most individuals affected by a resource regime have the authority to participate in the formulation and adjustment of its regulations.

4A. **Monitoring Users**: Accountable individuals or user representatives oversee the levels of resource use and provision.

4B. **Monitoring the Resource**: Accountable individuals or user representatives monitor the condition and health of the resource.

5. **Graduated Sanctions**: Penalties for rule violations begin mildly but escalate for repeated infractions.

6. **Conflict Resolution Mechanisms**: Swift, cost-effective mechanisms are in place at the local level to resolve disputes among users or with authorities.

7. **Minimal Recognition of Rights**: The government acknowledges the rights of local users to establish their own governance rules.

8. **Nested Enterprises**: Governance structures operate across multiple nested layers when a common-pool resource is intricately linked to a broader social-ecological system.

9. **Interweaving Knowledge Types:** Decision making that includes local ecological knowledge, practitioners' knowledge, and scientific knowledge.

10. **Adaptive Management:** An iterative way to manage resources that acknowledges uncertainty and encourages experimentation through a structured cycle of goal-setting coupled with monitoring and a revision of those goals

11. **Institutional Diversity:** Institutional diversity as a system element that enables resiliency through multiple institutional actors

3 Methodology and Methods

The theoretical foundation of this dissertation informs and requires a mixed-methods study based on an interdisciplinary research design that aims at practically and conceptually integrating document and semi-structured interview analysis, roundtable discussions, participant observations and biological field research to provide comprehensive and nuanced answers to the research questions. By combining these methods, the study leverages their individual strengths to open up new perspectives and facilitate the emergence of novel insights. The combination of these different approaches in analyzing the same phenomenon aims to lend the study further credibility and is done to corroborate as well as contradict findings across data sets. This reduces the bias of a single method or data source and contributes to a social-ecological perspective. A social-ecological perspective is the foundation of this research and is operationalized through the Social-Ecological Action Situation Framework.

Integrating qualitative methods such as document analysis, interview studies, participant observations and roundtable discussions with a biological regression analysis offers a comprehensive approach to research by combining substantive depth with statistical observations – combining the how and why with the what. The choice to use qualitative research methods as a guiding principle to investigate brown shrimp fisheries comes from its capacity to explore intricate social phenomena through active engagement with individuals in their respective lifeworlds. This approach was further enriched by explicitly incorporating an interdisciplinary perspective, thereby combining insights from practical and scientific knowledge to address the research questions in a more comprehensive way. From a theoretical perspective, without the inclusion of practical knowledge, we fail to build a comprehensive systems understanding that acknowledges and considers the potential local impact of proposed actions or policies (Chapter 2.2).

In this study, the document analysis provides a foundational understanding by identifying patterns, themes, and historical contexts within existing documents. Building on this, an interview study allows researchers to explore individual and collectively shared perspectives, uncovering nuanced insights that may not be found in written documents. Roundtable discussions then enrich the findings by fostering dialogue among actors, such as fishers, by encouraging the exchange of ideas and validating or challenging preliminary conclusions made by the researchers. These qualitative methods lay the groundwork for a robust regression analysis of the discard shrimp mortality rate, ensuring that statistical models are informed by real-world contexts and meaningful variables. By integrating these approaches in sequence, a more integrated understanding of complex phenomena is possible.

Brown shrimp are used as a boundary object through which climate change and climate change adaptation are approached with almost all actors involved in fisheries. Boundary objects are used as anchor points to connect multiple social worlds and to facilitate communication between them (Star and Griesemer 1989). A boundary object can be a concept, idea, or material artifact that is used by different social groups or disciplines but is interpreted differently by each of them. Despite these differences, it enables interaction, collaboration and coordination because it provides a shared point of reference (Star and Griesemer 1989) around which things, actors, processes and methods can gather and be carried out. Using brown shrimp as a boundary object ensures that the study remains interdisciplinary and balances ecological modeling with social knowledge, which makes the research more robust, contextually grounded, and useful for both scientific and policy applications. By centering discussions around brown shrimp, it becomes easier to translate qualitative narratives into actionable variables for statistical analyses and to communicate quantitative findings back to actors in a way that resonates with their lived experiences. This methodology therefore, considers and accounts for both numerical trends and the lived experiences of the actors involved in fisheries.

In the analysis of the qualitative data, an abductive process of drawing inferences was followed. This involves selecting or formulating provisional hypotheses that best explain a specific empirical case or dataset compared to alternative hypotheses and then testing it through further investigation. Abduction is a process of discovering new concepts, ideas, and explanations by being open to and identifying unexpected phenomena and insights that cannot be adequately accounted for by existing hypotheses or analytical concepts (Douven 2021). The key distinction between induction and abduction lies in their process of reasoning: both are ampliative, meaning their conclusions extend beyond what is logically contained in their premises and which makes them non-necessary inferences. Non-necessary inferences are conclusions that can be drawn from the information that is given, but are not the only possible interpretation. In other words, they are plausible or reasonable interpretations, but they are not logically required based on the available evidence. However, abduction involves an implicit or explicit reliance on explanatory considerations, whereas induction simply does not. A distinctive characteristic of abduction, which it shares with induction but not with deduction, is its violation of monotonicity. This means that certain conclusions can be inferred abductively from a subset of premises, even though those same conclusions cannot be inferred abductively from the full set (Douven 2021). To illustrate these aspects: Two fishers, Tom and Karl, had a serious falling out last year over fishing territories. However, they were just seen working together on the same boat. Given these two premises alone, one might reasonably infer that they have reconciled and are now on good terms again. However, now we add a third piece of information: Tom and Karl are among the few remaining independent fishers in their region and were recently forced into a producer organization agreement by new fisheries regulations. With this additional premise, the original inference—that they are friends again—may no longer be warranted. A better explanation for their collaboration could be that they are working together out of necessity rather than friendship. Their cooperation may be purely strategic rather than a sign of renewed friendship. This demonstrates how adding a new piece of context can shift the best explanation and change the inference one initially drew. In sum, abduction allows the researcher to identify surprising elements within the data and offers explanations that reconcile empirical evidence with existing theories. Through an iterative engagement, the analysis moves beyond mere description, thereby enabling an interpretive depth that integrates data and theoretical constructs (Douven 2021).

The following section is going to give a detailed account of the rationale informing the methods described above, as well as the data collection process and the analytical steps that were taken during the research process. The methods are going to be set in relation to the theoretical foundation of this dissertation when possible. First (Chapter 3.1), I am going to explain the approach as well as the analytical frameworks used (Social-Ecological Systems Framework & Social-Ecological Action Situation Framework), followed by (Chapter 3.2-3.3) the qualitative document and interview data collection and analysis as well as the roundtable discussion groups (Chapter 3.4). Then (Chapter 3.5), I outline in detail the sampling and data collection as well as the logistic regression analysis applied to my biological data – the rate of immediate mortality of discard shrimp. Finally (Chapter 3.6), I explain why the mixed-method, interdisciplinary approach chosen for this case study is innovative, theoretically substantive and produces richer sets of data through integration.

3.1 Analytic Frameworks

The methodological approach of this study was considerably shaped by the complex adaptive systems thinking (Chapter 2.1.1) and process ontological (Chapter 2.4) systems understanding of fisheries that formed an inter- and transdisciplinary perspective to generating data. Process ontology fits especially well with social-ecological systems research, as it frames change as the constitutive characteristic of a system. The framework through which the EU's fisheries governance system, and specifically the brown shrimp fishery, is analyzed reflects this by being fundamentally grounded in a complex adaptive systems understanding.

Schlüter et al. (2019) developed the Social-Ecological Action Situation Framework (SEAS Framework) as an analytical tool to capture emergent phenomena in social-ecological systems. The framework follows a complex-adaptive system approach by emphasizing relationally, context dependency, self-organization, dynamism and complex causalities and therefore fits well with this research ontology. The Social-Ecological Action Situation Framework builds on the idea of an action situation, providing a conceptualization of social-ecological systems that emphasizes interactions between social and ecological components and their connections across different levels, thereby prioritizing processes over substances (Chapter 2.4). The goal of this framework is to facilitate the formulation of hypotheses about configurations of action situations that hold the potential to explain the emergence of social-ecological phenomena. The specific configuration of action situations for any emerging phenomena under study is guided by theory. The action situations in the analysis of the potential brown shrimp fishery collapse (Chapter 9) were based on Adaptive Governance Theory, with its focus on the interplay between governance levels and the integration of different knowledge systems. The framework draws on resilience thinking (Chapter 2.1), which views social-ecological systems as complex, adaptive, and deeply interconnected (Folke 2016). It also incorporates the concept of action situations, understood as an interaction context defined by human and non-human participants and the rules governing their interactions, as outlined in Ostrom's Social-Ecological Systems framework[5] (McGinnis and Ostrom 2014). Schlüter et al. (2019) expand Ostrom's Social-Ecological Systems framework to better enable interdisciplinary analyses of emergent phenomena, allowing for a social-ecological perspective. Their key innovation consists of the introduction of two new types of action situations: social-ecological action situations and ecological action situations. Social-ecological action situations capture the relationships and interactions between humans and non-human entities that underpin and give rise to emergent phenomena. Ecological action situations focus on interactions among ecosystem components that can either constrain or enable social-ecological action situations (Figure 13). The idea of the framework is based on the assumption of multiple interconnected layers of processes. At the foundational level are interactions between individual or collective actors and ecological entities, which then give rise to an action situation (Figure 13). To analyze and understand an emergent phenomenon, the interactions and contexts deemed theoretically or empirically relevant are heuristically selected and conceptually represented as action situations. This is done for brown shrimp analysis (Chapter 9), which is based on an extensive systems analysis of the fisheries governance at the European and Member State level (Chapter 4-5), the analysis of the self-management plan (chapter 6) as well as the role that polycentricity in brown shrimp fisheries (Chapter 7) and ideology that underpins the European fisheries governance (Chapter 8). In addition, Adaptive Governance Theory, with its focus on the interplay between governance levels and the integration of different knowledge systems, informed the specific configuration of action situations that were chosen. Each action situation is defined by its components, actors, governing rules and other factors shaping the interactions. The outcomes of one action situation can influence the rules, structures, or participants of another action

[5] making, the SEAS framework is compatible with the SES framework

situation through feedback processes. These meso-level influences are depicted as links connecting different actions situations.

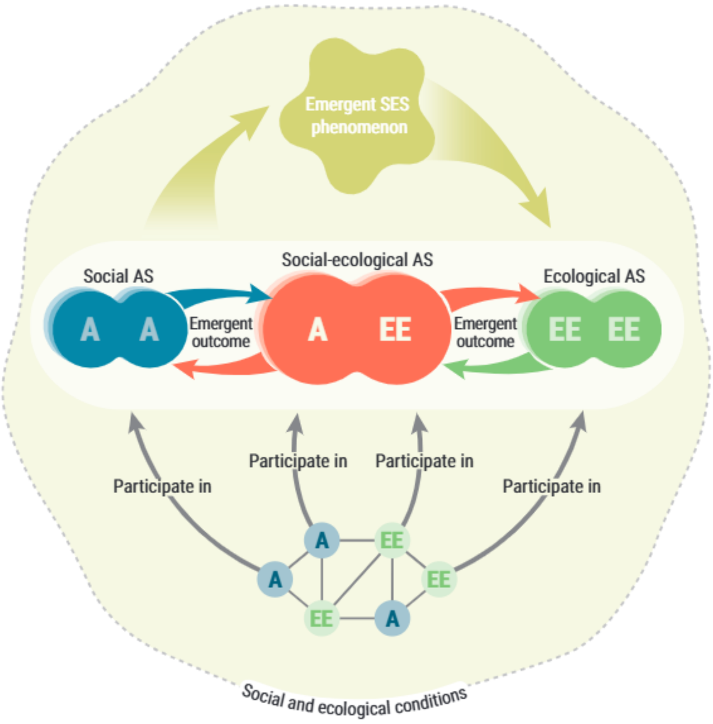

Figure 13: A generic conception of the Social-Ecological Action Situation Framework. A = individual and collective actors, EE = ecological elements (Biggs et al. 2021, 14)

Both human actors and ecological entities possess agency, defined as the capacity to act or manifest actions. However, the nature of their agency differs. The intentional behavior exhibited by humans versus the response to environmental stimuli observed in ecological entities is not the same (Latour 1993; Latour 2013). Human actors can intentionally and reflexively respond to changes in social-ecological system outcomes, making these outcomes partially dependent on an individual's cognitive processes. In contrast, ecological or biophysical entities primarily respond to information or material feedback from their surrounding environment. It is important to note here that the Social-Ecological Action Situation framework does not impose any specific stance on the ontological differences between human and non-human actors/entities or the underlying concepts of agency attributed to ecological entities. Instead, it encourages researchers to clearly articulate the position they adopt in their analysis regarding their theoretical assumptions, with the aim of eradicating any implicit theoretical assumptions. My conception of agency used within the context of the action situation does not adhere to any specific conception of human behavior, such as the boundedly rational actor (McGinnis 2011, 2014). Such a conception acknowledges that actors vary in their interests, motivations, beliefs, interact within social or social-ecological networks, and hold the capacity to intentionally choose whether to follow or modify the rules that structure their interactions. It is, furthermore, important to note that the Social-Ecological Action Situation framework does not advocate a particular stance or functional perspective on whether outcomes are driven primarily by the rules governing interactions, the agency of the participants, or a combination of both. It rather enables the use of different theoretical perspectives when analyzing emergent phenomena (McGinnis 2011, 2014).

I have adapted the terminology of the Social-Ecological Action Situation framework to better reflect a process ontological approach (Chapter 2.4) – as seen in Figure 14. Processes interact with one another, collectively giving rise to events. Essentially, processes and events are identical in nature - the distinction here lies in the perspective. Events are simply subsets of processes that are experienced by a conscious being, setting them apart from the broader set of processes (Hertz et al. 2020).

Rather than referring to action situations, I am going to use the terminology ecological and social action situation "processes". These processes jointly give rise to social-ecological action situation "events". These, in turn, give rise to an emergent phenomenon. This phenomenon then alters the possibility space from which ecological and social processes emerge (Figure 14).

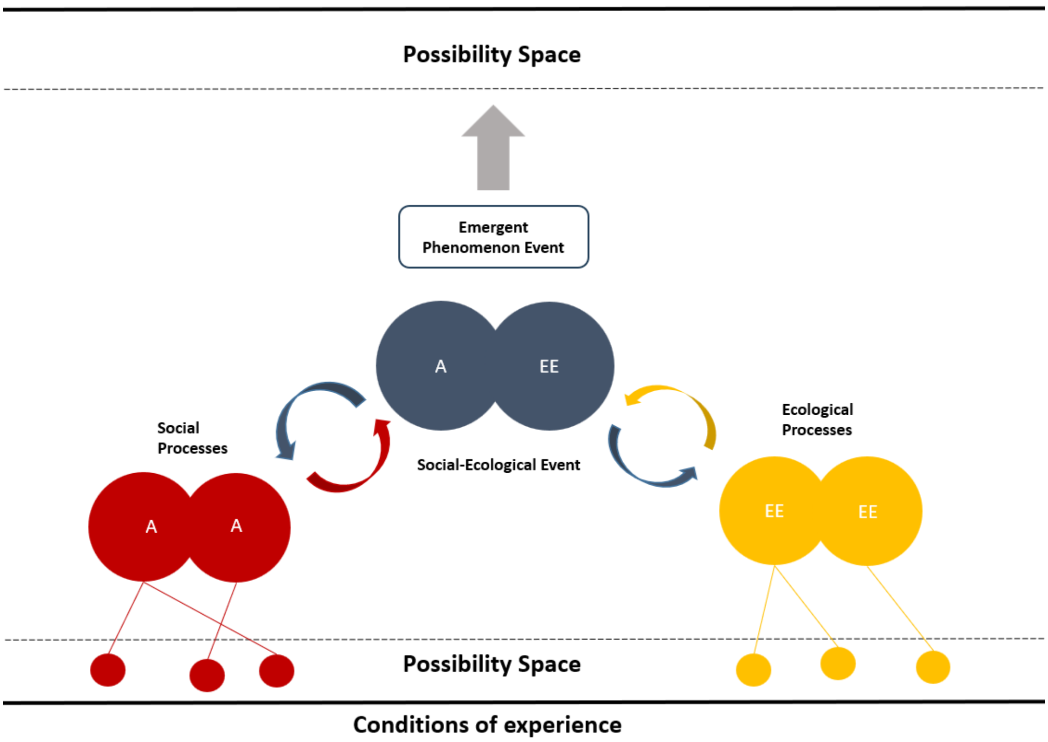

Figure 14: Integration of process ontological elements (for details see Figure 10) into the Social-Ecological Action Situation Framework (for details see Figure 13)

A social-ecological action situation process is generally characterized by human actors, ecological entities and the social and biophysical rules and structures that govern their interactions. Human actors in a social-ecological action situation can, for example, include individuals, groups, or organizations—such as resource users, monitoring agencies or communities—that interact with components of an ecosystem. Ecological entities encompass any element of an ecosystem, such as a fish stock in a coastal area that both impacts and is impacted by human actors (Biggs 2021b).

A social action situation process is defined by human actors, their capacities, and the rules, structures and actions that govern their interactions. An actor in an action situation is conceived as an individual that holds a position, possesses certain information, and exercises a degree of control, while the interactions between participating actors are guided by sets of rules and their knowledge thereof. These interactions produce outcomes, such as the creation of a new rule or a modification of existing rules. Simultaneously, these rules structure a social action situation and may be reflexively adjusted based on evaluations of outcomes (Schlüter et al. 2019).

An ecological action situation process is defined by the participating ecological entities, their attributes, and the biophysical rules that govern their interactions. Ecological entities can include individual organisms, groups or populations of organisms. These entities possess attributes like spatial distribution, productivity, growth rates and receive information which cause them to interact with other entities. Examples of interactions among ecological entities include predation, competition for resources, recruitment and disease. These interactions lead to outcomes, such as changes in population size through predator-prey dynamics, that can have both short- and long-term consequences for ecological entities. An ecological action situation is governed by biophysical rules such as the climate, food web structure or anthropogenic impacts (Schlüter et al. 2019).

It is important to highlight that the distinction between social, ecological and social-ecological action situations is done for analytical reasons. All human action is embedded in and interconnected with biophysical environments.

Additionally, I am integrating Basurto, Gelcich and Ostrom's (2013) classification system for benthic small-scale fisheries (Table 3) as the conceptual foundation and methodological orientation on which to build the empirical analysis of the brown shrimp case study within the Social-Ecological Action Situation Framework. Its focus on governance processes in small-scale fisheries makes it ideal for the classification of the southern North Sea brown shrimp fishery and offers methodological potential for a multi-faceted, interdisciplinary document analysis being based on Ostrom's Collective Action Theory design principles. Furthermore, based on my research ontology and epistemology (Chapter 2.5), I have expanded the classification system to include the variable "A7.2 perception of SES" (Table 3).

Not all the variables listed in Basurto, Gelcich and Ostrom's (2013) classification system for benthic small-scale fisheries (Table 3) are used in the analysis of the brown shrimp case study (Chapter 9), only the ones relevant from an Adaptive Governance Theory perspective. Those that will be used for the analysis and classification are going to be presented in detail in Chapter 9. I am using the social-ecological system framework as a heuristic tool to organize information as well as an analytical tool to work through the complexity of the case study to produce plausible adaptation options. The framework will only be used directly in the analysis of the threat of fishery collapse in Chapter 9.

Table 3: Classification system of benthic fisheries based on Basurto et al. (2013) with the addition of "A7.2 perception of SES" as a new category.

Category	Code	Description	Category	Code	Description	Category	Code	Description
Resource Systems (RS)	RS1	Sector (e.g., forests, pasture, fish)	Actors (A)	A1	Number of relevant actors	Governance Systems (GS)	GS5.1.2	Support funding
Resource Systems (RS)	RS1.1	Marine benthos	Actors (A)	A2	Socioeconomic attributes	Governance Systems (GS)	GS5.1.3	Restoration efforts
Resource Systems (RS)	RS2	Clarity of system boundaries	Actors (A)	A3	History or past experiences	Governance Systems (GS)	GS5.2	Non-government organizations
Resource Systems (RS)	RS3	Size of resource system	Actors (A)	A3.1	Crisis	Governance Systems (GS)	GS5.2.1	Capacity building
Resource Systems (RS)	RS3.1	Carrying capacity	Actors (A)	A3.2	Duration	Governance Systems (GS)	GS5.2.2	Linking
Resource Systems (RS)	RS4	Productivity of system	Actors (A)	A4	Location	Governance Systems (GS)	GS5.2.3	Bridging
Resource Systems (RS)	RS4.1	Stock status	Actors (A)	A5	Leadership	Governance Systems (GS)	GS5.2.3.1	Unions
Resource Systems (RS)	RS4.2	Biophysical factors	Actors (A)	A6	Social capital	Governance Systems (GS)	GS5.2.3.2	Cooperatives
Resource Systems (RS)	RS5	Equilibrium properties	Actors (A)	A6.1	Trust and reciprocity	Governance Systems (GS)	GS6	Rules-in-use
Resource Systems (RS)	RS6	Predictability of system dynamics	Actors (A)	A7	Knowledge of SES/mental models	Governance Systems (GS)	GS6.1	Property rights
Resource Systems (RS)	RS7	Storage characteristics	Actors (A)	A7.1	Mechanism to share knowledge about the fishery	Governance Systems (GS)	GS6.1.1	Open access
Resource Systems (RS)	RS7.1	Storage in their natural habitat	**Actors (A)**	**A7.2**	**Perception of SES**	Governance Systems (GS)	GS6.1.2	Monopoly and total allowable catch
Resource Systems (RS)	RS7.2	Storage in a human-designed facility	Actors (A)	A8	Importance of resource	Governance Systems (GS)	GS6.1.3	Catch shares
Resource Systems (RS)	RS8	Connectivity	Actors (A)	A8.1	Economic dependence	Governance Systems (GS)	GS6.1.4	Territorial use privileges
Resource Systems (RS)	RS9	Location	Actors (A)	A8.2	Cultural dependence	Governance Systems (GS)	GS6.1.4.1	Sea-bed tracts
Resource Units (RU)	RU1	Resource unit mobility	Actors (A)	A9	Technologies available	Governance Systems (GS)	GS6.1.4.2	Individually owned fishing spots
Resource Units (RU)	RU2	Growth or replacement rate	Actors (A)	A9.1	Ownership of technology by fishers	Governance Systems (GS)	GS6.1.4.3	Territorial use communal rights
Resource Units (RU)	RU3	Interaction among resource units	Actors (A)	A9.2	Homogeneity	Governance Systems (GS)	GS6.2	Operational rules
Resource Units (RU)	RU3.1	Reproduction	Governance Systems (GS)	GS1	Policy area	Governance Systems (GS)	GS6.3	Collective-choice rules
Resource Units (RU)	RU3.2	Settlement	Governance Systems (GS)	GS1.1	Environment	Governance Systems (GS)	GS6.4	Constitutional rules
Resource Units (RU)	RU4	Economic value	Governance Systems (GS)	GS1.1.1	Benthic marine	Governance Systems (GS)	GS7	Norms and strategies
Resource Units (RU)	RU5	Number of units	Governance Systems (GS)	GS2	Geographic rage	Governance Systems (GS)	GS8	Network structure
Resource Units (RU)	RU6	Distinctive characteristics	Governance Systems (GS)	GS3	Population	Governance Systems (GS)	GS8.1	Horizontal
Resource Units (RU)	RU6.1	Hatchery	Governance Systems (GS)	GS4	Regime type	Governance Systems (GS)	GS8.2	Vertical
Resource Units (RU)	RU6.2	Wild	Governance Systems (GS)	GS4.1	Democratic	Governance Systems (GS)	GS9	Monitoring
Resource Units (RU)	RU7	Spatial and temporal distribution	Governance Systems (GS)	GS4.2	Autocratic	Governance Systems (GS)	GS9.1	Social
Resource Units (RU)	RU7.1	Patchy	Governance Systems (GS)	GS5.1	Government organizations	Governance Systems (GS)	GS9.2	Biophysical
Resource Units (RU)	RU7.2	Random	Governance Systems (GS)	GS5.1.1	Support enforcement	Governance Systems (GS)	GS10	Sanctions
Social, Economic and Political Settings (S) S1, Economic development, S2 - Demographic trends, S3 - Political Stability, S4 - Other governance system, S5 - Market						Governance Systems (GS)	GS10.1	Graduated sanctions
S6 - Media organizations, S7 - Technology						Governance Systems (GS)	GS10.2	Grim trigger strategies

3.2 Document Analysis

Building on this analytical conceptualization, a document analysis provided the foundation for this dissertation. A document analysis is a qualitative research method that involves systematic evaluation and interpretation of documents to gain an understanding of their content, context, and meaning (Prior 2003). It is particularly useful in studying written records, texts, and artifacts, making it suitable for research based on archival materials, policy documents, and other forms of written records. The use of document analysis as a research method acknowledges the subjective nature of documents and recognizes that they are products of specific socio-cultural, political, and historical contexts. According to Bowen (2009), a document analysis enables researchers to uncover implicit and explicit meanings within texts, identify themes, thematic patterns, and examine the processes and structures that shape the creation and dissemination of documents as well as their possible impact on social contexts. The method complements other qualitative research, such as interviews and observations, by providing additional contextual data and validating findings through triangulation.

My analysis is based on previous research, government documents, newspaper articles, meeting notes, website content, press releases and research proposals - as well as institutional reports and maps. These documents were selected with regard to their particular relevance to the research question and their importance in understanding the phenomenon under investigation. Purposive sampling was done and complemented by theoretical sampling based on the theoretical framework developed above (Thiel and Moser 2019). The documents serve a number of specific functions: They provide a more complete and deeper picture of European fisheries governance by way of providing supplementary data, tracking policy change and supporting or refuting findings of the interview study (Bowen 2009). First, documentary material was used to provide context by giving background information, historical insight and providing supplementary research data. These insights were first used to contextualize and supplement data from the semi-structured interviews. Second, the information from the documents was used to enrich interview guides by suggesting new or different questions to be asked. Third, documents were empirically used to track change and development in European fisheries governance. Fourth, documentary material was assembled to embed data from the interview study to interpret and understand various perspectives on the issue (Bowen 2009).

The document analysis consisted of an iterative process of skimming, thorough examination and interpretation of the data. The documents were selected based on previous empirical, theoretical and methodological research relevant to the research questions and based on snowball sampling of documents. EU documents were also regularly and systematically reviewed as well as up to date information on climate change impacts. This procedure was informed by a content analytic process in which information was organized into categories based on the research questions through a first-pass document review that identified relevant and meaningful paragraphs of texts or visual data, separating relevant from non-relevant information[6] (Bowen 2009).

3.3 Interview Study

The semi-structured interviews built on the foundation laid by the document analysis. They were conducted with people involved in fisheries and based on an interview guide that was informed by the previously outlined document analysis. This enabled me to traverse between empirical data and theory, allowing for the expected and unexpected detection of patterns and themes emerging from the data (Biggs 2021a). It provided, moreover, the opportunity to hypothesize explanations for unexpected findings and ensured that the analysis remained dynamic and responsive to the complexities of the data and the field of research.

The choice of semi-structured interviews, as opposed to surveys, was a deliberate methodological decision. Surveys, while useful for capturing broad trends, often limit respondents' ability to provide nuanced or context-specific insights, primarily addressing what is the case. In contrast, semi-structured interviews offer a dialogical space where participants can elaborate on their experiences, clarify meanings and speak about sensitive issues - addressing the how and why of an issue. The social nature of the interview process offers additionally the possibility for an iterative and spontaneous refinement of questions during the interview, ensuring that emerging themes are thoroughly explored and represented (Biggs 2021a).

Semi-structured interviews were utilized as the principal method of data collection, chosen for their capacity to balance structure with flexibility. This ensured an alignment with the study's objectives while allowing participants the freedom to articulate their perspectives without undue preconceptions or unarticulated constraints. An interview guide, developed with input from diverse disciplinary perspectives and based on the document analysis, facilitated a comprehensive exploration of key topics while leaving ample room for participants to introduce unanticipated topics (Biggs 2021a). The purpose of the interviews in the context of this investigation consisted in exploring and uncovering issues facing the brown shrimp fishery from the point of view of those involved in fisheries – fishers, politicians and administrative staff. The interview guide[7] that was developed consisted of an introductory section, five thematic sections and one self-reflective section of the interview itself.

[6] While there are overlaps between the document analysis done here and a content analysis, a quantification process is skipped.

[7] For further information on the interview guide please contact the author.

Rather than starting with pre-established ideas about existing problems, a bottom-up approach was used to identify issues of relevance. Depending on the interview partner (fisher, administrative personnel or politician), the guide was slightly adapted to fit that person's role within the fisheries structure in order to avoid non-relevant questions while sticking to the core of the interview guide. The first thematic section of the interview guide related to the self-image and work as a fisher. The second one is the family history with regard to fishing. These two sections were omitted in the interviews with administrative personnel and politicians. The third section related to changes within the community of fishers, the fourth one to self-organization and its structures, and the fifth one to the future of the North Sea inshore fishery. The last section consisted of four questions intended for the interviewee to reflect on the interview and facilitate future cooperation:

- "We have talked about a lot of issues: Is there something else important that you want to tell us and which have not talked about?"
- "Are there place and / or themes that we should research and whom should we contact regarding these?"
- "Would you be willing to bring us in contact with relevant actors?"
- "How should we continue to work together?"

In total, 31 interviews were done – 16 with fishers, 5 with politicians and 10 with administrative staff – from 2020 to 2024 by researchers of the CliCCS C3 project "Sustainable Adaptation Scenarios for Coastal Systems". It is noteworthy that individuals currently occupying administrative roles were formerly fishers, giving them insights derived from multiple perspectives. Interviews were conducted in multiple ways in part due to the Covid-19 pandemic: such as video or voice calls, face-to-face on-land and on-board interviews. Interviews lasted between 21 minutes and 2 hours and 50 minutes. Purposive sampling was applied to identify participants from all relevant groups and snowball sampling to recruit interviewees (Thiel and Moser 2019). Especially within the small community of German inshore North Sea fishers, snowball sampling proved to be an effective method of recruiting interviewees, as the referral by a community member proved to hold a lot of weight and was therefore effective in the recruiting process. All interviews were audio-recorded with the participants' informed consent and later on transcribed verbatim by a company specialized in processing data from audio into written formats for qualitative research.

Methodologically particularly relevant were six interviews done on-board commercial fishing cutters. These on-board interviews belong to the family of mobile methods (Büscher et al. 2011). In qualitative research, mobile methods represent an approach that involves the physical dwelling in a place during the research process, breaking away from the normal sedentary, static, place-bound settings such as face-to-face on-land interviews conducted in offices or homes. These methods emphasize the importance of spatial, embodied, engaged and dynamic contexts in understanding social phenomena. The goal is to study participants' experiences in situ, capturing the interplay between their actions, environments, and the social structures that permeate these environs. On-board interviews, as part of mobile methods, allow for emplaced interactions between the seascape and the interviewee. They provide the opportunity for the interviewee to share embodied and spatial experiences of the seascape and on-board lifeworld with the interviewer (Harrison 2016).

Table 4: Date, Cutter and its length as well as the fishing region for the on-board interviews

Month	Date	Vessel Length	Location
April	25-27.04.2022	18m	North- Frisia
July	19-20.07.2022	17m	East- Frisia
August	28-31.08.2021	16m	North- Frisia
September	20-21.09.2021	24m	East- Frisia
October	16-19.20.2021	24m	East- Frisia
November	15-16.11.2021	16m	North- Frisia

All on-board interviews were done by the author on brown shrimp fishing vessels during commercial fishing trips that lasted between one and four days (Table 4). The captain was interviewed, if possible, towards the end of the fishing trip in order for trust and a personal relationship to develop. A point was made to intervene as little as possible in the everyday on-board processes and to set the interviews around the regular processes on-board. The interviews were conducted while the captain was on the bridge, steering the vessel. This adds another layer of depth and generates thick data of emplaced interactions as he is working, while the interview is taking place. The process of working in combination with the seascape are key stimuli that entice novel resonances to interview questions (Döring and Ratter 2021).

Selective participant observations during the time on-board captured additional contextual details, including non-verbal cues and situational observations. They provided background information for the interpretation of the on-board interviews (Spradley 2016). While on-board, I also sampled discard brown shrimp, collecting data on their immediate mortality and its connection to temperature and other abiotic factors as part of the “CRANMAN” project (Chapter 3.5). The project studied the biology of brown shrimp and its fishery within the context of the existing self-management plan. Sampling the discarded shrimp and collecting data on their vitality, length, and carapace both during the day and at night, and for as many hauls as possible, meant that I was often outside longer than the deckhand needed for manually sorting the catch. These circumstances created a shared experience of working long hours and, at times, being cold and tired. Such shared experiences helped build trust, demonstrating that I was capable of working hard—an aspect that all fishers I interviewed considered particularly important. Spending extensive time on deck also provided valuable insight into the everyday lifeworld of fishers and, consequently, offered me a different perspective on them and their work. This experience influenced the way I asked questions during interviews and shaped the conversations I had on board. In turn, it changed not only how they perceived me, but also how I perceived them.

My positionality had a significant influence on the rapport that emerged prior to the interviews. As a white, northern German man in his thirties, I shared aspects of social background and everyday experience with many of the fishers. This facilitated a sense of familiarity and led them to perceive me as sympathetic to their concerns - opening conversational pathways that might not have been available, for example, to a female researcher.

The analysis of the interviews – on-land as well as on-board – followed the principles of thematic sampling to present and identify recurring and unexpected patterns in the interview data following Braun and Clarke (2012; 2017). A thematic analysis involves conceptualization and interpretation through the structuring and ascription of codes and construction of themes (Kiger and Varpio 2020). It can be used to reveal patterns of interpretation in a systematized way and to disclose the structural, cultural and social context "*enabling the development of knowledge that is constructed through interactions between the researcher and the research participants*" (Kiger and Varpio 2020, 847). A thematic analysis is therefore a method particularly suited for sedentary and on-board interviews.

Central to a thematic analysis are themes and categories. Whereas categories provide description and organization, a theme is a "*patterned response or meaning*" (Braun and Clarke 2012, 63) that is more abstract and based on interpretation. The identification of themes is not bound by the frequency a particular category appears in the data set, thereby allowing the researcher the possibility to go beyond the personal view of the interviewee. Using a deductive approach, themes related to the Adaptive Governance theoretical frame were generated, while in an iterative process, an inductive approach was taken to derive themes from the data at hand.

The analysis follows Braun and Clark's (2012; 2017) thematic analysis guide which consists of several steps: Step 1 is the familiarization with the data, which means repeated, thorough and active reading of the content of the interviews. In step 2, initial and tentative codes are generated. Codes are well-defined conceptual entities, while at this stage themes were not yet generated. Hence, codes were derived deductively based on my theoretical framework, while patterns reflected in the data were coded inductively. A coding manual was written with the aim of developing a detailed record and a documentation for potential changes in the future. Single extracts were, when appropriate, labeled with multiple codes capturing and highlighting the multilayered and faceted structure of the data. In the next step, I examined all codes to find themes of shared and broader significance. The process of deriving themes is active and by its nature interpretative. In step 4, themes are reviewed in a two-stage process. First, I asked myself if there was adequate support in the data for each theme – meaning their content-based relevance rather than their frequency. Second, I asked myself whether the themes accurately represent the entire data set. Deviating from Braun and Clark's guide for interviews, I incorporated discussion groups conducted (Chapter 3.4) in this process in order to validate my coding and themes while revisions continued throughout the entire analytic process. In step 5, themes were defined and checked for their unique insights and contribution to the overall research questions. In a final step, the results were incorporated into the analysis of the potential future collapse of the German brown shrimp fishery (Chapter 9). The categories and themes extracted from the interview data gave a unique insight into the social-ecological system of the brown shrimp fishery by providing practical knowledge - especially of climate change perception and the governance structure (Clarke and Braun 2017; Braun and Clarke 2012).

3.4 Roundtable Discussions

Roundtable discussions enhanced the research process and enriched the results by challenging the preliminary findings of the interview study and document analysis. A roundtable discussion is a qualitative method of generating data in which a moderator guides a discussion within an interest group about a pre-selected topic (Romsdahl 2020; Barton et al. 2014). Following the iterative and bottom-up approach of this study, roundtable discussions were organized with fishers and administrative staff in order to get feedback on the preliminary results - following step 4 of the thematic analysis (Chapter 3.3). The focus of the roundtable discussion was getting feedback on the preliminary results of the thematic analysis, which were included in the final analysis. Four roundtable discussions were organized – three with fishers (RTD1: 7 people, RTD2: 8 people, RTD3: 2 people) and one with administrative staff (RTD4: 2 people). All Roundtable discussions were audio recorded (with the participants consent) and transcribed verbatim. A colleague and I moderated the discussions together. Participants were selected based on their willingness to engage with the research, while ensuring that a diverse range of topics and standpoints were present in the discussion rounds. However, rather than focusing on the group to be as heterogeneous as possible, participants were selected who were believed to work well together. For the roundtable discussion with the administrative staff this procedure was not necessary. When choosing a location for the roundtable discussion, we consulted one participant for recommendations. This approach aimed to ensure an environment in which participants felt comfortable and relaxed, thereby supporting substantive and constructive discussions (Barton et al. 2014).

The discussion between the participants and the research team was grounded in a presentation of the preliminary findings from the interview study. To facilitate an engaged and productive exchange, an operating plan was developed in advance of the roundtable discussions. We asked the participants to react in real time to the presentation and posed questions to individual participants, explicitly asking for their opinion. We began the roundtable discussions by introducing ourselves and outlining the aim of the interview study, as not all participants had taken part in it. Following this, the participants introduced themselves, after which we proceeded with the presentation (Romsdahl 2020). We put an emphasis on working together *with* the participants in a multi-year process rather than just *about* them, which was communicated to the participants multiple times (Karrasch et al. 2024). This format allowed for an open discussion among all participants on the results and provided deep feedback. The aim of this format was to be explorative in capturing patterns of opinions in reaction to the interview study while disagreements and deviations were documented (Romsdahl 2020; Barton et al. 2014). These were included in the presentation at the next roundtable discussion while also being incorporated as part of step 4 of the thematic analysis guide (Chapter 3.3).

3.5 Discard Shrimp Mortality Analysis

The process was complemented by an analysis of the survival rate of discard brown shrimp. As a boundary object, shrimp function as a connector between fishers' and researchers' lifeworlds, which enabled collaboration and coordination by providing a shared reference point (Star and Griesemer 1989). Understanding the data collection process is, therefore, vital for assessing how the brown shrimp function as a boundary object within my research.

To determine the rate of immediate mortality in the commercial brown shrimp fishery, ICES guidelines on conducting discard survival studies were followed (Breen and Catchpole 2021). As these are mostly focused on fish and, in part, not suitable for small crustaceans, specific adaptations were made. Vitality scores and captive observations were combined in order to fulfill ICES requirements. However, for this dissertation, only vitality scores are relevant and therefore discussed. The vitality of undersized discard shrimp was recorded during commercial fishing trips to determine the rate of immediate mortality. Drum-sieves were used in the on-board sorting process on all vessels and a number of biotic and abiotic data related to their immediate mortality were collected. In total, six multi-day fishing trips with four different vessels were sampled in August, September, October and November of 2021 as well as April and July of 2022.

3.5.1 Biotic data

The biotic data collected during the fishing trips were the vitality score, the length and the carapace hardness of discard shrimp. A random sample of discard shrimp was taken at the beginning and the end of the on-board sorting process for each sampled haul with a dip net. The shrimp were immediately transferred into two separate 30-liter containers with fresh seawater. Fifty animals from the beginning and the end of the sorting process were randomly selected from these containers. A vertical sampling of shrimp was done in the water column to avoid a clustering of vitality classes at the very top or bottom of the container. All sampled shrimp were placed into a small holding tank and then individually taken out to first record the vitality class, followed by their length and carapace hardness (Figure 16). All measurements were done on deck and each shrimp was, on average, out of the water for about 30 seconds. Each shrimp was then classified into one of three vitality classes: 1) alive *with* an active escape response (tail flipping), 2) alive *without* an escape response (no tail flipping) and 3) deceased. The vitality class of a shrimp was determined by lightly touching the shrimp with spring steel tweezers to trigger an escape response. The body length was measured to the lower millimeter from the tip of the scaphocerite to the tip of the telson (Figure 15).

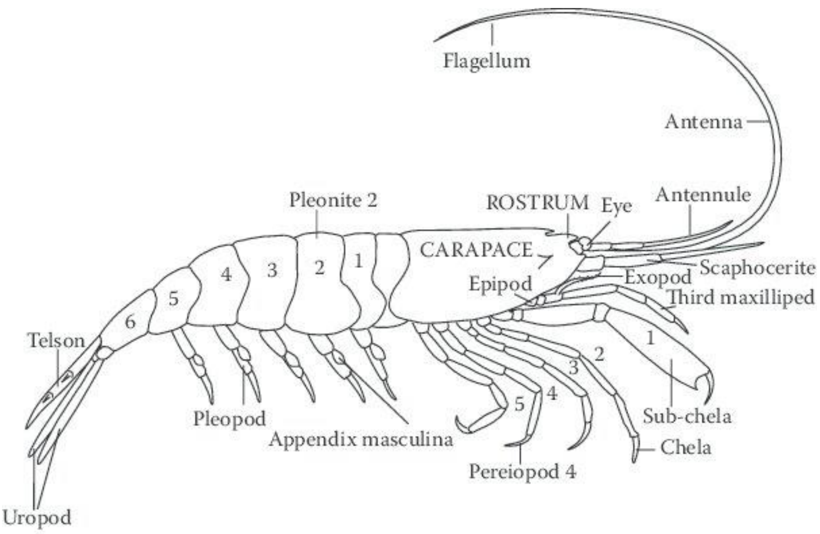

Figure 15: Morphology of Crangon crangon (Campos and Van der Veer 2008, 68)

If limbs were missing, the length was recorded as unidentifiable. The carapace hardness was tested using spring steel tweezers. All Shrimp were classified into three categories: 1) soft: pressure from the tweezers results in a “permanent” disfiguration of the carapace; 2) medium: the carapace can be pushed in, but it bounces back; and 3) hard: the carapace cannot be pushed in using reasonable force with the spring steel tweezers.

Figure 16: The process of collecting biological data on discard shrimp. On the left is the setup of the data collecting station, including the instruments used. On the right, I am in the process of collecting data. Photos by the author

3.5.2 Abiotic data

In addition to biotic data, abiotic variables were also recorded in order to analyze their influence on the immediate mortality of undersized discard shrimp. These abiotic variables include haul duration, haul volume and water as well as air temperature. The goal of the analysis was to give actionable advice to fishers on how to reduce the survival rate of discard shrimp. My understanding of what constitutes actionable advice in the brown shrimp fishery was strongly shaped by the time I spent on board and by the conversations I had with captains and deckhands.

Water temperature was logged every minute using a Ceradiver that was fixed to the deck of the vessel (Schlumberger Water Services). The air temperature was logged every minute with a Barodiver, which was attached to the beam of the trawl (Schlumberger Water Services). The temperature was measured with an accuracy of 0.01 °C and rounded to 1 °C to be able to better compare temperature categories. This was done to make the data usable and less abstract in the real world of commercial fisheries. As a robust animal used to temperature changes throughout the tide cycle, temperature increases below 1 °C are were assumed not to have an effect on the survival probability (Campos 2009).

To determine the catch volume, the total volume capacity of the pit of each vessel was calculated as a geometric body (m^3). For every sampled haul, the distance (in cm) from the catch to the top of the pit was measured at the same position. This distance was then used to calculate the catch volume. As the catch was never level in the pit, it was difficult to obtain exact measurements and, therefore, the catch volume should be treated as an approximation rather than an exact figure. Rather than comparing haul volumes directly, haul volume categories were established. Haul volumes below 200 liters were excluded as outliers. Based on a descriptive analysis of the data, three categories were established: 1) below 868 L (bottom 25 %), 2) 868 to 1358 L (middle 50 %) and 3) above 1358 L (top 25 %). To determine the influence of haul time on the rate of immediate mortality, three categories were established: 1) under two hours, 2) two to three hours or 3) over three hours. Both for haul volume and haul duration, this categorization makes a comparison of the influence of low and high values with average values possible, showing how deviations from normal conditions influence mortality rates.

In order to capture the influence of the time spent in the on-board sorting process, a binary proxy variable was established for those sampled at the beginning and those at the end of the on-board sorting process. This variable simply serves as an indicator whether prolonged time out of the water and in on-board sorting process has an influence on the rate of immediate mortality.

3.5.3 Binary Logistic Regression Analysis

By including a quantitative analysis of juvenile discard shrimp mortality, I was able to do two things: First, I was able to talk about climate change with the actors using a concrete, existential example in their lifeworld instead of an abstract, global phenomenon. Second, the data generated provides valuable insights into the effects of climate change on a keystone species of the Wadden Sea—an aspect that has thus far been largely overlooked and is therefore of considerable ecological and social relevance. By integrating the qualitative findings, we provided a contextual frame grounded in practical knowledge, allowing for the formulation of actionable policy recommendations and climate-change adaptation options for the sector's transition toward a climate-smart fishery. The statistical data, meanwhile, offered a means of engaging stakeholders with localized, lifeworld-relevant manifestations of climate change.

To determine the influence of the recorded biotic and abiotic factors on the immediate mortality of juvenile discard shrimp, a binary logistic regression analysis (Diekmann 2007; Bärlocher 2008) was done based on data collected from 3597 juvenile discard shrimp. This model's strength lies in the inclusion of both biotic and abiotic variables through which it captures the different dimensions of influence that determine the survival probability of undersized discard shrimp. The data of 1310 discard brown shrimp from the April 2022 fishing trip was incomplete and therefore excluded from the binary logistic regression analysis. It was, however, used in the descriptive analysis of the variables involved in the immediate mortality of juvenile discard shrimp (Chapter 9).

The vitality scores of undersized discard shrimp were transformed into a binary variable ("alive" and "deceased") and used as the dependent variable in the binary logistic regression analysis. Those shrimp that were alive with an escape mechanism (1 class) and those that were alive without an escape mechanism (2 class) were categorized as “alive”. While there is an argument to be made that discard shrimp without an escape mechanism (due to e.g. significant injuries) have a low chance of long-term survival, this fact is not taken into consideration in this analysis. The focus here was on immediate mortality after the drum sieve. There is, moreover, no reliable data on the long-term survival rate of injured brown shrimp in the wild (Temming et al. 2022b; Temming et al. 2022a).

The initial variable selection was based on a previous study on discard survival (Temming et al. 2022a). There was a strong positive linear relationship between air and water temperature (Pearson’s r = 0.91, p-value < 0.001), while the other variables did not correlate with one another. We examined how air-water temperature differences affect survival, finding only a slight increase in survival as the temperature gap widens (Spearman’s ρ = 0.051, p-value = 0.002). Therefore, although the relationship is statistically significant, it is very weak and may not be practically meaningful. For the descriptive as well as logistic analysis, water temperature was therefore used as an explanatory variable.

The final model selection was done based on an iterative, stepwise process and based on the Akaike Information Criterion (AIC) score. The AIC estimates the quality of each model, given collections of models for a dataset. As an estimator of prediction error, it provides a criteria for model selection (Tran and Arabnia 2015). R version 4.2.2 and the “Logit” function of the “lessR” package (Gerbing, 2025) were used in the analysis. The final model equation is the following:

$$log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 temp_{H_2O} + \beta_2\ sorting_{time} + \beta_3\ carapace_{hardness} + \beta_4\ length_{body} + \beta_5\ haul_{dur} + \beta_6\ haul_{vol} + \beta_7(haul_{dur} \times haul_{vol})$$

In this model,

p_i denotes the probability that individual *i* was deceased.
β_0 is the intercept, and β_1–β_7 are regression coefficients representing the effects of the predictor variables on the log-odds of mortality.
temp_{H_2O}: is the median bottom-water temperature experienced by individual *i*
sorting_{time}: is the time elapsed during the sorting process
$\text{carapace}_{hardness}$: represents the carapace hardness category
length_{body}: is the individual body-length category
haul_{dur}: refers to the duration that a haul takes
haul_{vol}: refers to the catch volume
($\text{haul}_{dur} \times \text{haul}_{vol}$): The interaction term allows the effect of haul volume on mortality to vary with haul duration.

All categorical predictors were treated as factors and estimated relative to reference levels, and coefficients quantify effects on the log-odds scale.

We applied statistical predictive modeling using the *predict()* function of the fitted logistic regression model to estimate immediate discard mortality across a range of temperatures. A water temperature range of 10–23 °C was applied while holding the other covariates constant. The biotic and abiotic variable categories chosen to be held constant were those of an average commercial fishing haul: A haul volume between 868 and 1358 L, a haul time between 2 and 3 hours and shrimp with a hard carapace. I decided to do the predictive modeling for shrimp that had been exposed to little time on-board and therefore included the sorting process variable using shrimp that were sampled at the beginning of each haul. Therefore, the results represent a conservative rather than an extreme estimate.

The results of both the logistic regression analysis on mortality rates of discard shrimp as well as the modeling on the influence of high summer temperatures on the progression of mortality rates are discussed in Chapter 9.8.

3.6 Methodological Integration

This dissertation's mixed-method approach integrates document, semi-structured interview analysis and roundtable discussion with biological field research to provide comprehensive and nuanced insights. These methods in their analytical sequence are informed by a social-ecological systems understanding that is operationalized through Schlüter et al.'s (2019) Social-Ecological Action Situation Framework. By integrating these methods into a common research design, the study leverages their individual strengths to open up new perspectives and facilitate the emergence of novel insights.

The document analysis serves as the foundation, allowing researchers to examine existing texts, policies, reports, and historical data to identify patterns, themes, and gaps in knowledge. This initial step helped frame the research questions and further informed the selection of subsequent methods. Building on this, an interview study enabled direct engagement with individuals, capturing their experiences, perspectives and motivations that may not have been explicitly documented elsewhere. The Interviews added depth to the research by uncovering actors' insights, personal narratives and framings as well as emerging themes. The next layer, roundtable discussions, enhanced the research process by fostering interactive dialogue among multiple actors. These discussions expanded the findings from the document analysis and interview study by encouraging debates, allowing diverse viewpoints to surface within the group of actors, refining the results of the document and interview analyses. The collaborative nature of roundtable discussions contributed to producing a richer understanding of the social dynamics within the groups, potential causal relationships, and practical implications, which can be informative and instrumental in shaping the variables and hypotheses for regression analysis.

By including a quantitative analysis of juvenile discard shrimp mortality, it was possible to do two things: First, I was able to talk about climate change with the actors using a concrete, existential example in their lifeworld instead of an abstract, global phenomenon. Second, the collected data provided important evidence regarding climate change effects on the keystone brown shrimp. Incorporating qualitative results allowed for the construction of multiple contextual frameworks informed by experiential and practice-based knowledge, facilitating the development of policy-relevant and adaptive responses within the sector. Meanwhile, the statistical analysis enabled a structured engagement with stakeholders by situating climate change impacts within the local social-ecological context.

By structuring the research process in this order, each method builds on the previous one, ensuring that the study is consistent, contextually rich and analytically robust. The qualitative methods provided depth, meaning, and conceptual clarity, while the regression analysis added precision and climate change context to the brown shrimp. Together, this mixed-method approach led to a more integrated understanding of the complex phenomena under investigation, bridging the gap between theoretical exploration and empirical validation while also emphasizing the relevance of an ontological perspective instead of just an epistemological one.

4 Fisheries Governance: Europe

In Part three of this dissertation, I address and analyze the role and shortcomings of the European Union, its Member States and the self-management capacity of the industry. The focus lies on political governance (government) structures and the self-management system of the industry. As an interconnected, multi-level system, European fisheries governance influences all fisheries within European waters. Examining the self-management in brown shrimp fisheries without a concrete understanding of the roles, responsibilities and relationships between the EU, Member States and self-management level would ignore deeper path dependencies and process interdependencies (Chapter 2). This part's structure is informed by Adaptive Governance Theory in that the analytical focus are the three governance institutional levels EU, Germany and self-management (Chapter 4-6), coupled with an analysis about their interdependencies (Chapter 7). Therefore, the leading research question for this part is:

(Q2) What are the systemic constraints of the EU's fisheries governance structure under climate conditions?

Based on the research ontological understanding that I have developed in my theoretical analysis (Chapter 2.5), the assumption is that too much institutional rigidity has a negative effect in complex adaptive systems. It does not allow for co-evolutionary mechanisms between the governance and ecological entities of a system to take place and adapt to changing conditions, such as Climate change effects (Chapter 2.5). For fisheries, this would mean that too much governance rigidity and an inability to adapt to changing boundary conditions would lead to unsustainable fishing practices. I therefore hypothesize that:

H4: The multi-level European fisheries governance system is not designed to deal with uncertainty – that is to be flexible and adapt to new conditions. It therefore produces unsustainable fisheries.

In order to test the hypothesis, it is split into two parts. In the first part, the flexibility of the EU's governance system is tested using a descriptive analysis (Chapter 4-6.1), while the second part (Chapter 6.2-7) analyzes if the rigidity produces unsustainable fisheries in the EU using Adaptive Governance Theory through an inferential analysis. This chapter describes the conception of the CFP, analyzing its capacity to adapt to climate change through the analytical dimensions polity, policy and politics using the conceptual lens of path-dependency, showing that the CFP is rigid and not designed to deal with uncertainty.

4.1 The Conception of the Common Fisheries Policy

In Europe, much like the rest of the world, fishing is an activity steeped in tradition that has a tendency towards conservatism and is reluctant to changes in management – both from politicians and the industry (Peñas Lado 2019). This tendency is exemplified through the German brown shrimp fishery, as the following quote shows:

> *„Weil ich hatte ja schon gesagt, dass unsere - unsere Fischerei extrem konservativ ist, ja, die wollen im Prinzip, ja, lasst uns in Ruhe und wir machen weiter wie bisher." (I5, Pos. 107)*
>
> *"As I've said before, our fishery is extremely conservative, yea, they more or less want, yea, to be left alone and continue business as usual" (I5, Pos. 107)*

The rapid cultural, economic and ecological changes that are unfolding due to climate change impacts and mitigation efforts are deeply impacting European fisheries. Societal changes towards the industry (EU Action Plan 2023), area closures due to wind park developments (Hereon 2025) and the northward movement of important stocks (EEA 2024a) are just some of the aspects that are felt. To understand the EU's fisheries governance of today and identify its shortcomings within the context of climate change, we need to look at the historical conception of the CFP and its development through its institutional structure, policy development and political bargaining processes. The goal of this section is to evaluate the CFP in order to identify the most pressing issues with regard to rigidity. The analysis is not only limited to the CFP but includes Germany's fisheries policy and looks at the wider fisheries governance within Europe. Therefore, the analysis goes beyond the CFP in form of the Basic Regulation as the key legislative act (policy) but also employs relevant institutions (polity) and decision-making processes (politics) (Belschner et al. 2019). Politics is the procedural aspect of the political, the conflicts or the consensus that are born out of diverging interests or interest-led actions. Politics as the procedural aspect is to be distinguished from polity as the institutional, and policy as the decision-content aspect. Policy is the content of decisions made by the government and other national, inter- and supranational institutions with the authority to make publicly binding decisions, such as the Council of the European Union (Nohlen and Schultze 2010). These three political dimensions are useful analytical tools to identify and highlight interconnections (Belschner et al. 2019). By examining all three dimensions, an integrated understanding of political phenomena is possible, while simultaneously considering institutional structures, decision-making processes, and policy outcomes. They can also reveal how changes in one dimension can affect others: institutional reforms (polity) might influence policy-making processes (politics) and outcomes (policy). This section heavily employs Ernesto Peñas Lado's work on the CFP (Peñas Lado 2016; 2019). He served as an official at the European Commission's Directorate-General for Maritime Affairs and Fisheries (DG MARE), holding the position of Director for

Policy Development and Coordination. This position provided him with unique insights into, and access to, not only policy outcomes but also the internal policy-making processes of the EU institutional framework.

The Common Fisheries Policy can be attributed to the early years of European integration. The Treaty of Rome, which established the European Economic Community in 1957, did not feature a specific chapter on fisheries policy. The goal for a continent still recovering from the Second World War was to increase agricultural output and to translate this into the need for a specific agricultural policy. Fisheries, on the other hand, were not seen as something in need of future action at the European level. Most of the fishing activity of the Member States at the time (Belgium, France, Germany, Italy, Luxembourg and the Netherlands) took place outside the jurisdiction of their three nautical mile territorial sea, in only partially regulated international waters (Peñas Lado 2019).

The treaties of Rome established the Common Agricultural Policy in 1957 (**polity**) with the only mention of fisheries in Article 38(1). Article 38 establishes the inclusion of agricultural products into the common market, such as *"the products of the soil, of stock farming and of fisheries and products of first stage processing directly relating to these products"* (TFEU 2012, Article 38). This led to the framing of fisheries and their products as agricultural products, therefore falling under the Common Agricultural Policy. Consequently, fisheries were regarded as having the same objectives as those laid out in the CAP. These objectives have survived until today through Article 39 of the Treaty on the Functioning of the European Union:

"*to increase agricultural productivity by promoting technical progress and by ensuring the rational development of agricultural production and optimum utilisation of the factors of production, in particular labour [**1**]; thus to ensure a fair standard of living for the agricultural community - in particular by increasing the individual earnings of persons engaged in agriculture [**2**]; to stabilise markets [**3**]; to assure the viability of supplies[**4**]; to ensure that supplies reach consumers at reasonable- prices*.[**5**]" (TFEU 2012 Article 39)

Fishing and agriculture have fundamentally different economics and therefore pursuing the same objectives can have quite different outcomes. In fisheries, more investment and labor often lead to overfishing and in the long-term lower yields, while in agriculture higher yields are produced in the long-term. The Treaties of Rome fail to reflect these differences with consequences that influence fisheries governance in the EU up to this day (Peñas Lado 2016).

While the treaties' objectives seem ordered, there is no formal hierarchization. Time scales play a key role in fisheries management, which makes a hierarchization of objectives important in deciding which management actions to take, as they can have vastly different outcomes. The CAP, however, does not provide any clarity on whether short- or long-term considerations are more important - nor does it provide a hierarchy of objectives (TFEU 2012).

Looking at the first objective, productivity in wild fisheries may have the opposite effects in the short- when compared to the long-term. The same is true when looking at ensuring the viability of the supply of fish. In effect, fishing less in the short-term may provide more fishing opportunities in the long-term. However, in EU fisheries management, short-term considerations have traditionally prevailed over long-term ones (Peñas Lado 2016). European fisheries policy can thus be seen as the continual search to implement Article 38 of the CAP in the best way possible (TFEU 2012). To find a way to merge these objectives and adequately deliver a compromise short-, mid- and long-term goals. To this day, this compromise remains the main difficulty and conundrum of European fisheries governance. Almost all decisions, either implicitly or explicitly, are related to this (**Policy**) (Peñas Lado 2016).

As more coordination between Member States around agriculture and trade was established, it became clear that a common approach to fisheries was needed because of shared stocks and diverse interests (**Politics**). Following the European Fisheries Convention of 1964, the territorial sea in EU waters was increased to 12 nautical miles (Peñas Lado 2016). In the 1970s, the situation became more pressing. With the extension of Exclusive Economic Zones from 12 to 200 nautical miles, the area under national jurisdiction significantly expanded, therefore bringing more fish stocks under potential EU control. European fisheries governance has also been significantly influenced by changes in membership size. In 1972, fishing rights played a major role in the negotiations of the United Kingdom, Ireland and Denmark to join the European Economic Community. In 1985, Greenland withdrew from the Community and in 1986 the accession of Portugal and Spain, as well as the reunification of Germany in 1990, were of further influence (Popescu 2024). Since 2020, Brexit has had an impact on the European fishing sector, with the UK's extensive fishing grounds leaving the jurisdiction of the CFP (Peñas Lado 2019). In June of 2024, the accession negotiations of Ukraine started with future implications for stock management in the Black Sea (DGMARE 2024).

The CFP is subject to path dependencies that are born out of its historical conception and development. The European traditionalist and conservative approach to fisheries governance from both politicians and industry can be best examined using the political dimensions polity, policy and politics as analytical tools.

4.2 Polity: Institutional Changes of the Common Fisheries Policy

The legal basis for the CFP gradually evolved from the Treaty of Rome. In 1992, the treaty of Maastricht specifically recognized, for the first time, a European fisheries policy by distinguishing the Common Fisheries Policy from the Common Agriculture Policy. The objectives of the new Common Fisheries

Policy, however, remained unchanged from the Treaty of Rome and anchored in the Common Agricultural Policy. Maastricht also introduced subsidiarity as a notion that enabled the EU to act outside its exclusive competences (Peñas Lado 2016).

The Treaty of Lisbon in 2007 introduced two new major legal developments. First, the management and conservation of biological marine resources were enshrined as one of only five exclusive competences of the EU (TFEU 2012). Secondly, a co-decision mechanism between the European Council and the European Parliament was introduced. However, new objectives for the CFP were - again – not introduced. Changing objectives and the legal basis of the CFP could have likely created even more obstacles to the adoption of the Treaty of Lisbon. However, the general understanding among politicians and the industry was that the objectives of the CAP, and by extension those of the CFP, were valid and not in need of change (Peñas Lado 2019).

Article 43(2) of the Treaty of Lisbon stipulates that reforms and regulations are passed by the ordinary legislative procedure, a co-decision mechanism (TFEU 2012). This is notwithstanding the adoption of reference prices and fishing opportunities, which is the sole decision of the Council under Article 43(3) (TFEU 2012). Until 2007, fisheries legislation was decided by the Council of Ministers. Since then, regulations are decided in a co-decision process by the Council of Ministers together with the European Parliament through negotiations facilitated by the European Commission. Regulations are negotiated and adopted based on an agenda set by the European Commission. In a green paper, major challenges and changes are outlined while the Commission runs a consultation process with relevant and interested actors with the Directorate General (DG) MARE carrying out the work within the Commission. After the consultation process with the relevant actors, a proposal is adopted and sent to the Council and Parliament. The Fisheries Committee of the Parliament is in charge of amendments to the proposal of the Commission. The committee is made up of Members of the European Parliament (MEPs) with a core fisheries constituency. The Environment Committee has a chance to comment on the proposal, and those comments have to be taken into consideration, but it does not have a lead role. In both committees, a rapporteur is in charge of the respective draft negotiations. Amendments to the proposal, or ratification of it, is done during the Parliament's plenary session. Changes to the proposal by the Fisheries Committee are often voiced by Parliament based on wider political considerations. The position adopted by the plenary session is then the mandate of the European Parliament for the negotiation with the Council of Ministers. An important exemption to this process is the adoption of total allowable catches (TACs). The setting of TACs, as well as the allocation of quotas, lies exclusively with the Council of Ministers - which is made up of the Fisheries Ministers of each Member State. The decision mechanisms in the European Parliament and the Council of Ministers are quite different. In the Council of Ministers, each member has votes proportional to their population

and ratification or amendments require a qualified majority. This means that even with negative votes by some of the Member States, decisions can be adopted (Peñas Lado 2016; Orach et al. 2017).
The Treaty of Lisbon serves as an example of how institutional changes (polity) can have major influences on both the decision-making process (politics) and the scope of a policy. It enshrined the management and conservation of marine biological resources as an exclusive competence of the EU, but it has also changed the decision-making process within the CFP. Regulations are decided in a co-decision process by the Council of Ministers together with the European Parliament through negotiations facilitated by the European Commission, making negotiations more complicated by including diverse interests in the negotiation process (Chapter 4.4) and therefore less flexible.

4.3 Policy: Common Fisheries Policy Reforms

The state of today's European fisheries policy is best understood from a historical perspective. Over the years, successive layers of policy have been developed on top of one another. While new ones have been introduced relatively easily, removing old layers proves to be very difficult even today. A tendency to protect the status quo prevails - both from institutional and private actors (Peñas Lado 2019). There have been several constant elements in the CFP, such as the relative stability key, which have survived three consecutive reforms (1992, 2002 and 2013).

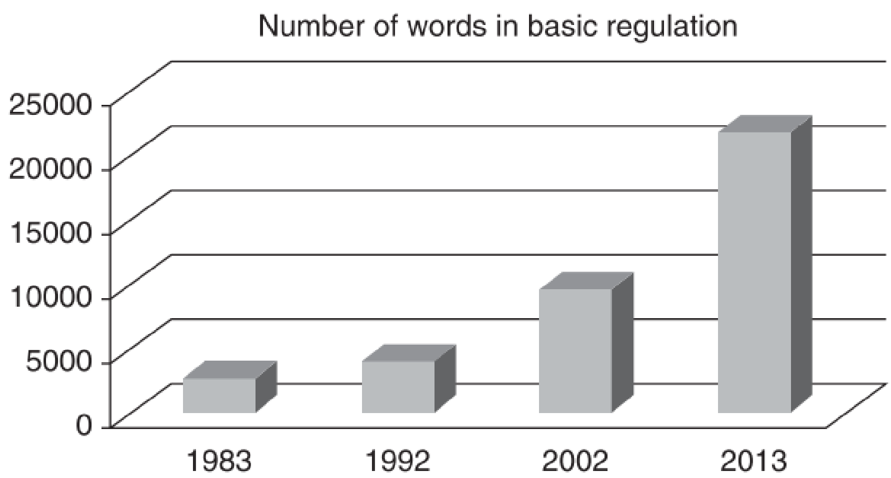

Figure 17: The evolution of the number of words on the basic regulation (Penas Lado 2019, 5)

The CFP tries to balance the different interests of various institutional and private actors, which makes change difficult. Most actors involved in fisheries dislike the complexity of the CFP, but they are very wary of what change might mean for them. The 2013 reform period saw many demands for change, but in the end, new elements were introduced (landing obligation, regionalization, MSY) rather than old ones renegotiated (TACs, quotas and relative stability), highlighting its policy path-dependency. The reason for a constantly growing CFP is the tendency towards clarification and enlargement of policy scope by including new policy principles. The evolution of the word count in the basic regulation (Figure 17) of the CFP serves as an illustrative example of this tendency (Peñas Lado 2016; Peñas Lado 2019): In 1983, the European Council adopted Regulation No 170/83, establishing a new generation of fisheries policy through the first CFP. The Regulation enshrined the concepts of **relative stability**, a **commitment to EEZs** as well as conservative management measures founded on **Total Allowable Catches** (TACs) and **quotas** (Verdins and Popescu 2025).In 1983, the European Council adopted Regulation No 170/83, establishing a new generation of a fishery policy and the first CFP. The Regulation enshrined the concepts of **relative stability**, a **commitment to EEZs** as well as conservative management measures founded on **Total Allowable Catches** (TACs) and **quotas** (Verdins and Popescu 2025).

Regulation (EEC) No 3760/92 was passed in 1992 as the first reform to the CFP. Its main goal was to counteract overfishing as a result of the serious imbalance that existed between catch potential and fleet capacity. Its goal was to reduce the size of the community fleet while simultaneously trying to absorb the social impact through structural reforms. It introduced **fishing effort** as a concept to restore balance between fishing activity and available resources and **access through a licensing system.** However, the 1992 CFP reform was not effective in addressing overfishing as the depletion of numerous stocks continued, sometimes at an even faster rate than before (Verdins and Popescu 2025).

The main goal of the reform in 2002 was to build a sustainable future for the fisheries sector by trying to balance job security for fishers, supply guarantees for consumers, while at the same time preserving fragile ecosystems. The reform introduced long-term approaches to fisheries management in the EU, such as the preparation of emergency measures in the form of **multiannual recovery plans** for stocks outside of safe biological limits and **multiannual management plans** for stocks inside safe biological limits. The reform, furthermore, created **Regional Advisory Councils**, which consisted of scientific experts, fishers, environmental groups, representatives of sectors related to fisheries as well as regional and national authorities, with the aim of giving fishers a greater say in the decision-making processes. The **European Fisheries Control Agency** was established in Vigo (Spain) as a result of the reform with the aim of ensuring effective and transparent monitoring (Verdins and Popescu 2025).

Again, the reform fell short of addressing the problem of overfishing and some stocks continued to further decline. Discards in fisheries became a publicly prominent issue in the inter-reform period that had previously remained unnoticed or had been ignored (Peñas Lado 2019). Due to this development, the Commission launched a public consultation process in 2009 in which new principles should govern EU Fisheries and bring them forward. For the first time, the Council and the Parliament were both part of the negotiation process and an agreement was reached on 1 May 2013 (Verdins and Popescu 2025). The new fisheries regime was to be based on three pillars (Verdins and Popescu 2025):

1. the new CFP (Regulation (EU) No 1380/2013),
2. The common organization of the markets in fishery and aquaculture products (Regulation (EU) No 1379/2013) and
3. the new European Maritime and Fisheries Fund (EMFF) (Regulation (EU) No 508/2014)

The reforms of the CFP show that there is an unwillingness to negotiate old elements, such as the relative stability key. Actors involved in fisheries dislike its complexity but are wary of what renegotiating old elements might mean for them. This makes policy more inflexible in reacting to changing boundary conditions, such as climate change. The 2013 reform is a good example of this. While the reform period saw many demands for change, rather than renegotiating old elements (TACs, quotas and relative stability), it saw the introduction of new elements (landing obligation, regionalization and MSY) (Peñas Lado 2019). This tendency is the reason for a constantly growing policy scope and deserves a closer look.

4.3.1 2013 CFP Reform

The main focus of the 2013 CFP reform is on long-term, environmentally sustainable fisheries and on achieving economic, social and employment benefits. The aspects of the latest reform to highlight are (Peñas Lado 2019; Verdins and Popescu 2025):

- **Maximum sustainable yields (MSY):**
  The latest CFP set MSY as the main target for all fisheries by 2022. Fishing mortality is set at F_{MSY} - the maximum rate of fishing mortality for a given stock and the basis for a MSY stock.

- **Landing obligation:**
  The discard of animals has been banned since 2019, except in special cases(De minimis rule).

- **Regionalization:**
  Decentralized governance is to bring decision making closer to the fishing grounds. EU legislators draw up the general framework while Member States develop the implementing measures and cooperate at the regional level.

- **Multiannual ecosystem-based management:**
  Bolster the role that in the 2002 reform had been given to multiannual plans by taking a more ecosystem-oriented approach, with multi-species and -fisheries plans within the regional framework of the EU's geographical areas.

Maximum Sustainable Yield is not only the management objective of the CFP but also of fisheries management in international law. MSY is most commonly defined using the definition provided by the Organization for Economic Co-operation and Development :

“Maximum sustainable yield [MSY] is the largest long-term average catch or yield that can be taken from a stock or stock complex under prevailing ecological and environmental conditions.” (EEA 2025a)

The exact interpretation and measurement of MSY, and in fact the concept of MSY in general, has been hotly debated. MSY can be measured and implemented through various approaches, each addressing different biological, economic, and governance dimensions. Measurement models may take the form of production models, age-structured models, or stochastic simulations. These models can be operationalized through different management targets, including sustainable harvest (F_{MSY}), a target biomass level (B_{MSY}) or a biomass threshold that triggers fishing reductions to prevent recruitment failure (MSY $B_{trigger}$) (Peñas Lado 2019). Besides these differences in the interpretation and implementation of MSY, there is some more fundamental critique of the concept at large. Prominent fishery scientist Sidney Holt considered MSY to be the:

> *“worst idea in fisheries management…[that]… both enthrones and institutionalizes greed. It is a perfect example of pseudo-science with little empirical or sound theoretical basis. As a target for management of fisheries, or even as the anchor for so-called ‘reference points’, it is inadequate and its pursuit increases the likely unprofitability, and even collapse, of fisheries.“ (Holt 2011)*

At the time of the 2013 reform, MSY was considered to be the best solution to achieving the objectives of Article 39. Above all, MSY for the first time represents an objective that aims at the long-term sustainability rather than short-term political considerations. However, the regulation did not specify whether MSY should be viewed as a limit or an objective, a range or a point value, fishing mortality or biomass (Peñas Lado 2019). Important to the discussion is also Article 119 of the United Nations Convention on the Law of the Sea (UNCLOS), of which the EU is a signatory. The Article says to *“maintain or restore populations of harvested species at levels which can produce the maximum sustainable yield, as qualified by relevant environmental and economic factors.” (UNCLOS 2025).* The wording “as qualified by relevant environmental and economic factors” clearly indicates that other considerations are to play a role that may deviate MSY from a single point value. With the EU being a signatory to UNCLOS, this aspect is important to bear in mind. There are two ways to implement MSY: through biomass (B_{MSY}) or through fishing mortality (F_{MSY}). The biomass approach sets out to bring a stock to a level where it can reproduce at maximum sustainable yield, while the fishing mortality approach exploits a stock only at a sustainable level, whatever the size of that stock may be. Implementing B_{MSY} consequently means accounting for all factors and therefore establishing more precautionary catch limits. Using fishing mortality as a management strategy proposes that harvesting happens based on abundance in a sustainable manner (Peñas Lado 2019). Fishing mortality instead of biomass is used for the implementation of MSY. B_{MSY}, however, is set as an aspirational objective as seen in Article 2 of the 2013 CFP:

"In order to reach the objective of progressively restoring and maintaining populations of fish stocks above biomass levels capable of producing maximum sustainable yield, the maximum sustainable yield exploitation rate shall be achieved by 2015 where possible and, on a progressive, incremental basis at the latest by 2020 for all stocks." (CFP 2013)

There are different opinions when it comes to the exact interpretation of the article. Some environmental non-governmental organizations (eNGOs) and researchers argue that fishing mortality values are to ensure biomass is above B_{MSY} levels (Peñas Lado 2019). The decision to exploit stocks at F_{MSY} rather than B_{MSY} stems from scientific limitations and policy implementation challenges. F_{MSY} represents the rate of fish removal rather than the stock size needed to achieve MSY. The rate of stock removal can be directly controlled by regulators through quotas and fishing effort restrictions. The approach fits within the governance frame of the old policy elements. The implementation of MSY is therefore a continuation of the old governance elements and does not provide for more flexibility. This is also true for the other newly introduced elements like regionalization and landing obligation.

Discards are a problem in fisheries in general, not only in the EU, and were identified as a systemic problem by the mid 1990's (Verdins and Popescu 2025). The Commission proposed a bottom-up and collaborative approach in 2007, but their proposal did not work. As a result, a top-down approach was implemented during the reform 2013 and a detailed discard plan was decided upon with a relatively short phase-in period and a specific delivery date. This was a high-profile political decision for fear that a long and gradual phase-in period would be seen as a political failure, highlighting the role of the political dimension in policy evolution. The reason for this top-down approach, despite evidence from countries such as Norway that a gradual and bottom-up approach yields better results, was a shift in public sentiment and attention towards the issue of discards (Peñas Lado 2019). Public attention, and consequently the political importance of a discard ban, has arguably led to a focus on the result of the current fisheries management rather than on the underlying causes of over-exploitation and missing fisheries control. The sweeping top-down approach has led to a one-size-fits-all solution for the entire EU fleet, despite drastically different discard numbers. In Article 15 of the 2013 CFP, the inter-annual flexibility (Article 15.10), cross-species flexibility (Article 15.8) and especially the *de minimis* tolerance (Article 15.5 (c)) were fixed in law (Peñas Lado 2019). *De minimis* exemptions allow for "*up to 5 % of total annual catches of all species subject to the landing obligation*" (CFP 2013, Article 15.5 (c)) to be legally discarded if there are limited environmental impacts, persistent selectivity challenges and disproportionate costs associated with landing the catches. Peñas Lado (2019) criticizes this one-size-fits-all approach and the EU dogma of a level playing field. He argues that too much attention was paid to politics, most notably how a strict policy would be perceived publicly, were given disproportionate weight. As a result, policy flexibility for different fisheries came to be viewed as a political loss, highlighting the influence of political sentiment on the policymaking process. By not taking the different realities of European fisheries into account, the landing obligation makes the policy more rigid.

Peñas Lado (2019) underlines that the landing obligation is an opportunity for the industry to develop the marketability of species that have so far been neglected. While I agree with him that the industry can develop new markets as a result of the current policy, I see this as a potential risk for species that so far have not been in the focus of the industry. The landing obligation in its current form, and embedded in the current system of EU fisheries governance, may encourage the exploitation of these non-managed species, paving the way for their overexploitation (Chapter 8).

The regionalization of the CFP offers significant potential for flexibility, particularly by establishing a legal framework that gives stakeholders a genuine voice and enables management that is more attuned to real-world issues. Although some Member States, such as the United Kingdom, initially viewed regionalization as an opportunity to shift decision-making power away from Brussels and partially re-nationalize the policy, this was never the intent of the European Commission. Instead, regionalization should be seen as a way to bring decision-making, especially on technical matters, closer to the fishing grounds and stakeholders. Therefore, making it more responsive to regional differences, specific needs, and adaptable to evolving circumstances and challenges (Peñas Lado 2019). Advisory Councils (AC) were introduced to become regionally focused or thematic bodies, reflecting the geographic and sectoral diversity of EU fisheries. Examples include the North Sea Advisory Council (NSAC), the Baltic Sea Advisory Council (BSAC), and the Long Distance Advisory Council (LDAC). Each AC is composed of representatives from the fishing industry, including small-scale and industrial sectors, as well as environmental NGOs and other stakeholders - such as consumer groups and aquaculture representatives. They provide non-binding advice to the European Commission, the European Parliament, and Member States on issues such as the implementation of the CFP, fisheries management plans, and conservation measures. Their recommendations are based on consensus, although minority opinions can also be recorded and forwarded to decision-makers. Stakeholder bodies are intended to play a crucial role within the framework of regionalization. Their proposals are supposed to form the foundation for regional measures agreed upon by the relevant Member States and largely replace national administrations in designing and brokering agreements. However, due to the complexity and diversity of legitimate stakeholder interests across Europe, this is challenging (Peñas Lado 2019). Accompanying a role change of the ACs in the 2013 reform was also a compositional change. The participation of non-industry interests was raised to 40% from one-third. While the role of Advisory Councils used to be a reactive one by commenting on initiatives by the Commission, the new ACs are expected to propose solutions to specific problems. However, except for the compositional change, their structure remained untouched (Peñas Lado 2019). Regionalization as a process within EU fisheries governance, therefore, has the potential to create more flexibility for fisheries management, which holds especially true under regional climate change uncertainty.

4.3.2 Inter-Reform Periods

The CFP is characterized by the need to balance stability with adapting policy and management to new circumstances. Inter-reform periods are necessary for a continuous adaptation of fisheries management in the EU. They provide time to implement and assess the effects of reforms, address new challenges and prepare for the next cycle of policy development (Peñas Lado 2016; 2019).
During inter-reform periods, the focus is on implementing the latest reforms and it involves putting rules, regulations, and measures into practice that were passed in the most recent reform cycle. Key aspects such as quota management, the promotion of sustainable fishing practices and most recently the enforcement of the landing obligation are monitored and adjusted as needed. The Commission, as well as the Member States and the industry, monitor the new rules and regulations during the inter-reform periods (Verdins and Popescu 2025; Peñas Lado 2019). This includes the impacts on stocks, the marine environment and the socio-economic status of fishing communities. The result of these monitoring activities are regulatory changes, updates to management plans, and the introduction of new measures to address specific issues without having to wait for a full policy overhaul. Towards the end of an inter-reform period, discussions normally begin in preparation for the next major reform. This process involves gathering input from a wide range of actors, including fisheries scientists, industry representatives, environmental NGOs, and Member States (Peñas Lado 2019).
Some substantial changes have been introduced in inter-reform periods, without touching on the legal basis of the previous reform. An example of such a change is Maximum Sustainable Yield. MSY as a long-term objective was progressively introduced following the 2002 reform via a Commission Communication and was effectively applied in practice prior to its formal consolidation in the 2013 reform (Peñas Lado 2019). The Commission’s publications in inter-reform periods are an indicator of their foci and future policy direction. The reports can give indications about possible future directions of the CFP, or at the very least, show the agenda with which the Commission is going to open the negotiation process (Chapter 4.3.3).
Four reports on the functioning and future of the 2013 CFP reform were published:

1. **Functioning of the CFP after the reform of 2013**
   Communication on “The common fisheries policy today and tomorrow”

2. **Protecting marine ecosystems**
   “EU Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries”

3. **Energy transition in the EU fisheries and aquaculture sector**
   Communication on “Energy Transition of the EU Fisheries and Aquaculture sector”

4. **Common market organisation**
   Report on “Implementation of Regulation (EU) No 1379/2013 on the common organisation of the markets in fishery and aquaculture products”

The functioning of the CFP after the 2013 reform is evaluated in the Communication on “The common fisheries policy today and tomorrow”, which is a comprehensive assessment of the Common Fisheries Policy since the last major reform in 2013 and outlines challenges and future priorities. The report highlights significant improvements in the sustainability of EU fisheries due to the implementation of the MSY approach, which has guided the setting of fishing limits. The reports see the move towards regionalization as successful by involving actors more directly and allowing for more tailored fisheries management measures at the regional level. Challenges are identified in the areas of compliance, balancing economic and environmental objectives and adaptation to climate change. One of the ongoing challenges identified is ensuring uniform compliance with CFP rules across all Member States. Effective monitoring and enforcement of the landing obligation are areas in need of further improvement. The report discusses the relevance to better balance environmental sustainability with the socio-economic viability of the fishing industry. It also emphasizes the increasing impact of climate change on marine ecosystems, fish stocks and consequently EU fisheries. It calls for the CFP to be more adaptive and resilient to these changes and outlines future direction and sets priorities for enhancing sustainability, supporting small-scale fisheries, strengthening regionalization and supporting innovation in fisheries. The report suggests that regionalization should be further strengthened to enable more localized and effective management of fisheries, tailored to specific regional ecological and socio-economic conditions (COM 2023c).

The protection of marine ecosystems is highlighted in the “EU Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries”, which outlines a comprehensive approach to enhancing the sustainability and resilience of marine ecosystems and fisheries in the EU. The plan is aligned with the European Green Deal and the EU Biodiversity Strategy, focusing on preserving marine biodiversity and improving ecosystem health, through which the long-term sustainability for the fishing industry is to be ensured. The action plan emphasizes the need to protect and restore marine ecosystems, highlighting their essential status for the sustainability of fish stocks and the

broader marine environment. It seeks to ensure that fisheries management practices contribute to the sustainability of fish stocks, the resilience of marine ecosystems and to expand habitat protections, reduced bycatch and rebuilding degraded marine ecosystems. Moreover, the plan proposes measures aimed at safeguarding critical marine habitats, including the expansion and effective management of Marine Protected Areas (MPAs), the implementation of ecosystem-based spatial planning, and the prohibition of bottom-trawling gear within MPAs. These measures form part of the present analysis and will be further examined in Chapter 8. By protecting and restoring ecosystems, the action plan seeks to enhance the resilience of EU fisheries, ensuring they can continue to provide economic and social benefits while adapting to environmental changes, such as climate change (EU Action Plan 2023).
The European Commission's Communication on the "Energy Transition of the EU Fisheries and Aquaculture Sector" outlines a strategy to reduce the carbon footprint of these sectors by enhancing their energy efficiency and promote the use of renewable energy. This initiative is part of the broader European Green Deal and aims to help the EU's fisheries and aquaculture sectors to become more sustainable, resilient, and competitive. It underscores the importance of aligning the fisheries and aquaculture sectors with EU climate goals, especially achieving climate neutrality by 2050 through the reduction of greenhouse gas emissions. It emphasizes the need to decrease the sectors' heavy dependence on fossil fuels, reducing their carbon emissions and vulnerability to fluctuations in energy prices. Limited access to financing and the high cost of adopting new technologies are the main barriers for small-scale fisheries. The communication promotes the use of renewable energy and improving the energy efficiency on-board, suggesting an increased use of the EU’s structural funds. It highlights capacity building and innovation support as key for the future. Collaboration between industry stakeholders, governments, and research institutions to achieve the energy transition is put at the center (COM 2023a).
The European Commission's report on the "Implementation of Regulation (EU) No 1379/2013 on the Common Organisation of the Markets in Fishery and Aquaculture Products" assesses the effectiveness of the Common Market Organization (CMO) Regulation in achieving its objectives. Its objectives are to stabilize markets for fishery products, improve transparency and promote sustainable fishing practices and sustainably sourced products to align them with the broader objectives of the CFP and the European Green Deal. The report notes that the implementation of labeling requirements has improved market transparency by allowing consumers to make more informed choices, thereby promoting products from sustainable sources. The regulation has contributed to greater market stability, particularly by enhancing the role of producer organizations in managing supply and demand, helping to stabilize prices. The report identifies inconsistent implementation of CMO Regulation among the Member States – especially the role of producer organizations. The report underscores the

importance of strengthening producer organizations to further enhance market stability. It suggests that producer organizations could benefit from additional support and funding, particularly in developing and implementing plans that support goals. The report recommends stronger enforcement of the CMO Regulation across Member States to ensure consistent application (COM 2023b).

4.3.3 Potential Future Policy Priorities and Direction of the CFP

These inter-reform period reports and communications have key foci in common. They emphasize biodiversity conservation and habitat protection as well as the sustainable harvesting of stocks under an MSY regime and the continued expansion of stakeholders' involvement in management decisions through processes of regionalization. Likely, these foci will be present in the Commission's green paper for the start of the upcoming CFP negotiations, either in 2025 or 2026. However, a likely scenario can be that rather than introducing new concepts, the green paper is going to focus on the full implementation of the concepts of the 2013 reform (Möllmann, C. 2025, personal communication). What remains to be seen is how this is received in the Member States and by the Council, the Parliament, the industry and environmental NGOs. Besides fishery specific elements, the negotiations about the future policy and its implementation are also going to depend on the political realities within the broader context of the European Union. The 2024 European Parliamentary elections have seen a right-wing push as have many national elections (van Rij et al. 2024). The fisheries committee is an example of this right-wing push. Fisheries have always been dominated by national interests and it remains to be seen what impact on actual policy an influx of nationalist politicians might have. Looking at the Commission's reports and communications discussed above, it is likely that some proposals will be supported while others are going to be rejected.

The broader politics of the EU are likely to support a continued push for regionalization, while there will likely be some push back against further expanding environmental conservation priorities. At the European parliamentary elections on June 6th, 2024, the far-right European Conservatives and Reformists Group (ECR), Patriots for Europe Group and Europe of Sovereign Nations (ESN) together won 187 seats. They did not perform as well as anticipated by many experts ahead of the election (van Rij et al. 2024), but their influence on both European and Member States politics could have a profound impact on European fisheries' governance. As of 2024, there were six far-right parties in government in Europe: Finland, Italy, Croatia, Hungary, Slovakia and the Czech Republic (Politico 2024), potentially affecting the composition of the European Council and Council of Ministers. Eurosceptic parties and their leaders have an influence on the positions that Member States take in the Council, favoring national processes instead of European ones. Moving decision power from Brussels to Member States could be seen as a major victory by Eurosceptic parties even beyond fisheries governance. Brexit has shown what a major (symbolic) influence fisheries rights have compared to their share of the GDP in both the United Kingdom and the European Union. While the EU sought to protect one of the only policy sovereignties that it has, in the UK, fisheries served as a symbol for an overreaching Brussels (Peñas Lado 2019).

In the European Parliament's (2024-2029) Committee on Fisheries (PECH), a nationalist political shift is also visible. One of the committee's Vice-Chairs, Guiseppe Milazzo from Italy, is a member of the ECR. Other far-right MEPs in the committee are from Croatia, the Netherlands, Hungary and France. Germany's only regular member, Siegbert Frank Droese, is a member of the far-right Alternative für Deutschland (AfD). In total, seven out of 27 regular members are far-right candidates (PECH 2025). However, not only is the composition of the PECH important in determining fisheries policy, but also the wider make-up of the European Parliament. Deals struck in fisheries are dependent on wider political considerations within the Union. Some of the far-right's main concerns are migration, European enlargement and foreign policy towards regimes such as Russia. Fisheries policy might be used as a bargaining tool with regard to these wider political concerns.

European climate policy, particularly the Green Deal, is a prominent policy area under attack by the far-right. While policies, directives and acts related to the Green Deal have been finalized, their implementation could be undermined in the future. The ECR Group opposes the 90% carbon reduction target by 2040 that was proposed by the Commission (van Rij et al. 2024). Strongly opposed by the far-right is also the Nature Restoration Law that seeks to rehabilitate at least 20 % of the EU land- and seascape by 2030 – with the aim of restoring all degraded land by 2050. The pan-European protests by farmers have shown that these issues are media-effective and good publicity for far-right parties. As a result, and in reaction, some centrist parties are already walking back their commitments to the Green Deal. A prominent example is the European People's Party's (EPP) manifesto opposing the phase-out of combustion engines by 2035 (van Rij et al. 2024). These changes to the overall policy direction by center right parties could have a significant effect on fisheries governance. Although it is difficult to predict what influence these policy trends are exactly going to have. However, with the new seat allocations in parliament and a rather conservative PECH (PPE=7) the role of nature conservation going forward could experience more difficulty than in the past.

Regionalization and conservation are greatly influenced by the wider political context within the European Union. A continued expansion of regionalization is, on the one hand, beneficial for the flexibility of fisheries governance and, on the other, seen as a win by the right-wing and conservative movement. Regionalization is therefore likely to be expanded, while a continued expansion of conservation policy will probably experience headwinds.

4.3.4 Policy Interactions and the CFP

Fisheries governance in the EU does not happen in a vacuum of input and output controls or technical, but is integrated into horizontal and vertical institutional frameworks that influence how decisions are made. The following highlights the effects of these policy interactions through the example of the Common Organisation of the Market's influence on the self-management of the brown shrimp fishery. This will show that, when talking about fisheries governance, it is not enough to talk about the politics, polity and policy dimensions with regard to harvesting quantities, but that a wider lens needs to be applied.

The Common Organisation of the Market (CMO) is a CFP pillar that ensures the economic viability of fishery as well as aquaculture products. Producer Organizations are officially recognized within the CMO as institutions with the goal of improving the economic return for their members and promote sustainability. They are explicitly allowed to adjust their production to meet market requirements through a marketing and production plan that stabilizes prices (Steenbergen et al. 2017).

Producer Organizations have traditionally played a key role in fisheries management. In Germany, for example, the POs used to have a self-imposed landing cap until the 1980's that were developed in conjunction with the industry (fisher, 2025, personal communication). In the CMO, producer organizations are recognized as instruments to deliver the CFP objectives through production and marketing plans and are subject to competition regulations. In the Member States, competition regulators are in charge of consumer protection and the interpretation of consumer protection regulations. Consumer protection regulation authorities in the Netherlands played a significant role in the self-management process of the brown shrimp fishery, highlighting that fisheries governance functions within the broader governance framework of the EU. In the Netherlands, the role of the Dutch Authority for Consumer Protection and Markets (ACM) is to ensure well-functioning markets and the fair treatment of consumers and investigate grievances (Steenbergen et al. 2017).

The 1990's had seen a rapid increase in landings of brown shrimp, resulting in low prices and a saturated market. Producer organizations from the Netherlands, Germany, and Denmark, along with trading companies, established a trilateral body intended to set a minimum shrimp price and restrict landings. The brown shrimp market structure was oligopolistic, with the two largest traders controlling 75-85 % of the market. The ACM in 1999, after a complaint by a new trading company, started an investigation into the existing market organization. For infringements of the European competition law, agreements on landing limits and minimum prices, it fined the parties to the trilateral agreement €13.8 million in 2003. The ACM ruled that the absence of a TAC on brown shrimp suggested that the landings limits were not within the management responsibilities of the producer organizations. The same was ruled to be the case for claims by the industry that landing limits were in part a tool for the conservation of the shrimp. Regarding the minimum prices set, the ACM ruled that minimum prices were outside of the guidance and withdrawal prices with the CMO, when in fact the prices were substantially higher than the European guidance and withdrawal prices (Steenbergen et al. 2017).

In 2007, a few years after the ruling, the Dutch brown shrimp fishing industry entered the process of Marine Stewardship Council certification and, consequently, self-management once again became an issue. For the MSC certification, the industry needed to prove that they 1) sustainably target stocks, 2) that there is a minimal environmental impact of the fishing activity and 3) that they have an effective management scheme, which included a self-management plan based on a Harvest Control Rule (HCR) and mesh size restrictions. This time, the industry consulted the ACM to determine whether their management plan was consistent with competition regulations. The ACM regarded the Harvest Control Rule as yet another attempt to raise prices and ruled that scientific evidence was required to demonstrate its necessity for stock conservation. Following this, research concluded that fishing is the main mortality driver of adult brown shrimp and that current levels of exploitation could lead to growth overfishing (Temming and Hufnagl 2015). This led the Dutch ministry and industry to establish an NSAC Brown Shrimp Focus Group in 2011. An ICES request from the German and Dutch governments resulted in advice in 2014: *"management of the Crangon crangon fishery in the North Sea would have benefits for the fishery in terms of sustainable yield and for the environment (taking ecosystem, mixed-fisheries, and multispecies considerations into account)" (ICES 2014, 1).* There was, however, a lack of consensus regarding an EU-level management request, driven by ongoing fears that EU management might entail the implementation of TACs. In 2015, the German and Dutch fishers abandoned their individual MSC certification attempts and started, together with the Danish fishers, a trilateral MSC certification (Steenbergen et al. 2017).

The brown shrimp case shows the role of horizontal policy pathways in natural resource management. In theory, given the vertical and nested embeddedness of the fisheries policy framework, there should be no barriers to self-organization. The CFP and national fisheries management regulations provide ample scope for POs, at both the collective action and operational levels, to implement management measures. However, EU competition law—and its interpretation in the Netherlands—operates in parallel to the fisheries management framework, and the interaction between the two significantly affects the industry's capacity for self-organization.

The brown shrimp case study highlights the importance of closely aligned parallel institutional frameworks. If there is ambiguity in the translation of rules from the constitutional level to the collective action level (vertical interaction), or if there is a mismatch between different institutional frameworks at the same level (horizontal interaction), it affects sustainable management at the collective action level (Chapter 2.4.2). Parallel constitutional regulations, which may not initially appear related, are an integral part of this resource management context as shown in the case of the brown shrimp (Lewis and Aligica 2024; Steenbergen et al. 2017).

4.4 Politics: Negotiating the Common Fisheries Policy

The interplay between policy change and stability is the result of the balance between actor groups that traditionally dominate policy debates and usually tend to favor stability. Policy change can happen when advocacy coalitions impose new policy images and implement those through shifts in leadership. However, radical change happens most often due to outside factors in policy communities (Orach et al. 2017; Orach and Schlüter 2021).

Policy decisions have long been dominated by the fishing industry. The 2013 reform has seen somewhat of a change to that status quo, as environmental NGOs have used changes in political leadership and the co-decision process to their advantage. As a result, two out of three main elements of the latest reform were not supported by the industry: the *landing obligation* and *MSY objective by 2020*. The third one – *regionalization* - was only supported by some within the industry (Peñas Lado 2019).

The 2013 reform process was the first that followed the ratification of the Lisbon treaty in 2009 and brought in the European Parliament as a co-decision maker (Peñas Lado 2016), thereby reshaping the institutional field (polity) in which negotiations are taking place (Orach et al. 2017). During previous reforms, lobbying of interest groups usually took place at the national level and, to some extent, in the Commission. With the inclusion of the European Parliament, environmental interest groups (IG) focused their efforts on Brussels (Orach et al. 2017) and were better able to integrate their preferences into the 2013 CFP reform compared to industry groups. While environmental IG coalitions were able to self-organize and present common and coherent ideas, the industry suffered from internal disagreements. While the industry might not have been able to prevent the introduction of the landing obligation or MSY, the industry did, however, affect the way reforms were implemented. It successfully included the gradual implementation of a discard ban and a *de minimis* regulation (a minimum amount of discards in cases where selectivity is difficult to achieve or disproportionately costly) (Orach et al. 2017).

Not only the inclusion of Parliament in decision making (Peñas Lado 2019), but also the pro-environmental orientation of decision makers and public sustainability sentiment played a major role in the success of environmental interest groups in lobbying the reform process. The industry failed to successfully adapt to the changed institutional framework and public sentiment as expressed in the following quote of an environmental interest group representative taken from Orach et al. (2017, 95):

> *"The Commission usually came out with good proposals, ensuring sustainability, but the Council would then put a different reality onto it. They are the member state governments, they are under pressure from the fishing sector and there is a lot of money at stake, so they would usually water the policies down … But at the same time the Lisbon treaty was about to come into force, so for the first time we would have the Parliament involved in the fisheries reform as well […] Suddenly you have two political players as co-decision makers and the MEPs are directly elected, so they are much more open to having public speak to them because they are looking at their votes."*

The industry focused on lobbying at the national level and trying to influence the Council's position. It was present during the agenda setting stage in the Commission, indicating that it simply chose not to lobby Parliament (Orach et al. 2017). This shows that the industry miscalculated the impact that institutional change (polity) had on the political process (politics) and finally the policy decision. Besides this, pro-environmental positions held by key decision-makers also greatly influenced the ability of environmental IGs to include their ideas in the reform:

> *"During the time we were also very lucky. We had in a way a little bit better fisheries committee than we normally have because we had Isabella Lövin from Sweden, who was extremely engaged and outspoken. She actually changed, in my view, the whole feeling of the committee because before the MEPs just wouldn't show up. If you came to a committee meeting, there were 2–3 MEPs there and then some assistants – and that was it. And then she was there. Ulrike Rodust, a German MEP who had the file, was very engaged, Chris Davies, an MEP from the UK, was also very engaged, setting up a cross-party group called Fish for the Future. Suddenly at each meeting there were 6–7 MEPs who spoke, who actually created a bit of a 'critical mass', and there were much better reports coming out of the Committee than we had seen in the previous legislature."* (Environmental interest group representative in Orach et al. 2017, 96)

Beneficial to pro-environmental IGs was the public interest in a discard ban, fueled by eNGOs on the one hand and by campaigns like "FishFight" that advocated against the high levels of discard in European fisheries:

> *"Discards were not such a big part of the proposal. I think this came out just before the proposal was out. So, he [Celebrity Chef] reinforced the idea of a discards ban and it really became a priority for the Commissioner because of this message. Because of this video that went viral, they heard complaints from the UK people: "why are you throwing fish overboard?" This made the discard*

ban, especially in the UK, politically hard to go against. Because there were already people signing up the petition … This was a very big impact and it directly changed the proposal." (Environmental interest group representative in Orach et al. 2017, 96)

The EU Parliament is, however, not unanimously pro-environmental protection. On January 18th 2024, Parliament voted in favor of two own-initiative reports that were pushed through by then EPP rapporteur Gabriel Mato (371 in favor, 92 opposed, 92 abstentions). Mato calls on fisheries not to be "sacrificed on the altar of the environment" (Struna 2024). The reports are critical of several elements of the 2013 reform like MSY. He calls on the Commission to appoint a dedicated fisheries commissioner, arguing that Virginijus Sinkevičius's dual role as Commissioner for both Fisheries and the Environment is problematic. With regard to the action plan of the Commission, Niclas Herbst (EPP) criticized that the Commission did not sufficiently take into account socio-economic factors. In his view, the simple ban of bottom-trawling should be replaced by regional solutions – developed in conjunction with regional actors (Struna 2024).

Looking towards the new CFP reform process, it remains to be seen if the pro-environmental attitude of the Parliament remains. The industry may have learned from its mistake(s) ten years ago and is allocating more resources to lobby the EU Parliament. With the far-right gaining seats in Parliament in the 2024 European elections and potentially gaining more power, both in the Council and in the Commission, it remains to be seen what influence these politicians are going to be able to wield in the reform process (van Rij et al. 2024). With Europe still recovering from high inflation and firmly engaged in the war in Ukraine, it might be possible that environmental protection in fisheries is used as a horse trade to get concessions in other policy areas.

The legal basis is often not the reason for the pre-eminence of rigidity in European fisheries, e.g., management instruments such as TACs, as this chapter has hinted at. It is the conservatism of traditional practice that stands in the way of a more flexible governance system (Peñas Lado 2019). Article 39 of the TFEU does not indicate that every single technical detail needs to be specified. To a large part, this was done because of the high value that Member States are placing on the notion of a level playing field (Peñas Lado 2019). Therefore, it is not solely the policy of the EU that determines fisheries governance but also political negotiation processes and the electoral systems that shape them.

4.4.1 Politics, Institutions and Geography

While the interplay between political success and institutional structure on green policies has been acknowledged and researched, the role of geography has been largely overlooked (Rickard 2022) in fisheries. After having examined the role of interest groups at the European level, the following will describe and analyze the green subsidy share in fisheries through a geography lens - focusing on the role that the electoral institutional setup plays in Member States. Using commercial and recreational fisheries as examples, I will show the influence of geographic concentration of the fishing sector on the lobbying success of interest groups with regard to green policies.

Interest groups that are geographically concentrated, such as the fishing industry, often hold a political advantage in nations with plurality electoral systems, single-member districts, and candidate-centered elections. Conversely, interest groups that are more widely dispersed tend to wield greater influence in countries with proportional electoral systems and party-centered electoral competition. This carries significant implications for environmental policy, as competing interest groups frequently possess different geographic characteristics. Extractive industries, for instance, are often geographically concentrated due to their reliance on respective natural resources (Shelburne and Bednarzik 1993).

The fishing industry is one such example, as its dependence on fish stocks results in regional concentration. Consequently, it is able to exert greater political power in plurality electoral systems, where politicians compete for votes within clearly defined geographic constituencies. In contrast, in proportional representation (PR) systems — where parties receive legislative seats in line with their national vote share — the fishing industry tends to have less political sway. Environmentalists, often more dispersed geographically, generally have a stronger influence in PR systems compared to plurality systems (Rickard 2022). Countries that have proportional electoral systems and party-centered electoral competition are more likely to allocate a higher portion of their total subsidy budget to environmentally friendly subsidies, all else being equal. Furthermore, when accounting for electoral institutions, countries with more successful Green parties also tend to dedicate a larger share of their total subsidy budget to environmentally friendly subsidies (Rickard 2017; 2022).

Consequently, political parties in PR systems are less focused on garnering votes in any particular region. In fact, catering to the demands of geographically concentrated groups can undermine a party's appeal on a national level, potentially reducing its overall share of the national vote. This could be detrimental for parties in PR systems, where legislative seats are allocated in proportion to the percentage of votes received (Rickard 2017). On average, in countries with a PR system, green subsidy shares are 22 % higher compared to plurality systems, even when Green party vote shares are included. When Green parties win a larger share of the vote, more is spent on environmentally friendly programs. An increase in the vote share by 5 % results in a 9 % point increase in green subsidies (controlled for GDP per capita and the size of the fishing industry) (Rickard 2022).

Based on research and a classification system by Rickard (2022), green subsidies in Germany account for about 95 % of the total subsidies, while in France and Spain, it amounts to only about 10 %. Looking at the electoral systems and the size of the industry in countries can help to explain this discrepancy. France has a majoritarian electoral system and is a unitary state with power centralized in Paris (EU France 2025; Nohlen and Schultze 2010). It had the second highest share (14.1 %) of landings in the EU by weight in 2021 (STECF 2023). While Spain has an electoral system of proportional representation, it is a unitary state with much power residing in Madrid and the highest share in landings (EU Spain 2025; Nohlen and Schultze 2010; STECF 2023). These observations at least raise the question of how state structure and the electoral system play into the adoption of green policies.

A sector that could further lend support to my argument of the importance of geographic concentration and electoral system success is recreational fishing. Marine recreational fishing in the EU has an economic footprint of €10.5 billion and supports about 100 000 jobs. In select cases, it also has a big impact on stocks, with 1.8 % of mackerel (ICES division 3 & 4) and 72 % of European eel (ICES division 3a,4 & 7) catches being done by recreational fishers (Hyder et al. 2017). Despite this, in part, significant impacts (Ferter et al. 2013), recreational fisheries are underrepresented in discourses about fisheries management. Part of the explanation may lie in the geographical distribution of recreational anglers and the political influence they exert as voters. By virtue of being geographically displaced, they represent an influential voting section in electoral systems of proportional representation (Rickard 2017; 2022). Regarding green policy implementation, this dynamic could manifest as comparatively weaker regulations for anglers, reflecting politicians' apprehension in jeopardizing a key constituency of voters. A German study by the Thünen-Institute helps to paint a picture. The study looked at 21.000 recreational fishers from 2005 to 2015 and found in on-site surveys that the annual cod catch varied between 1.2 and 2.7 million cod on the German Baltic coast. On average 140.000 anglers had a total annual effort of 1 million fishing days (Strehlow 2022).

As seen in Figure 18, landings from the commercial and the recreational fishery move closer together from 2005 to 2015. While commercial landings of cod decreased by 60 %, the recreational fisheries' landings increased by about 10 % compared to 2005. In 2015, the landed catches by the recreational sector actually exceeded those from the commercial fisheries. The study also showed that only about 30 % of the interviewed boat anglers were from either of the two federated states bordering the Baltic Sea, Schleswig-Holstein or Mecklenburg-Western Pomerania (Strehlow 2022).

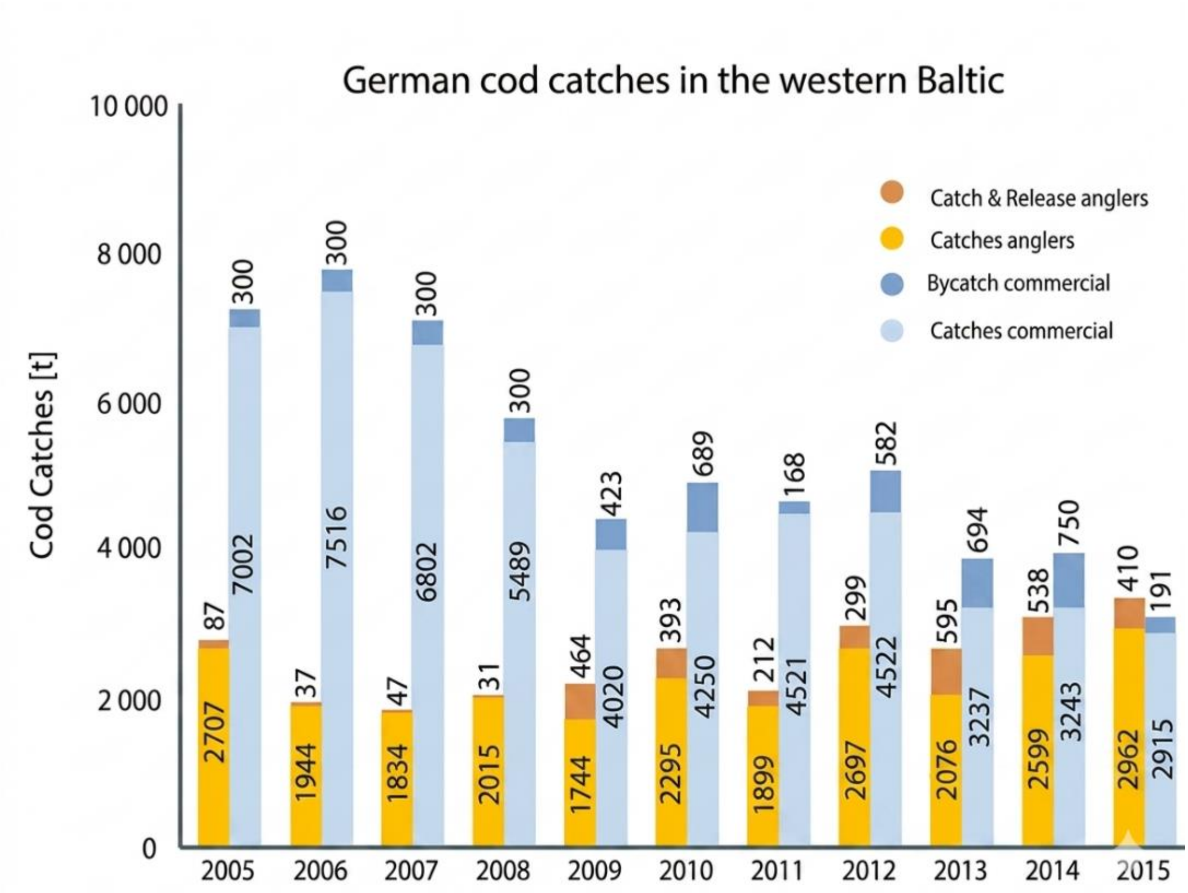

Figure 18: German Cod catches in the western Baltic distinguishing between commercial and recreational fisheries from 2005 to 2015 (adapted from Strehlow 2022).

This shows that the marine recreational fishery sector is far less geographically clustered than the commercial sector with potential voters distributed across Germany - which is of special relevance in a system of proportional representation (Rickard 2022). According to the "Deutscher Angelfischer-Verband e.V" in Germany, 6.64 million people over the age of 14 participated in recreational fisheries at least once in 2021, representing a huge potential voter pool (DAFV 2023). This is reflected in the 2021 German government's coalition agreement's one paragraph referring to fisheries:

„Wir setzen uns für den Erhalt der Fischerei an unseren Küsten ein. Wir werden auf europäischer und internationaler Ebene eine faire, wissenschaftsbasierte Ermittlung und Zuteilung der Fangquoten einfordern. Dazu werden wir eine „Zukunftskommission Fischerei" initiieren, um Empfehlungen für eine nachhaltige Fischerei und Aquakultur, Binnen- und Hochseefischerei zu erarbeiten. Wir wollen die Grundschleppnetz-Fischerei beschränken und Fangtechniken artenspezifisch anpassen sowie eine naturschutzgerechte Regulierung von Stellnetzen. ***Wir erkennen die Leistung der Anglerinnen und Angler für den Natur- und Artenschutz an****."* *(Coalition Agreement 2021, 37)*

„We are committed to preserving fisheries along our coasts. We will advocate for a fair, science-based assessment and allocation of fishing quotas at the European and international levels. To this end, we will initiate a "Future Commission for Fisheries" to develop recommendations for sustainable fisheries and aquaculture, both inland and deep-sea. We aim to restrict bottom trawling, adapt fishing

techniques to specific species, and implement nature-friendly regulations for set nets. ***We recognize the contributions of anglers to nature and species conservation****." (Coalition Agreement 2021, 37)*

While the second last sentence lays out the changes and restrictions for the commercial fisheries, recreational fishers are highlighted as important for nature conservation and stock protection without referencing the potentially deleterious impacts of recreational fisheries – as the example of recreational cod catches in the western Baltic shows (Strehlow 2022). The German electoral system could serve as an explanation for highlighting recreational fisheries in such a positive light. With recreational fishers distributed across the entire country, their impact on the electoral success of parties could be significant.

4.5 Integrating Rigidity, Uncertainty and the Common Fisheries Policy

I have shown, through the use of the political dimensions polity, policy and politics, that the CFP is characterized by rigidity at the European level - and a high level at that. Its rules are neither easy nor quick to change and laid down as legislation in detail (Peñas Lado 2019). The CFP is not only rigid, but it is also complicated and mistrust among the Member States made it necessary to agree on all details, which led to long negotiations between 1977 and 1983. The waves of successive enlargement of the Union have since continued to fuel this tendency. An emphasis on securing vested interests has led to a complicated policy that does not allow for a flexible interpretation of different Member States (Peñas Lado 2019) and is therefore ill-equipped to deal with rapidly changing context conditions - such as Climate Change.

The inclusion of Parliament in the decision-making process through an institutional change of the Treaty of Lisbon (polity), although a democratic necessity, has arguably made the process even more rigid. Two main outcomes are the result: 1) a decision-making process that has become so complicated and time consuming that there is little willingness to react to emerging developments or new circumstances once a decision is made and 2) too much emphasis is put on negotiating technical details, such as relative stability, rather than overarching political questions (politics) (Peñas Lado 2019). By sidestepping larger political questions and diving into technical details, the EU is ill-equipped to deal with the uncertainty that climate change brings. While some stocks show spatial variability without clear trends, others show unambiguous trends in their movements northward (ICES 2016). As a result, the CFP's fixed spatial management is going to produce mismatches between regionally present fish stocks and the TAC allocation. ICES (2016) identified 19 species that showed changes in their spatial distribution, with eight species of “big movers” (Anchovy, Anglerfish, Cod, Hake, Herring, Mackerel, Megrims and Plaice). The report concludes that:

“The main management implication is the mismatch between regional abundances and TAC allocation, with hake and mackerel as clear examples. This mismatch, in combination with the landing obligation, could result in choke species issues and challenges the relative stability currently used to distribute quotas.” (ICES 2016, 2)

ICES identifies main risk areas that will be affected by climate change induced species shifts. The report names the seas west of Scotland (northward shift), the Celtic Sea (warming and lower primary production), the Norwegian Sea as well as Skagerrak and Kattegat (increase abundance) and the North Sea (warming and latitudinal shift) (ICES 2016). The EU’s system of relative stability (TAC and quota system) is based on ICES management areas. As a result of climate change, the distribution of many stocks is changing at an unprecedented speed. The association between stock abundance and management areas is becoming increasingly obsolete. This represents the most pressing challenge that the CFP is facing within the context of climate change (Peñas Lado 2019). As already mentioned, the CFP is structurally and conceptually ill-equipped to deal with and manage the speed of these changes and the uncertainties that climate change is bringing.

However, to a certain degree, institutional inertia is a positive attribute because it ensures stability within a governance system in the face of short-term fluctuations. Problems arise when necessary change is resisted, leading to two major consequences. First, fish stock sustainability can be endangered if institutional arrangements do not adjust to changing environmental circumstances. Second, when a mismatch between the governance mechanisms and ecosystem functioning occurs In the European Union, climate change driven range shifts of species pose challenges to previously established jurisdictional boundaries. This may lead to conflicts between countries within the EU but also with neighboring states (Peñas Lado 2019).

Moreover, climate change exerts diverse effects on fish stocks, including distributional shifts, recruitment failures, and in some cases enhanced productivity (Saborowski and Hünerlage 2022; ICES 2016) . However, evidence of the effects of this shift on institutions is still lacking (polity). Changes in stock distribution are undoubtedly going to lead to the revision of scientific areas and, therefore, to a mismatch between scientific and management areas. While changing scientific areas is not a quick process in and of itself, and scientific advisory bodies show their own institutional inertia, reforms in scientific areas do occur as the case of plaice in the North and Baltic Sea shows. ICES changed scientific areas in 1992, 2013 and 2016 while management areas remained the same. Changes to management areas, however, likely require the renegotiation of the relative stability key. Because this key serves as the structural backbone of the CFP, political actors are deeply reluctant to revisit it—illustrating the tension between what policy demands and what politics permits (Schuch et al. 2021).

The most prominent example of a mismatch between species distribution and management area is that of the horse mackerel (*Trachurus trachurus)*. It also gives insight into the political process of renegotiating management areas (politics) and may foreshadow things to come. While mismatches between scientific and management areas are not uncommon in EU fisheries management, there has only been one case where the management area has been adjusted to match the one: the horse mackerel, specifically the Western stock (France, Norway, Ireland and the UK) and the North Sea stock (France, Germany, Denmark, Sweden, Norway and the UK) (Schuch et al. 2021). In the following, Schuch et al.'s (2021) analysis of the institutional inertia of adjusting management areas will be examined using the analytical dimensions polity, politics and polity. The horse mackerel case serves as a glaring example of how long scientific and management areas that are mismatched take to be resolved.

ICES first pointed out in 1999 that management and scientific areas did not match for both stocks, however, only in 2010 did the process of renegotiating the management areas and recalculating national quotas conclude. During the whole process, fishing quotas were distributed based on knowingly outdated management areas (Schuch et al. 2021). The timeline of the negotiations showcases this protracted process. Only in 2005 did the Pelagic Advisory Council agree with the assessment of ICES that the management area should match the scientific area for the horse mackerel and started pushing for a long-term management plan. In July of 2007, the AC proposed a management plan to the Commission based on the scientific area, assuming the alignment of scientific and management area. The plan, however, did not address the implications for national quotas and the Commission discussed the calculation of new quotas for the new management areas in a non-paper (a non-binding and unofficial discussion paper). While the Commission wanted the Pelagic AC to weigh in on the issue, the AC declined, stating that it was a *"political issue, which should be left to the Member States to be resolved"* (politics) (Schuch et al. 2021, 7). The Commission sent the proposal for the management plan to the council in 2009, without having solved the issue of national quotas. It did not present a plan how the changes to the agreed TAC would translate to national quotas and acknowledged in the Annex of the proposal that the mismatch between scientific and management areas undermined the principles of good governance. The Commission simply proposed the TAC for the Western Stock of horse mackerel to be increased and the North Sea stock to be reduced (Schuch et al. 2021). It produced another non-paper (DS 621/09) in which the possibilities for a sharing rule for the new TAC were discussed. The discussion between the parties revolved around using past catches or average national quotas as a benchmark for the new stability key, with member states arguing opportunistically depending on which solution worked to their advantage. In the end, a partial agreement was reached due to the implementation of a flexibility clause through which parts of the catch of the Western quota could be used under the North Sea quota and vice versa (Schuch et al. 2021). The first new official quotas were released in January of 2010 and France, Germany, the Netherlands, and the United Kingdom were allowed to declare 5% of their North Sea stock quota under the quota for the Western stock. Similarly, Denmark, Germany, France, Ireland, the Netherlands, Sweden, and the United Kingdom could declare up to 5% of their Western stock quota under the North Sea stock. This redistribution of quotas had substantial implications for the allocation of fishing opportunities for the North Sea and Western stocks, as Denmark historically held the majority of the TAC for the North Sea stock. The relative size of the Danish quota was reduced by around 20 percentage points, while the Netherlands' share of the North Sea TAC increased by about the same amount. The stock shares for other countries remained relatively stable, with changes of around 1 to 2 percentage points. Adjustments to the relative stability key for the Western stock were smaller. Ireland increased its share by about 3 percentage points, while the Dutch share decreased by about 5 percentage points (Schuch et al. 2021). However, when the Western and North Sea quotas are combined, there were no major changes to quota allocations. Denmark experienced the largest drop in quota shares with 1.6 % and Ireland experienced the largest increase with 0.25 % (Schuch et al. 2021).

The alignment of the scientific and management areas for horse mackerel was agreed on because, in the end, it was a division of biomass into two quotas. The Member States received about the same amount of quota as before and therefore the process produced no real losers. A case that would involve a true re-distribution of quotas would be even more challenging (Schuch et al. 2021). A northward shift of stocks could lead to conflict between Member States but also with non-EU countries, such as Norway and Iceland. The EU lacks a transparent institutional (polity) or policy mechanism of resolving mismatches between scientific and management areas, but rather relies on political negotiations (politics). Adjustments are decided on a case-by-case basis, which makes the process even more protracted and uncertain in its outcome. Climate change will increase cases of misalignment, making a political solution necessary and tricky at the same time.

Schuch et al. (2021) highlight that scientific bodies like ICES and STECF, alongside policy and administrative entities such as the Council, function with distinct role identities. They argue that a significant challenge has been the interaction between scientific and policy institutions within the EU fisheries management framework and that this leads to different prioritizations throughout the management process. I argue that while distinct role identities exist, the major issue is ironically a missing political process. A missing political process in which clear objectives are negotiated that lead to institutional (policy) and policy changes, based on which advice from the different bodies can be weighed against one another. Political negotiations are therefore the reasons for the rigidity of fisheries governance, but also the solution to the system's failings.

A political process that negotiates clear objectives is not only necessary at the EU, but also at the Member State level. Without clear objectives of Member States that consider their regional specificities, the political process that is needed to adapt to climate change is difficult to achieve. Germany serves as an example of missing regionalized objectives, which hinders adaptation spanning from administration via science to the fishers themselves.

5 Fisheries Governance: Germany

Apart from the EU, the Member States also play an important – although sometimes overlooked role in European fisheries governance. Under the Common Fisheries Policy, EU member states enforce fisheries conservation and management measures via EU Fisheries Regulations by modifying their national Fisheries Acts. They are also required to fully comply with the United Nations Convention on the Law of the Sea and the United Nations Fish Stocks Agreement (MSC 2023). This chapter will explore the role of Germany as a Member State in fisheries governance, specifically in the brown shrimp fisheries, and will try to show that a lack of regionally specified objectives contributes to the overall system rigidity under climate change conditions, using a descriptive analytical approach. Similar to Chapter 4, this approach is, on the one hand, supposed to examine the rigidity of the fisheries governance system and, on the other, develop the empirical foundation for the empirical analysis of the brown shrimp fishery in Chapter 9.

In Germany, responsibilities for marine fisheries lie both with the federal government and the federated states. The role of the federal government is to ensure that the broader regulatory obligations are met under the CFP. It negotiates with the Commission and Parliament, focusing on issues regarding international fishing policy, third parties and quota allocation. The federated states are responsible for the domestic implementation of the CFP measures, in particular areas such as fisheries control, inspections and compliance with technical restrictions (Hilborn and Hilborn 2017; MSC 2023).

The Federal Ministry of Food and Agriculture (Bundesministerium für Ernährung und Landwirtschaft - BMEL) is the responsible authority at the national level for drafting policies, guidelines and objectives while also enacting fisheries law and fostering action at the EU level. Enacted into German law is the CFP by the Marine Fisheries Act (Seefischereigesetz) from 1984. The Marine Fisheries Act is the foundation of commercial sea fishing in German law, particularly in the exclusive economic zone of the North Sea and the Baltic Sea. Additionally, it regulates the duties and responsibilities of the authorities overseeing marine fisheries within the German exclusive economic zone, while the federated states are responsible for coastal and inland water fisheries. These can enact their own laws and execute federal laws in territorial waters (COFAD 2020). Three federated states within Germany have coastal waters: Lower Saxony (Niedersachsen), Schleswig-Holstein and Mecklenburg-Western Pomerania (Mecklenburg-Vorpommern). However, within the geographic scope of this study, only Lower-Saxony and Schleswig-Holstein are of relevance. The Fishery Acts of Schleswig-Holstein (Fischereigesetz für das Land Schleswig-Holstein) as well as the Lower Saxony (Niedersächsisches Fischereigesetz) apply within their borders. The Thünen-Institute is the scientific body responsible for advising the BMEL on fisheries. It is comprised of the Institute for Baltic Sea Fisheries, the Institute of Fisheries Ecology and The Institute of Sea Fisheries (MSC 2023).

The European Maritime, Fisheries and Aquaculture Fund (EMFAF) provides financial support to the fisheries and maritime sectors. The fund is tasked with helping to achieve sustainable fisheries and conserve marine biological resources. In Germany, implementation and administration of the EMFAF are shared responsibilities, as the federal level oversees the overall operational program and ensures that the national goals align with EU policies. It also manages funds that are related to nationwide or interregional projects. The federated states administer funds locally for, e.g. the modernization of a fishing vessel to improve safety or environmental performance. Importantly, modernization projects that are tied to increased efficiency are not funded. Other Initiatives related to fishing, such as costal community projects or the maritime industries, are also eligible to be funded (EMFAF Germany 2025).

Hilborn and Hilborn (2019) criticize the lack of apparent national, government-specific objectives for the fishery sector by the German government. Germany's only identifiable objectives are the CFP's foundational objectives. The lack of identifiable national objectives is also reiterated by interview partners with knowledge of the German national fisheries strategy:

> *„[…] ich würde schon sagen, dass es da nicht so einen großen Plan, eine Strategie gibt und ja, nein, deswegen eine stringente Fischereipolitik gibt es nicht."* (I18, Pos. 101)

> *„[…] yes I would say that a big picture plan does not exist, that a strategy exists and no, that's why there isn't a coherent fishery political strategy"* (I18, Pos. 101)

At least at the federal level there is no strategy for fisheries in Germany, although one is needed:

> *„Das heißt, eigentlich bräuchte es einen strategischen Plan, wie man das umsetzt und dann halt eben auch die Indikatoren dafür definiert und dann eben sich an die Umsetzung macht und natürlich auch die anderen Interessen berücksichtigt, aber wenn man sich völkerrechtlich für bestimmte Ziele entschließt, dann müssen die auch umgesetzt werden. Und das kann man nicht mit 17 Leuten im BFN Naturschutz machen oder mit einer Abteilung im BMEL, was irgendwie … ja, die irgendwie nicht handlungsfähig ist, weil dieses Ministerium einfach nicht handlungsfähig ist in vielen Bereichen. Ja, auch wenn … von der Führung her."* (I18, Pos. 107)

> "*That means there actually needs to be a strategic plan, how to implement it, including the definition of indicators, and then moving forward with execution while, of course, taking other interests into account. But if certain goals are decided under international law, they must also be implemented. And you can't do that with 17 people at the BfN for nature conservation or with one department at the BMEL, which is, well… not really capable of taking action because this ministry is simply not effective in many areas. Yes, also in terms of leadership*." (I18, Pos. 107)

This lack of objectives, coupled with a lack of strategy, is not only questioned by people on the inside but also criticized by fishers:

„Und da komme ich natürlich auch irgendwo dahin, wo ich dann natürlich sage oder frage, ob die Fischerei grundsätzlich in Deutschland noch gewollt ist“ (I3, Pos. 201)

*„And I get to a point where I say or ask, are fisheries still wanted in Germany?” (*I3, Pos. 201)

This is a fundamental question is asked by many fishers: Are we still wanted?
From the interviews and informal conversations, I can see that this uncertainty is a major problem. Despite the fact that fishers would be unhappy with a clearly stated objective to reduce German fishing capacities, they also stressed that such clarity would at least give them greater planning security for the future. The lack of national objectives for the whole fisheries sector in Germany makes governance rigid. A national strategy based on national objectives was never developed and, therefore, EU objectives are simply followed.

5.1 Germany’s Fisheries Management

Germany's fishing opportunities are managed through a licensing system in conjunction with individual non-transferable and community quotas. Commercial fishers must hold a fishing license to operate and require individual fishing permits for quota stocks. Most commercial fishing is regulated by quota limits, which exist in two forms: full-time fishers receive individual quotas that are vessel-bound and non-transferable, while part-time fishers access a national quota. Quotas are non-leasable and non-transferable, but they can be swapped between Producer Organizations. They are attached to a vessel rather than an owner. The classification of full-time and part-time commercial licenses is based on the proportion of income derived from fishing. Germany complies with the EU entry-exit scheme, which mandates that Member States can only add new fishing vessels if an equivalent amount of capacity is removed from the national fleet. Consequently, new fishers must purchase existing vessels to enter the industry (Carpenter und Kleinjans 2017).
Quota allocation is based on criteria established by the Marine Fisheries Act of 1984. They can include past participation, the economic value of the fleet and market conditions. Additionally, the Act allows the authorities to consider the negative impacts of limiting fishing opportunities. In practice, the historical track record is the primary criterion used for allocation, with catch records from 1986-87 and 1989-90 serving as fixed reference periods for the North Sea and Baltic Sea, respectively. These criteria must be followed both by the ministry when allocating to Producer Organizations and non-PO full-time fishers, as well as by the POs themselves. Part-time fishers do not receive individual quotas but have access to a national quota pool that sets monthly limits and applies fishing closures as needed (Carpenter und Kleinjans 2017). The ministry also reserves a portion of the national quota for in-year

hardship allocations. Fishers can apply for a share of this reserve during the year, and any excess quotas are distributed via a standardized process towards the end of the year. Only a small percentage of the national quota is available for part-time fishers and the hardship fund. Over 95% of quotas are allocated to full-time fishers. POs have the ability to pool quotas by buying vessels and their corresponding quota. Within a PO, members can use a vessel's associated quota and use track records to allocate quotas. Most of the fisheries in the German context are managed through this quota system. However, for non-managed species like brown shrimp, no quota or effort-based management is in place at the constitutional level. Instead, only technical regulations apply (Carpenter und Kleinjans 2017).

5.1.1 Brown Shrimp Management

In the following, I outline the rules and regulations governing brown shrimp fishing at the constitutional level, while Chapter 6 provides a detailed examination of the fishery's self-management system. An analytical distinction between the higher and lower levels of political governance is important at this point in order to identify the shortcomings of the brown shrimp management system. As Dutch, Danish and German vessels fish the same brown shrimp stock and are MSC certified together, the different Member States' constitutional rules and regulations are of particular importance.

In Germany, a general fishing license is issued to all fishing vessels, while those eligible to fish inside the "plaice box" using beam trawls receive a special license. The plaice box is a designated marine conservation area in the North Sea designed originally for the protection of juvenile and spawning flatfish species and restricts fishing vessels to 24m in length and 300 hp. It was introduced as a fisheries management tool by the European Union in 1989 (Amelot and Hintzen 2022) and is located in the southeastern part of the North Sea covering the coastal areas of Germany, Denmark and the Netherlands (Figure 19).

A majority of all fishing for brown shrimp is done inside the plaice box (Örey et al. 2025). Brown shrimp fishing licenses are not renewed regularly as brown shrimp fishing is regarded as an ongoing activity by the government. During the development and designation of Natura 2000 sites in Germany, the Netherlands and Denmark independent assessments of impact activities such as shrimp fishing were conducted. Due to the dynamic hydrography and sedimentology of the Wadden Sea environment, the effects of shrimp fishing were considered to be within acceptable limits (Fock et al. 2023; MSC 2023) while ongoing monitoring of habitats and species ensures that additional management actions are taken if necessary (Fock et al. 2023).

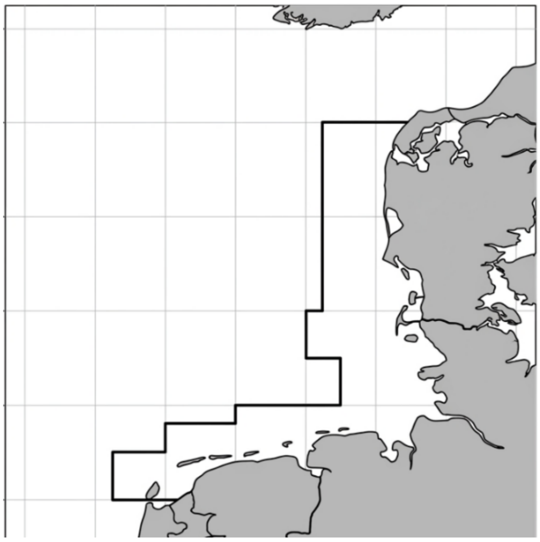

Figure 19: The "plaice box" in the southern North Sea (adapted from Amelot and Hintzen 2022)

However, there are small areas that are permanently closed to the fishery and some that are seasonally closed on a voluntary basis (Schleswig-Holstein) to protect molting shelducks (*Tadorna tadorna*). These areas are located south of the Hindenburgdamm and the Island of Sylt as well, as tidal creeks around the isle of Neuwerk and a few small areas in Lower-Saxony. Furthermore, there are larger areas that are closed to bottom trawling under nature conservation considerations, but these are outside of the main brown shrimp fishing territories - such as the Sylter-Außenriff and the Borkum Riffgrund. Other areas that are closed to bottom trawling are the offshore wind parks. These are, with the exception of “Riffgat” and “Nordergründe”, all outside of the 12 mile zone and have no direct effect on the brown shrimp fleets (MSC 2023). To verify compliance with closed-area regulations, the EU mandates that vessels send a VMS signal at two-hour intervals. However, in the latest assessment, it was noted that BMEL is considering raising the VMS transmission frequency to every 10 minutes. Moreover, vessels approaching within 4 nautical miles of a closed area would be required to transmit at even shorter intervals. When transiting a restricted area, vessels must travel at a speed of at least 6 knots - too fast for trawling (MSC 2023).

Management in the Netherlands and Denmark differs from the German approach. In the Netherlands, the number of licenses is capped at 220. The shrimp fishery is divided by two types of licenses: a) “Garnalenvergunning Kustwateren (GK)” a license to fish for shrimp in the Wadden Sea and all coastal waters and b) “Garnalenvergunning Visserijzone (GV)” a license to fish for shrimp in coastal waters only (not the Wadden Sea). As of the last report, 68 GK and 111 GV licenses were active (MSC 2023). If a vessel owner wants to enter the fishery with a new or existing vessel using either a GK or GV license, they must purchase a license with an equivalent engine capacity. A license obtained with excess engine capacity allows the surplus to be saved for later use, for instance, on another cutter(MSC 2023) and fishers are additionally constrained by limits on fishing days. Dutch waters are closed between 12:00 Friday and 00:00 on Sunday - establishing a weekend closure. Several areas in the Dutch Wadden Sea are either permanently or seasonally closed to shrimp fishing. These closures are part of an agreement signed by fishers, environmental NGOs and the government (Visserij in beschermde gebieden [Fishing in Protected Areas] – VIBEG50 and VisWad agreements) to meet the conservation objectives of the Natura 2000 sites. In contrast to Germany, Dutch fishers are required to have "black boxes" on-board to check whether or not they have been fishing in closed areas (MSC 2023). In Denmark, licenses are capped at 28. In order to enter the fishery, an existing license needs to be bought, and the engine capacity associated with it cannot be exceeded. Licenses are not subject to an annual review and there is no fishing for shrimp in the Danish Wadden Sea. The "Brown Shrimp Order" establishes a no take zone on the seaward side of the Danish outer islands – the so-called "Shrimp Line" (MSC 2023). There is also no trawling permitted within 3 nm of the coast to protect nesting birds. The fleet operates on a 12-week period in which fishing is prohibited from Friday 09:00 to Sunday 18:00.

In comparison to Denmark and the Netherlands, the fishery in Germany is fairly unregulated at the constitutional (Member States) level. Both countries have established mandatory weekend closures and extensive areas in which bottom trawling is either seasonally or permanently closed (e.g. "Shrimp Line"). Germany, however, has not established such a system, nor is it wanted by fishers. Their preferred mode of governing the resource is through self-management. German fishers simultaneously desire federal support—financial and otherwise—while resisting increased governmental intervention in the form of further regulatory measures:

> *„die [Fischer] wollen im Prinzip, ja, lasst uns in Ruhe und wir machen weiter wie bisher." (I9, Pos. 107)*
>
> *"[the fishers] they more or less want, yea, to be left alone and continue business as usual" (I9, Pos. 107)*

In theory, this lack of constitutional rules in Germany provides the sector the flexibility to adapt to new conditions arising from climate change. However, in practice, this results in a situation where every issue must be negotiated from the ground up. There is no real consensus among fishers what a future for the industry should look like. Similar to the EU level, in Germany, a political negotiation process is needed to establish constitutional level rules that implement a process that allows for flexible governance.

5.2 The Brown Shrimp as a Non-Managed Species

In 2011, a study for the Directorate-General for internal affairs of the European Parliament found that the "*Brown shrimp fishery remains to be one of the least regulated fisheries within the EU." (DG IPol 2011, 61)*. At the constitutional level (EU and Member States), the fishery is *de facto* not managed. There are no limitations on landings and consequently no quota system in place. There are no restrictions on fishing effort. Due to the fishing grounds being inside of the "plaice box", there are regulations on vessel size (24m) and engine capacity (300 hp or 221kw) (Council Regulation (EC) No 850 1998), but if the "plaice box" conservation status were to be lifted, few regulations would apply. However, conditions of the "Beam Trawl Lists" (EU regulations 850/98 and 1922/1999) include an aggregated beam length (24 m max) and a range of mesh sizes (16 – 32 mm). While there are no catch restrictions for brown shrimp, there are minimum commercial sizes for marketing shrimp with a carapace width of at least 6.8 mm for size-1 shrimp and 6.5 mm for size-2 shrimp (DG IPol 2011).

6 Fisheries Governance: Self-Management in the Brown Shrimp Fishery

The two most important entities in the self-organization and self-management plan of the brown shrimp fishery are the Producer Organizations (POs) and the Marine Stewardship Council (MSC). The first part of the chapter will further detail the brown shrimp self-management plan, while the second part will analyze the self-management plan with respect to Ostrom's design principles of sustainable self-organization.

Producer Organizations play a pivotal role in the implementation of the CFP and contribute to the sustainable management of fishery resources in the EU. Recognized and regulated under the CFP, POs consist of groups of fishers and fishing enterprises that collaborate to organize and manage their activities in line with sustainability and market-oriented goals. They are tasked with organizing and supporting their members to meet shared objectives, such as improving market access, stabilizing prices, reducing waste, and fostering the sustainable use of fisheries resources. POs assist in the effective management of quotas and fishing activities - ensuring their members adhere to EU policies on quotas (Peñas Lado 2016; 2019). They are tasked with an important role in mitigating overfishing by organizing and aligning their members' practices with the sustainable exploitation rates defined by the CFP. A core function is to develop production and marketing plans to align fishing efforts with demand and reduce pressure on stocks. These plans, approved by national authorities, outline strategies to promote sustainable harvesting and profitable fisheries. POs assist their members in complying with the CFP's landing obligation, which requires fishers to land all catches of regulated species. By fostering innovative practices and improving fishing selectivity, POs are to help reduce unwanted bycatch and discard levels. They facilitate access to funding opportunities, such as those provided by the EMFAF, to modernize fleets or adopt sustainability measures. Without being a member of a PO, a fisher cannot have access to structural funds such as the EMFAF (Peñas Lado 2016; 2019).

Their functions are not only vital to achieving the economic and environmental objectives of the CFP but also intersect with non-government sustainability initiatives such as the Marine Stewardship Council certification process. The Marine Stewardship Council certification process is an independent assessment system that evaluates fisheries against a set of sustainability standards and receives royalties for licensing the certification. Achieving MSC certification allows fisheries to demonstrate their compliance with the best environmental practices, giving them access to new market opportunities and providing credibility to sustainability claims. POs are key facilitators in this process by coordinating efforts among their members to meet MSC standards. The POs and the MSC are tightly intertwined as the producer organizations are the clients of the Marine Stewardship Council and pay its fees (MSC 2023).

6.1 The MSC Management Plan

The MSC Brown Shrimp Management Plan certifies the sustainability of the brown shrimp fishery in the Wadden Sea. The objective of the management plan is "*…a sustainable North Sea brown shrimp fishery, by means of an ecologically responsible, co-managed fishery, with high long-term sustainable yield of the target species and minimized effects on the marine ecosystem" (MSC 2023, 42)*. The plan became operational on 1st January 2016 with the last amendment being adopted, at the time of writing, on 15th December 2022 (MSC 2023). The self-management plan rests on two pillars: the harvest control rule and a plan to successively increase mesh sizes. The increase in mesh sizes is in place to reduce growth overfishing of the stock (Temming and Hufnagl 2015) while the harvest control rule reduces the fishing effort when population densities are too low (based on landings within a predetermined period (MSC 2023).

A number of reasons lead fishers to seek an MSC certification: 1) Overcapacities, resulting in low prices for fishers; 2) production capacity issues and 3) a failed attempt to manage supply that was found to be in breach of Dutch and EU regulations as well as 4) pressure from wholesalers (Heiploeg International B.V.) all played a role in the industries decision (MSC 2023; Steenbergen et al. 2017).

Four POs from Germany, one from Denmark and seven from the Netherlands are MSC certified. The four German POs together established the MSC GdR. The Dutch POs established the Coöperatieve Visserij Organisatie, while the Danish fishers are all united in one PO Danmarks Fiskeriforening Producent Organisation (Table 5). These three institutions established the „Brown Shrimp Cooperative MSC Group" (MSC 2023).

Table 5: List of Producer Organizations and MSC entities by country

Country	MSC Entity	Producer Organization
Germany	MSC GdR	Erzeugergemeinschaft Küstenfischer der Nordsee GmbH., Erzeugergemeinschaft der Küstenfischer Tönning, Eider, Elbe und Weser we.V., Fisherei-Genossebschaft Elsfleth eG., Erzeugergemeinschaft der Deutschen Krabbenfischerei GmbH
The Netherlands	Coöperatieve Visserij Organisatie	Coöperatieve Producentenorganisatie en Beheergroep Delta Zuid U.A., Coöperatieve Producentenorganisatie Nederlandse Vissersbond U.A., Coöperatieve Producentenorganisatie en Beheergroep Noordelijke Visserij Alliantie (Northern Alliance) U.A., Coöperatieve Producentenorganisatie voor de Visserij Urk U.A., Internationale Garnalen Producenten Organisatie Rousant U.A.
Denmark	Danmarks Fiskeriforening Producent Organisation	Danmarks Fiskeriforening Producent Organisation

A Steering Committee, consisting of at least one representative and a deputy from each of the three constituent parties, serves as the primary decision-making body for the plan. Decisions are generally made by consensus. A project working group, with an unspecified personnel composition, assists the Steering Committee and the constituent POs by providing active support. The Steering Committee may also invite observers, experts, or presenters to participate in their meetings. Meetings are held at least once per year but can also be organized on an ad-hoc basis if necessary (MSC 2023).

In order to be part of the MSC certified Brown Shrimp fishery, vessels must be members of an associated PO. They do not have to be members of a PO in their country of origin but can join POs in a different country. However, their inclusion must not cause the capacity cap — based on the number of vessels and combined kW engine power of the respective participating countries — to exceed the values established on January 1, 2015 (Table 6):

Table 6: The kW and vessel number cap per country

Country	Vessel Number	Kilowatts (kW)
Denmark	28	5,213
Germany	213	41,198
The Netherlands	198	40,410

If other POs want to join the management plan, they will be restricted to the agreed upon kW engine power and number of vessels as of 1st January 2015. However, capacities can be increased if the Steering Committee has scientific advice that indicates that this would not "*move the fishery away from the target of high long-term sustainable yield* [or] *other measures that counteract the effect of increasing capacity on the long- term yield*" (MSC 2023, 257).

Vessels are limited to a maximum of 200 days (4,800 hours) at sea per year. If an increase in the average effort of the vessels is considered to work against the objective of achieving high long-term sustainable yields, additional unspecified measures will be implemented to mitigate or counteract this increase. The combined length of the beams, including the shoes, must not exceed 20 meters, and their total weight, including net, footropes, and other attachments, must not exceed 4,000 kgs. Trawl nets must include either a sieve net with a maximum opening of 70 mm or a sorting grid with a maximum opening of 20 mm, conferring with EU technical regulations (MSC 2023).

Shrimp must go through an on-board sorting process using sorting machines. The spacing between the bars must be set to the size of marketable shrimp. During the sorting process, constant water flow is used to aid the survival of discard catch. Another sieving process on-land is supposed to ensure that only marketable shrimp are processed for human consumption. The bar width in the sieving stations is 6.8 mm. The shrimp that fall through the bars, the so-called sievage, must be crushed unless it can be shown that it is intended for non-human consumption. The average sievage over a consecutive two week period cannot exceed 15 % of the total landings, otherwise penalties apply (MSC 2023).

For the Harvest Control Rule five reference points, set at 70%, 65%, 60%, 55%, and 50% of the average monthly Landings per unit effort (LPUE) observed in 2002 (a very low year) and 2007 (an average year), are used to establish precautionary triggers for restricting weekly fishing effort. At the end of each calendar month, the LPUE data from electronic logbooks and auction records are compared to the averages from the reference seasons. If the LPUE falls below the 70% precautionary reference point (reference value 1), then fishing for all vessels in the next two calendar weeks is limited to a predetermined number of hours. As long as the average LPUE remains below reference value 1, LPUE monitoring is conducted bi-weekly rather than monthly. Fishing effort is reduced incrementally as the observed LPUE falls below each successive reference point. The goal of reducing fishing effort is to allow smaller shrimp to grow to a larger size before being caught and to ensure that the observed fishing mortality (F) remains close to F_{MAX}, a proxy for F_{MSY} (MSC 2023).

The management plan includes various ecosystem considerations such as ETP species, seabed habitats, inorganic and oil waste as well as bycatch - such as undersized shrimp, protected species, common fish and common invertebrates. In order to reduce unwanted catch, an incremental mesh size increase is planned in combination with selectivity devices and water flow during the sorting process. The plan also commits the Brown Shrimp Cooperative MSC group to review alternative technical measures at least every five years that could potentially minimize unwanted catches. ETP species need to be registered with the respective PO administrator and individuals that are considered likely to survive need to be released (MSC 2023). The management plan monitors via VMS mapping the risk for sensitive habitats. However, the naturally highly dynamic system and the relatively light weight of the fishing gear are considered to be already existing measures that mitigate the fisheries impact on the seabed (MSC 2023). All inorganic waste produced on-board or caught during fishing operations must be landed and waste containing oil must be disposed of properly.

Control Union Certifications and Landwirtschaftskammer (LWK) were appointed by the client group to monitor and report on compliance with the management plan. Their inspection solely concentrates on the plan's requirements rather than any national or EU regulations. However, the technical requirements, such as mesh size and beam width, are equivalent to or more restrictive than any national or EU regulation. Members are required to permit inspections, while refusal will result in being deemed non-compliant. The plan mandates that at least 20% of the vessels in each country are inspected annually, each member PO is inspected at least once a year, and sieving stations are inspected at least twice a year. Inspection reports are submitted to the Steering Committee every three months (MSC 2023). POs are responsible for the compliance by their members, while infringements by POs or sieving stations are the responsibility of the Steering Committee. A detailed list of the penalties applicable as a result of infringements can be seen in table 7 (MSC 2023, 265).

Table 7: detailed penalty annex of the MSC brown shrimp fishery self-management plan (MSC 2023)

	Number of infringements and applicable penalty						Remarks
Management Plan Article	**1**	**2**	**3**	**4**	**5**	**6**	
C2.1 & C5.1 200 days & HCR	€ 100/hour or 2 hours/hour	€ 200/hour or 4 hours/hour	**Exclusion**				The penalty is calculated according to the number of hours at sea over and above the allowed number of hours.
C2.2 & C2.3 Beam width & gear weight	**Warning***	**Exclusion**					At the first warning, the member shall be given 14 days to change the gear, after which a second control shall be performed.
C2.4, C3.1, C4.1, C4.2 & C4.3 Mesh size & sieve net		€ 1000 or 48 hours	**Exclusion**				
C3.3 & C3.4 Sieving stations	**Warning**	**Exclusion**					In this case exclusion means that the sieving station will be excluded from MSC approved landing sites.
C3.5 Sievage percentage 15-17,5%	**Warning**	€125 + €3/kg or 6 hours + 8 min/kg	€250 + €3/kg or 12 hours + 8 min/kg	€500 + €3/kg or 24 hours + 8 min/kg	€1000 + €3/kg or 48 hours + 8min/kg	**Exclusion**	The member will only get a penalty if he has more than one landing within the two-week period. The added penalty, which relates to kg, is calculated from the kg of sievage above 15%.
C3.5 Sievage percentage >17,5%		€250 + €3/kg or 12 hours + 8 min/kg	€500 + €3/kg or 24 hours + 8 min/kg	€1000 + €3/kg or 48 hours + 8min/kg	€2000 + €3/kg or 96 hours + 8 min/kg		
C4.4 Effort reduction measure (up to 1 hour of violation)	€ 125/hour	€ 125/hour	**Exclusion**				The penalty is calculated according to the effort (as described in C4.4) in hours (rounded up to whole hours) above the allowed number of hours or during times where effort should be fully reduced according to the chosen reduction scheme. Each period that contains noncompliance to C4.4 counts as a single infringement.
C4.4 Effort reduction measure (from 2 hour of violation)	€ 250/hour	€ 250/hour					
D1.1 & E2.1 Data collection and ETP species	**Warning**	**Exclusion**					The member will be contacted (via text message or similar) as a reminder before an official written warning or exclusion is given.
G1.1 Refused control	€ 1000 or 48 hours	**Exclusion**					No warning is given.

The Brown Shrimp Cooperative MSC Group intends to extend its MSC certification process to potentially include vessels currently not part of the Group, such as those from Belgium and France. This extension is contingent upon these vessels, as well as auctions and producer organizations, complying with the rules and regulations set forth in the Group's Management Plan. The MSC Group intends to extend the process to include new vessels, during a time of significant drops in landings. The next chapter analyzes the sustainability of the MSC self-management plan (MSC 2023).

6.2 Sustainable Self-Management: Testing the MSC Management Plan

In the following, I will analyze the management's self-declared objective to foster "*…a sustainable North Sea brown shrimp fishery, by means of an ecologically responsible, co-managed fishery, with high long-term sustainable yield of the target species and minimized effects on the marine ecosystem*" (MSC 2023, 42) through the prism of Ostrom's best practice governance rules for the lower (collective choice and operational) levels of governance (Chapter 2.4.1). The analysis is going to focus on the first part of the objective, the "*ecologically sustainable, co-managed fishery with high long-term sustainable yield of the target species*" (MSC 2023, 42). The research project "CRANIMPACT" concluded that the fishery has a comparatively minimal effect on benthic ecosystems in the Wadden Sea (Fock et al. 2023), which attests that the second part of the self-management plan's objective is met.

Brown shrimp landings have, however, declined sharply since 2016. In the 1990's, landings had continuously increased and from 2003 to 2015 remained on average at around 35 000 t per year. Average landings have since 2016 declined to around 25 000 t in recent years, roughly a 25% decrease (ICES 2025). Whether landings are going to plateau at this level, drop further or continue to increase is a question that cannot be answered at this point in time. While Chapter 9 offers an integrated social-ecological analysis of the factors that could lead to a brown shrimp fishery collapse in the future, the target of the present analysis is the effectiveness of the self-management plan with respect to its own objectives. I argue that the management plan is not able to deliver a sustainable fishery and analyze the current situation of brown shrimp landings through Ostrom's six lower-level governance principles (Chapter 2.4) of sustainable, community-based management of common pool resources:

Principle 1) (A&B) User & Resource Boundaries: *Well-defined and locally acknowledged boundaries distinguish between legitimate users and non-users. Clear demarcations separate a specific common-pool resource from the broader social-ecological system.* Well-defined boundaries distinguish non-users from legitimate users (1A). In order to be part of the self-management plan, a fisher needs to be part of a participating PO. Resource boundaries are also well established as the brown shrimp are (for the most part) fished within the territory of the Wadden Sea (1B).

Principle 6) Conflict Resolution Mechanisms: *Swift, cost-effective mechanisms are in place at the local level to resolve disputes among users or with authorities.*

There are, to the best of my knowledge, no swift and cost-effective conflict resolution mechanisms in place that resolve disputes among users or with authorities beyond the national judicial systems. There are, however, informal ones at the local (harbor) level. I was told stories about extra-judicial action taken by fishers if certain rules were not followed. This included going on other fishers' vessels and dumping their catch in the water (fisher 2023, personal communication). The national judicial systems of the Member States provide effective, transparent mechanisms for the resolution of legal disputes. Section 19 of the Danish Fisheries Act lays out transparent mechanisms for the resolution of disputes about fisheries management decisions made by authorities and the Fisheries Minister. The judicial system also provides means of appeal and resolution. In Germany, section 16 of the German Fisheries Act provides a process for dispute resolution. The judicial system offers a route for appeal, but ultimately falls back on the EU court of justice. In the Netherlands, the Fisheries Act (Visserijwet 1963) establishes a transparent mechanism for the resolution of disputes (MSC 2023).

In my interviews, the topic of dispute resolutions was not mentioned as a major problem and I see this as supporting evidence that conflict resolution mechanism are not an issue that is of great importance in the self-management of the fishery.

Principle 5) Graduated Sanctions: *Penalties for rule violations begin mildly but escalate for repeated infractions*.

The management plan has formalized graduated sanctions. For the articles of the management plan that pertain to the guidelines that were agreed to be ecologically sustainable, graduated sanctions exist as shown in table 7. Sanctions can range from warnings or a monetary fine for a first infringement to exclusion after multiple infractions. The fine depends on the type of infringement. Surpassing the sieving percentage for undersized shrimp, for example, is not treated as serious as breaking the harvest control rule (table 7).

From conversations and the interviews that were done, not the graduated sanctions seem to be the problem but their application and enforcement as this quote from a German fisher shows:

> *„Und da wurden diese Schiffe, die haben dann aus diesen Rahmenbedingungen das Maximale rausgeholt und dabei auch noch schamlos betrogen. Das heißt, Motorisierung mit 300 PS, da haben die drüber gelacht. Mit 300 PS kriege ich diesen Klopper gar nicht mit bewegt, die Maschine. Die haben dann … da - da war der Markt, der Schiffbaumarkt war da auch anders. Da haben die Motorenhersteller Motoren entwickelt, die bei der Abnahme 300 PS hatten, aber dann durch irgendein Knöpfchen auf einmal 6-, 7-, 800 PS" (I3, Pos. 125)*

> *"And then these ships—well, they squeezed the absolute maximum out of these conditions and shamelessly cheated in the process. I mean, motorization with 300 horsepower? They laughed at that. With 300 HP, I wouldn't even be able to move this machine. Back then, the shipbuilding market was different. Engine manufacturers developed engines that had 300 HP during inspection but, with the push of a button, suddenly had 600, 700, or even 800 HP." (I3, Pos. 125)*

The enforcement of both technical restrictions from the constitutional level and the self-management plan were often themes of contention.

Principle 4 (A&B): Monitoring Users & the Resource: *Accountable individuals or user representatives oversee the levels of resource use and provision. Accountable individuals or user representatives* *monitor the condition and health of the resource.* POs are responsible for the compliance by their members, while infringements by POs or sieving stations are the responsibility of the Steering Committee. Control Union Certifications and Landwirtschaftskammer (LWK) were appointed by the client group to monitor and report on compliance with the management plan. These entities, however, only monitor compliance with the rules in the management plan and do not explicitly monitor national and EU rules and regulations. Under the current system, POs are tasked with monitoring and enforcing their own compliance. This may lead to difficulties in rule implementation and enforcement, especially in times of reduced landings and profitability, as reflected in the following quote:

> *“Und dann kamen [die] an, da haben wir dann festgestellt durch unseren MSC-Kontrolleur, dass die ich glaube, 175 Vergehen, Bruch mit unserem Managementplan hatten, ne, was nicht offiziell ist, aber wurde eben festgestellt.“ (I11, Pos. 319)*

> *"And then [they] came, and we found out—through our MSC inspector—that they had, I believe, 175 violations, breaches of our management plan. Not officially, but it was still discovered." (I11, Pos. 319)*

Federal and federated states agencies, as well as the Thünen-Institut, are responsible for the monitoring of users and resources, respectively. However, their decision has no direct effect on, e.g., the sanction scheme. There are, for example, no sanctions for violating engine kw capacities.

Principle 3) Collective Choice Arrangements: *Most individuals affected by a resource regime have the authority to participate in the formulation and adjustment of its regulations.* Most individuals affected by the resource regime can take part in collective choice arrangements. They do have some authority to participate, at least indirectly, in the adjustment of the resource regulations. Almost the entire brown shrimp fleet in Germany is part of the MSC certification scheme, which means that they are part of the four Producer Organizations that make up the MSC-GbR (Erzeugergemeinschaft der Deutschen Krabbenfischer GmbH; Erzeugergemeinschaft Küstenfischer der Nordsee GmbH; Erzeugergemeinschaft Tönning, Eider, Elbe und Weser w.V. and Fischereigenossenschaft Elsfeth e.G). As members of these POs, fishers are able to elect representatives. These representatives are then able to exert their influence on the steering committee, which makes decisions regarding the self-management plan. An illustrative case is the suspension of mesh-size increases in Denmark in favor of designing an effort-reduction plan (Chapter 6.1).

The management plan intended to increase mesh sizes in intervals from 20 to 26 mm. In 2020, the mesh size was increased in the Netherlands and Germany to 25 mm while it remained at 24 mm in Denmark. A study from the University of Hamburg (Temming et al. 2022b) had concluded that the benefits of previous mesh size increases were difficult to validate. Within the client group, there was also a lack of support for the measure. While in the Netherlands and Germany still approximately 50

% of fishers supported an increase to 26 mm, no such support existed in Denmark. Based on this information, the Steering Committee decided an increase to 25 mm in the Netherlands and Germany. To compensate for not increasing to 26 mm, effort reduction schemes were developed (MSC 2023). Despite this, many German fishers do not feel that they have the ability to influence the structure of the system or the self-management plan. Their impression is that there is so much division among German fishers that solutions are incredibly hard, if not almost impossible, to achieve. One issue that is identified by (German) fishers is that trust and, therefore, cooperation are dwindling characteristics in the community:

> *„Wir haben den [Erzeugergemeinschaft] GmbH-Teil, den betriebswirtschaftlichen Teil nicht strikt genug getrennt vom Erzeugerorganisationsteil. Das heißt, im Grunde verwalten wir nur die GmbH und das, was du meinst mit Zusammenarbeit zwischen Fischern, das ist total den Bach runter gegangen, das wird komplett überlagert dadurch, dass wir eben den GmbH-Teil, dass der Kram ordentlich läuft und so was, das wird gemacht, da sind unsere Geschäftsführer auch drauf ausgerichtet, aber der Verbandsteil, der kommt dabei vollkommen zu kurz. […] Aber das, was mal war und das, was du ansprichst, findet nicht mehr statt. Wir haben einmal im Jahr eine Hauptversammlung da sitzen wir dann mit den hundert Mann da zusammen, von Ditzum bis - bis Husum, das ist eine Jahreshauptversammlung, wo du überschwemmt wirst mit Zahlen und Berichten vom Jahr, und das, was eigentlich sein müsste, dieser Austausch, was du ansprichst, der findet da nicht mehr statt. (I27, Pos. 220)*

> *"We didn't separate the [PO] LLC part, the business management side, strictly enough from the producer organization side. That means, essentially, we're just managing the LLC, and the collaboration between fishers that you're talking about has completely gone down the drain. It's completely overshadowed by making sure the LLC side runs properly—that's what's being done, that's what our managing directors are focused on. But the association part is being totally neglected. [...] but what once existed, what you're referring to, doesn't happen anymore. We have one general assembly per year, where a hundred men from Ditzum to Husum, in our annual meeting, sit together, where you're overwhelmed with numbers and reports from the past year, but the actual exchange that should be happening—the kind of discussion you're talking about—just doesn't take place anymore." (I27, Pos. 220)*

In Respondek und Temming's (2022b) survey on the self-management plan and structure of the brown shrimp fishery, the vast majority of 78 German and Dutch fishers said that they were not sufficiently involved in the decision processes of the plan. Over 30 % said that if they were involved to a greater degree, they would more easily accept decisions that they did not agree with (Temming et al. 2022b). From the conversations that I had and the interviews that I have done, I see the fundamental problem – at least in the German case – with the fact that it seems incredibly hard for fishers to agree on issues within their own PO. This division is a major reason for the inertia that is not only active in the institutions but also at the fisher level:

> *„In der Gemeinschaft der Fischer, das - das ist ja immer so, das ist eher ein Problem der Fischer, dass die einfach nicht sehen, welche Organisationen sie da zur Verfügung haben, welche*

Möglichkeiten die eigentlich bieten, weil sie ihren eigenen Egoismus die ganze Zeit verfolgen. Das ist das Haupt-, der Haupthemmschuh in dieser ganzen Kiste, dass man auch einfach kein Wir-Gefühl erzeugt" (I8, Pos. 21)

"In the fishing community—well, that's always the issue. It's more of a problem with the fishermen themselves, that they simply don't see what organizations are available to them or what opportunities they actually offer because they're too busy pursuing their own selfish interests. That's the main obstacle in this whole thing—the inability to create any real sense of unity." (I8, Pos. 21)

This is one of the problems that needs to be solved first before, as demanded by fishers, a direct involvement in the decision-making process would make sense.

Principle 2 (A&B) Congruence with Local Conditions & Appropriation and Provision: *Rules for resource use and management align with the unique social and environmental context of the locality. Rules governing resource use match those governing resource replenishment; the sharing of costs corresponds to the sharing of benefits.*

The rules that are in use at the self-management level seem not to be able to ensure a sustainable resource use. The self-management rules do not align with the environmental context of the locality (principle 2A) or the rules that govern resource replenishment (principle 2B). The two pillars of the self-management plan are mesh size increases to combat growth overfishing and the harvest control rule to reduce fishing effort. The harvest control rule is based on monthly LPUE values, which are calculated by the steering committee using data provided by the POs. These monthly LPUE values are then compared to the reference values specified in the management plan. The reference values in the management plan are set at 70%, 65%, 60%, 55%, and 50% of the monthly average LPUE values recorded by the German fleet between 2002 and 2007. However, the management plan has no detailed description of exactly how the monthly LPUE values are to be calculated: whether it should be based on the entire fleet, on hours at sea or on fishing hours. Whether the fresh weight or the weight of cooked shrimps should be used as a reference point, the weight should include the discard shrimp or not. This results in a variety of possible combinations and calculation methods for the reference and monthly LPUE comparison values (Temming et al. 2022b). In reaction to this, the final report of the CRANMAN project recommends (Temming et al. 2022b) various adaptations to the existing HCR (further discussed in Chapter 10) or a regionalization of it. The question that arises with regard to regionalization here is, if effort restrictions come into effect in one of the regions, if there will not simply be a higher concentration of fishers in other regions? The HCR had shown only limited effectiveness in its first year (2016). Despite an overall very low stock, a reduction in fishing effort was triggered only during two short periods. For all scenarios in which a reduction in fishing effort is planned, it must be ensured that an actual effort reduction is taking place and not just an increase in

surrounding areas. Additionally, a spatial allocation of effort and landings is necessary to identify locally varying stock developments. So far, the HCR does not account for these local developments and, as a result, cannot protect locally low stocks from additional fishing pressure (Temming et al. 2022b).
Mesh size measurements were adjusted, allowing a 22.1 mm mesh to be legally considered a 24 mm mesh. Despite this fact, the long-term trend using DCF data shows a slight but significant improvement in the reduction of discard shrimp. Before the start of MSC certification, mesh sizes were sometimes as small as 20 mm, indicating that the increase in mesh size is already producing initial positive effects regarding the conservation of undersized shrimp. Increasing the mesh size further to 26 mm has raised concerns among fishers about potential losses of marketable shrimp escaping through these larger meshes. However, the mesh size comparison suggests that these concerns are likely unfounded. A comparison of the selection curves for onboard sieving and the "Hamburger sieving machine" revealed a relatively high inaccuracy of drum-sieving on-board, where unnecessarily undersized shrimp are cooked and marketable product is lost (Temming et al. 2022b). A limit for the number of ships and the combined kW power of the fleet is intended to freeze fishing effort at the level recorded by the authorities in the Netherlands, Germany, and Denmark as of January 1, 2015. The vessels are limited to 200 days at sea per year. However, in practice, this measure does not effectively limit fishing capacity as the yearly effort of many fishers falls below this threshold. Additionally, new fishers can still enter this fishery, or old vessels can be replaced with new builds. Currently, the fishery is de facto only constrained by the market (Temming et al. 2022b). Issues that were raised by German fishers regarding a sustainable fishery and are related to fishing effort and capacity limits are 1) the entry of so-called Euro cutters into the fishery and 2) the significant increase in the winter fishery:

> *„Was man ein bisschen … ein bisschen jetzt sieht, dass die - die holländischen Schiffe und hier jeden Winter so ein bisschen die - die - die Krabben wegfische, die rankommen, die eigentlich ablaichen wollen. Das merken wir eigentlich jeden Herbst, dass da auch im Winter sehr viel gefischt wird. Zu viel gefischt wird von Schiffen, die eigentlich in der Krabbenfischerei wenig zu suchen haben − bis gar nicht. Das ist ein Punkt, das merkt man glaube ich langsam etwas. Schiffe, die sind für Fisch gebaut, Quoten sind weg, Quoten werden reduziert. Es drückt alles in die Krabbenfischerei mit rein. Das merkt man jetzt immer Januar, Februar, März, wenn die Krabbe rankommen will, dass einfach diese … ich glaube, im milden Winter kann sie bis zu zweimal laichen und das … da ist … wird meiner Meinung nach zu weit westlich, zu doll drauf rumgehackt.“ (I1, Pos. 32)*

> *"You can see it a bit now… that the Dutch ships come here every winter and fish away the crabs that are moving in, the ones that are actually supposed to spawn. We notice it every autumn— that a lot of fishing happens in winter. Too much fishing, by ships that really have little to no place in crab fishing. That’s something people are slowly starting to realize. These ships were built for fishing other species, but now quotas are gone, quotas are being reduced, and everything is being pushed into crab fishing. You really notice it in January, February, and March, when the crabs are*

supposed to come in. I believe that in mild winters, they can spawn twice—but in my opinion, too much pressure is being put on them too far west." (I1, Pos. 32)

While there is some responsibility taken by German fishers regarding their current situation, much is externalized. Rather than questioning the MSC and self-management system, including the absence of weekend closures in Germany, Dutch Euro-Cutters are made responsible. And, in part, probably rightfully so, as the harvesting strategies do not match local conditions for a sustainable fishery.

The drop in landings by 25% compared to the period prior to 2016 indicates that the brown shrimp is not harvested sustainably. The analysis has shown that three main areas exist that negatively impact the plan's sustainability objective. First, the way the MSC system is set up, POs are largely to monitor and police themselves (principle 4). Especially in times of declining landings and profitability, this has the potential to lead to problems regarding rule enforcement, as shown through the example provided in the analysis. Second is the perception of fishers that they are not included in collective choice arrangements, but most importantly that they suffer from internal community division that leads them to be currently unable to adapt to the new situation (principle 3). By far the largest problem in meeting the sustainability objective of the self-management plan is congruence with local conditions as well as appropriation and provision (principle 2). The plan's rules simply do not match the realities of the social-ecological system in the context of sustainability. The harvesting rules are unable to prevent overfishing. Current rules on fishing effort encourage year-round fishing and the entry of so-called Euro-Cutters with fishing gear far outside the norm of those traditionally used in the fishery. It can therefore be concluded that the brown shrimp fishery's self-management plan is unable to meet its own sustainability standards of a high long-term yield of the brown shrimp. As the harvesting rules do not seem to adapt to changing ecological realities, it can be concluded that the self-management plan of the brown shrimp fishery is rigid and unable to adapt to new conditions. In the executive summary of the MSC report, it is stated that "*there is robust overarching governance and policy with respect to management of the fishery* " (MSC 2023, 16). As the self-management plan fails to deliver the sustainable fishery that it aspires to, I will be examining the "robust overall governance" that the MSC report identifies.

7 Polycentric Governance in European Fisheries

This chapter examines the role and effect of polycentricity in European fisheries governance's goal of long-term sustainable resource use. Chapter 4, and to an extend Chapter 5, have shown the rigidity of the European fisheries governance system. The system is ill-equipped to deal with uncertainty and non-linear as well as non-equilibrium behavior. Climate change is accelerating the ecological expression of these characteristics of complex adaptive systems at a rate not seen in EU fisheries governance history. The question that this chapter asks is if the EU's rigid fisheries governance system has produced unsustainable resource use?

The following analysis will examine whether the interplay of structure and process of the European fisheries governance system produces long-term sustainable resource use as an emergent outcome in terms of behavior and coordination. First, I will show that the EU's fisheries governance system is polycentric as based on Carlisle and Gruby's (2019) definition: "(1) many autonomous units formally independent of one another, (2) choosing to act in ways that take account of others, (3) through processes of cooperation, competition, conflict, and conflict resolution", adapted into three categories as seen in Table 2 (Chapter 2.4.2):

I argue that the CFP has achieved notable progress toward sustainable resource use in numerous European fisheries, even within its rigid institutional framework. However, if this rigidity is not addressed, the increasing pressure of climate change could significantly threaten the resilience and viability of the fisheries sector. Finally, I show that the governance of the German brown shrimp fishery lacks polycentric characteristics, and that this absence—when paired with the inherent rigidity of the CFP—creates significant risks of the fishery developing along an unsustainable trajectory.

7.1 Structural Characteristics

The European fisheries governance has the *structural characteristics* of polycentric governance by having *multiple decision centers* that are *autonomous*, have *overlapping authority* and *operate within a set of overarching institutions* (Baldwin et al. 2023).

European fisheries governance developed *multiple decision centers* at various levels of the governance structure. At the constitutional level in the EU, the Commission, Parliament and Council share power. The Commission serves as an agenda setter. The Parliament and Council engage in negotiating CFP reforms, while the Commission also controls and evaluates the application of the CFP by the Member States. In Parliament, the Fisheries Committee makes amendments to the Commission's proposal with the Environment Committee commenting on them (Chapter 4.2). Even though the Environment Committee cannot propose amendments, its comments have to be taken into consideration and therefore wield some influence. Amendments to each proposal are decided on during the Parliament's plenary session and changes to the Fishery Committee's proposal are, in many cases, based on wider political considerations. A proposal adopted by the plenary session is the mandate of the European

Parliament for the negotiation with the Council of Ministers, which is made up of Fishery Ministers from each EU country, giving the member states a direct say in the CFP and its reforms. The setting of TACs, as well as their allocation, lies exclusively with the Council of Ministers (Chapter 4.2). This provides the Member States with considerable power to negotiate based on other political realities since the process is not public and it is unknown what these negotiations actually entail. Therefore, the Commission - as the de facto executive of the European Union – as well as the Member States through their fishery ministers, and the European public through the Parliament, all function as decision-making centers. Through regionalization, Member States can develop plans for fisheries management, usually in conjunction with Producers Organization and Advisory Councils (Chapter 4.3). They are also involved in developing emergency measures to protect fisheries resources and disburse funds from the EMFAF. Here, POs play a key role on the self-organizational level by establishing production and marketing plans, helping to implement sustainable fishing practices while enhancing the economic viability of the sector. They can develop crisis measures, such as storing fish products to stabilize markets, and provide input to regional fisheries management measures. Through Advisory Councils, POs also have the opportunity to influence the Commission's policy proposals developed by DG Mare. On the operational level, self-organization schemes such as the MSC have the ability to develop fishery management plans that go beyond the rules and regulations of the EU or its Member States and consequently can be considered a center of decision making (Chapter 6.1).

Moreover, institutions at the constitutional, collective-action, and operational levels are designed to operate autonomously and independently, though still embedded within the broader constitutional structure of the EU and its Member States. Within the constitutional structure, the Commission, Council and Parliament function independently of one another. They are dependent on one another in negotiation reforms but their respective power stems from very different processes and they, therefore, follow different rationales and strategies in decision making. The Commission is nominated by the European Council and elected by Parliament. The Council of Ministers is made up of fisheries ministers of Member States that represent fisheries and wider interests. Parliament is elected by the EU public and therefore represents a very broad array of interests, both within and outside the Fisheries Committee (Chapter 4.2). At the collective action level, Producer Organizations are representing the interests of their members and operate autonomously from the interests of politicians in their Member State. At the operational level, self-management through certification schemes such as the MSC also provides a certain degree auf autonomy (Chapter 6.1).

In addition, institutions at all levels operate with *overlapping authority*. At the constitutional level, the Commission, Council and Parliament all have authority in the CFP. While the Commission is setting the agenda, the Council and Parliament negotiate the CFP in a co-decision mechanism. Thus, their authority overlaps in negotiating reforms. Within the fisheries governance system, overlapping authority also exists when it comes to fisheries management. The Commission monitors fisheries resources, adherence and implementation of the CFP (Chapter 4.2). Member States, however, also monitor the fisheries resources in their jurisdiction and design management plans as well as the distribution of quotas. Through market interventions, POs also have a significant role to play in fisheries management as they adjust fisheries products entering the market based on demand and supply. Self-organizing schemes, such as the MSC certification, adjust fishing effort and harvesting quantities through tools such as the harvest control rule. The harvest control rule is not based on management restrictions from the EU or Member States, but a self-imposed restriction potentially exerting significant influence on stocks and fisheries management in general (Chapter 6).

All these institutions at the constitutional, collective action and operational level *operate within a set of overarching institutions*. They operate within and through the Treaty on the Functioning of the European Union and through Member State legislation. The treaty of Lisbon, as indicated above, significantly altered the governance landscape by introducing the co-decision mechanism to the CFP, taking power away from the Council and Commission and making the governance system structurally more polycentric (Chapter 4.2).

This analysis of the European fisheries governance has shown that its structural characteristics are polycentric by having multiple decision centers that are autonomous, have overlapping authority and operate within a set of overarching institutions for the constitutional, collective action and operational level.

7.2 Dynamic Processes

The European fisheries governance system is characterized by dynamic processes *of mutual adjustment between decision centers* that make a system polycentric. At the constitutional level, negotiations between the Council and Parliament require each institution to adjust its position in response to that of the other. Through the Council, policy preferences of member states are injected into the negotiations while Parliament represents the diverse interests of the European public. The Council and Parliament’s position are both influenced by wider political considerations in the member states and the EU as a whole (Chapter 4.4). However, higher levels of governance are also influenced by action at lower levels. The Commission adjusts its position, for example, in a green paper, based on recommendations from Advisory Councils through which POs can influence policy debates. Producer organizations not only have an influence in the Advisory Councils but also directly lobby the

Commission, Parliament and Member States' governments and exert their influence this way – with varying degrees of success (Chapter 4.4). POs and institutions, like the MSC, adjust their positions based on rules and regulations passed in Brussels, a Member State or by judicial rulings – as the brown shrimp fishery shows. The role of the Dutch Authority for Consumer Protection and Markets interpretation of European consumer law in the case of the brown shrimp fisheries attempt to self-organize in the early 2000's exemplifies this (Chapter 4.3.4).

For most of the institutions, there are *low entry and exit costs.* At the constitutional level, one can argue that the concept of entry and exit costs does not apply. For POs, the result is mixed. Producer organizations representing wealthier clients or large corporations may have the financial capacities and expertise to influence policy and the management of stocks to their advantage. Small POs, or those representing small-scale fishers, may have limited resources to participate in lobbying activities and therefore are unable to influence processes at higher levels (Chapter 8). But again, the role of the Dutch Authority for Consumer Protection and Markets in the brown shrimp fishery exemplifies the high costs that can be associated with POs positioning themselves as major decision centers. Self-organization through an institution such as the MSC has the advantage that it has the knowledge and connections that are needed to work as a decision center at the operational level (Chapter 4.3.4). This is especially relevant since the CFP'S 2013 reform. Member States are required to reinforce the role of science by intensifying the collection of data and sharing of information on stocks, fleets and the impact of fishing activities (Chapter 4.3).

This analysis has shown that European fisheries are dynamically polycentric through processes *of mutual adjustment between decision centers* and *low entry and exit costs.* This complements the finding that the fisheries governance system is structurally polycentric, produced in Chapter 7.1.

7.3 Emergent Outcomes: Long-Term Sustainable Resource Use

The literature theorizes that the interplay between polycentric structure and dynamic, polycentric processes gives rise to *emergent patterns of behavior, interactions and outcomes* as well as *emergent and effective coordination throughout the system as a whole (Baldwin et al. 2023)*. This chapter empirically tests if polycentric structures and processes give rise to emergent sustainable outcomes.

As complex adaptive systems, fisheries produce a great number of *emergent outcomes*. Resilience of the fisheries sector through adaptive capacity against exogenous shocks, such as climate change related effects, and sustainable long-term resource use are two outcomes that are interrelated. I conceive neither sustainable long-term resource use nor adaptive capacity as outcomes at single moments in time but rather as emergent patterns of coordination and behavior. I have described the inertia and rigidity of the European fisheries governance system in Chapter 4, one example being the alignment of the scientific and management areas for horse mackerel (Chapter 4.5). So far, I have shown that while the CFP is still rigid, the reforms have brought improvements to the adaptability of the policy through e.g. regionalization of decision making (Chapter 4.3). A significant reason for the continued rigidity is the culture of distrust that results in negotiating technical issues at the European level (politics) rather than reform of policy elements, such as relative stability (policy) (Chapter 4.4). However, does this rigidity lead to unsustainable resource use in EU fisheries?

To answer this question, I operationalize long-term sustainable resource use along the fisheries objectives of the EU. The objectives of the CFP are stocks within safe biological limits, a profitable fishing industry, good wages for workers and a reliable supply of seafood at reasonable prices for consumers (Peñas Lado 2019). In the analysis, focus is put on an integrated, big-picture evaluation of the higher levels of governance. A more detailed analysis based on the lower levels of governance, similar to the brown shrimp fishery in Chapter 6.2, is simply not plausible with a fishery sector as diverse as the European one.

7.3.1 Fishing Within Safe Biological Limits

In the following, an evaluation of the EU's objective of fishing within safe biological limits is done. This evaluation is not based on a single moment in time but follows a process ontological logic (Chapter 2.3) and evaluates emergent patterns over time in a longitudinal rather than static approach (Chapter 2.5). For this reason, the development of fishing within safe biological limits in different European sea basins is discussed and evaluated from a decadal perspective.

However, before evaluating long-term trends in fisheries sustainability, a snapshot perspective will be given to get a picture of stock statuses in European oceans today. The Good Environmental Status[8] (GES) concept of the EU Marine Strategy Framework Directive is used for this evaluation and reveals strong regional differences. In the Baltic Sea and North-East Atlantic approximately 62 % of analyzed stocks meet at least one the of the two GES criteria and 29 % of stocks meet both. In the Black Sea and the Mediterranean, only 26 % of assessed stocks meet only one of the criteria (EEA 2024b). As can be seen in Figure 20, in the Greater North Sea, for 33 stocks, adequate information was available to do a Good Environmental Status assessment. Of these 33 stocks, 11 met two GES criteria and 12 met one.

[8] The evaluation is based on these two criteria: 1. level of exploitation, measured by fishing mortality (F); 2. reproductive capacity, assessed by spawning stock biomass (SSB)

In the Baltic Sea, 13 stocks were assessed and 4 met both criteria while 6 met one. However, in the Baltic, the total number of stocks fished commercially is only 19, while in the North Sea, it is 56. Therefore, the certainty of the aggregate sea basin assessment should be far greater with almost all of the stocks analyzed, compared to only about 60 % of stocks are analyzed in the Greater North Sea (EEA 2024b).

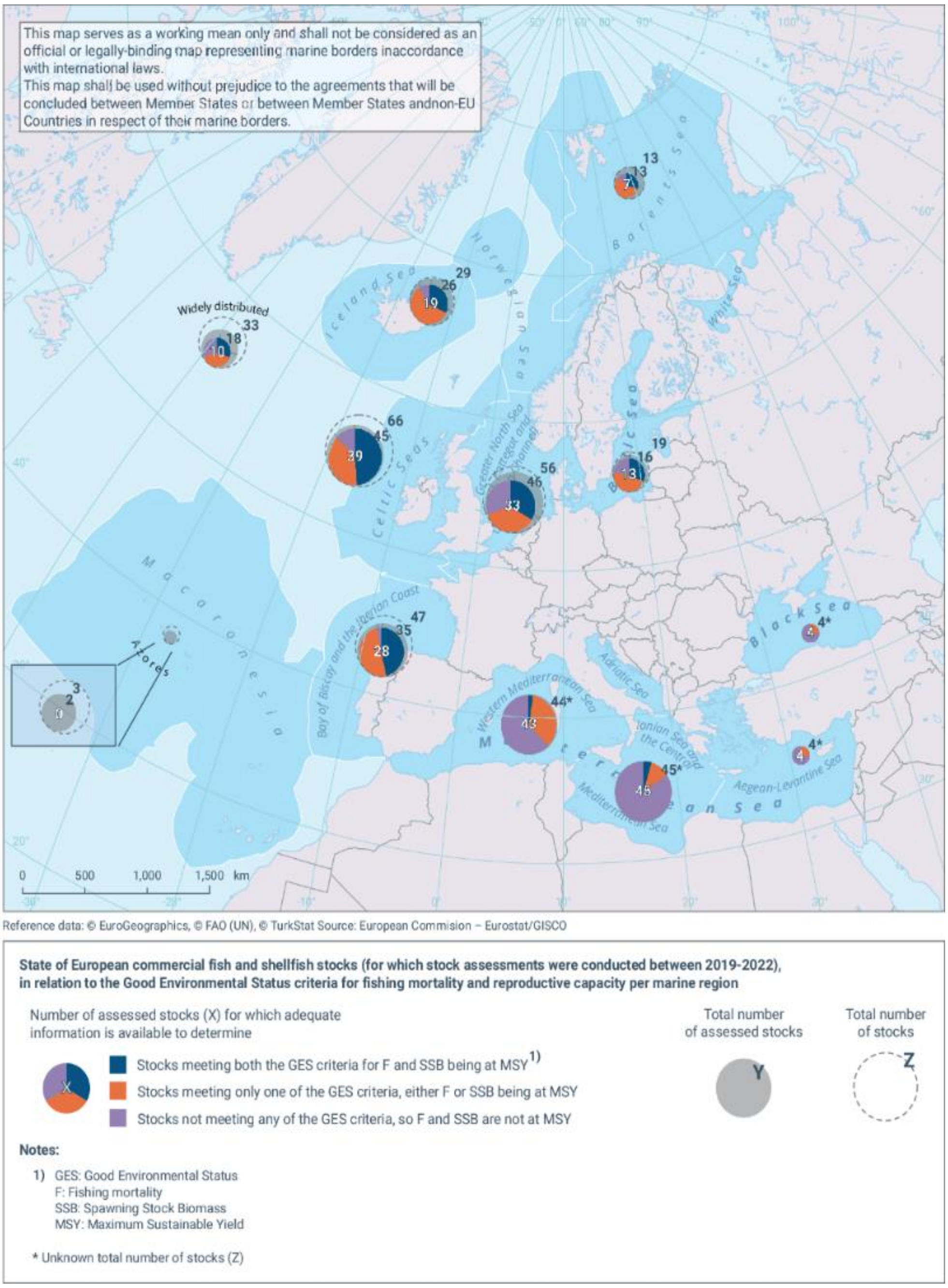

Figure 20: Description of Good Environmental Status of European fish and shellfish stocks (EEA 2024b)

Moving away from a snapshot perspective, it becomes apparent that the EU has managed, to a certain extent, to establish sustainable fisheries over time. However, there are again large differences between sea basins as exemplified by the North-East Atlantic and Mediterranean. For the North-East

Atlantic and Baltic sea stocks, fishing mortality rose from sustainable levels (F/FMSY≤1) in the late 1940's of about 1.1 to about 2 in the late 1980's to 2000. However, in 2021, fishing mortality had decreased to 0.8 (Figure 21) (EEA 2024b). While there is not as an extensive record available for the Mediterranean, fishing mortality has declined from about 2 in 2003 to about 1.7 (F/FMSY≤1) in 2020. Although still above sustainable levels, the long-term trend is moving in a positive direction (EEA 2024b). While substantial differences in stock sustainability exist between regional seas, the overall trend in European waters indicates a positive development toward more sustainable harvesting. Although significant differences exist in European waters.

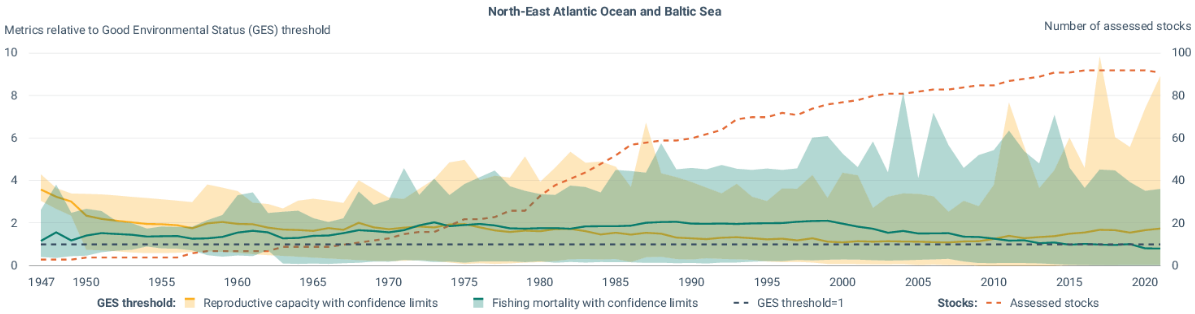

Figure 21: Development of Good Environmental Status in the North-East Atlantic Ocean and Baltic Sea since 1947 (EEA2024b)

7.3.2 Socio-Economic Sustainability

The analysis of the CFP's socio-economic objectives focuses on evaluating the profitability of the fishing sector alongside developments in wages. Again, a longitudinal, developmental approach is taken in the analysis. Not taken into consideration are the objectives of a reliable supply of seafood at reasonable prices, as this dissertation's focus is on the fishers and not consumers of seafood.

The European fleet in 2021 consisted of 71 628 vessels of which 54 213 were in use and active. The overall capacity has decreased from 2013-2021, declining in vessel number by 0.7 % and 1.7 % in GT while remaining stable in kW. Greece has maintained the largest fleet with 16.6 % of total vessels, followed by Italy with 16.3 % and Spain with 12.1 %. With 25.3 %, Spain holds the largest GT and, France, with 18.1 % the largest engine power of all EU fleets. The European fleet had a net profit (excluding subsidies) of €561 million in 2021. Of the revenue, 8.2 % was retained as net profit. France, Germany, Greece and Cyprus reported net profit losses, while the Spanish fleet reported a net profit of €170.5 million (STECF 2023).

121 917 fishers were employed in the EU fleet in 2021, corresponding to 81 747 FTEs. The Spanish fleet employs 24.6 % of all EU fishers, followed by Greece with 16.7 % and Italy with 14.7 %. (STECF 2023). Employment in fisheries has decreased from about 100 000 in 2014 to about 87 000 in 2022. However,

the average wage per FTE has increased substantially over the same period. This falls in line with the EU's objective to reduce capacities while increasing the standard of living for fishers. There are big differences in the EU between the small-scale and the large-scale sector[9] (STECF 2023).

The small-scale coastal fleet (SSCF), defined as vessels under 12 m in length using static gear, comprised 41,267 active vessels in 2021 and employed 59,948 fishers, accounting for 76 % of the active fleet and 49 % of all crew. The value of landings, however, only made up 16 % of EU landings in 2021, in terms of GTs, the SSCF only 7 %. The Mediterranean and Southern Western Waters, which make up 42 % and 32 % respectively, mostly influence the value of landings. The Mediterranean has experienced a decrease in the value landed since 2018, with a drop in the value landed of €523 million in 2018 to €395 million in 2021 (STECF 2023).

Small-scale fleets employ 49 % of the total crew and 40 % of all full-time equivalents (FTE). A decrease of 7 % of total fishers employed and 8 % of FTEs. The Mediterranean has the highest number of FTEs, followed by the Southern Western Waters and the Baltic. However, the Baltic has faced the most significant reduction in FTEs in the fleet from 2018-2020 (20 %). In 2021, the annual labor cost per FTE in the SSCF is estimated to be about EUR 22 500, an increase of 2 % compared to 2020. The Northern Western Waters (EUR 42 557) and the North Sea and Eastern Arctic (EUR 42 747) have the highest labor cost (STECF 2023). Small-scale fishers are predominantly self-employed. As owner-fishers, their returns encompass compensation for their labor and earnings from the capital they invest, including their vessel and other physical assets used in fishing. Net Value Added (NVA) represents the actual income remaining for the fisher after all expenses have been deducted. The average NVA per vessel in the SSCF shows an upward trend in most regions (STECF 2023).

Net profits have reached pre-pandemic levels in 2021 with an increase of 190 % compared to 2020. The Mediterranean, South-Western Waters and North-Western Waters recorded the largest recovery. The North Sea and Eastern Arctic continue to show a negative trend compared to 2018.

The EU large-scale fleet (LSCF) includes fishing vessels that are over 12 meters in length using static gears, as well as all vessels using towed gears. In 2021, the LSCF consisted of 12,704 vessels and employed 55,217 fishers, accounting for 23% of the total active EU fleet in terms of vessels and 45% (51% FTEs) in terms of employment. It contributed 74% of total EU fleet landings and 67% of the value of these landings. The LSF accounted for 45% of employment (55,217 jobs) and 51% of Full-Time Equivalent (FTE) positions (41,903) in the EU fishing fleet (STECF 2023).

While the LSCF remained profitable in 2021, net profit declined by 12.5% compared to the previous year. All Member States' LSF reported gross profits in 2021, although Cyprus, Germany, Finland, and Slovenia reported net losses. Net profit of the fleet was estimated at EUR 343 million (68% of the EU

[9] For a more detailed discussion about small-scale and large-scale fisheries in Europe see Peñas Lado (2019).

total) for 2021. Labor productivity (GVA per FTE) was estimated at EUR 53,500, remaining similar to 2020 levels. On average, the salary per FTE in 2021 was EUR 34,700 per year. However, all productivity indicators have seen a significant decline from 2015 to 2020 (STECF 2023).

European fisheries are overall profitable, although large differences between small-scale and large-scale fisheries exist. While the number of vessels and correspondingly the number of fishers employed is shrinking, as part of the objective to lower the EU's fishing capacities, wages per full time equivalent are rising. Although small-scale fisheries account for roughly 75 % of the EU fleet, they employ only about 50 % of fishers. From a resilience perspective, this distribution has advantages, as the small-scale sector contains far greater redundancies than the large-scale sector. If an individual small-scale fishing operation fails, it is unlikely to generate system-wide effects. This aspect becomes particularly important when considering the future uncertainties associated with climate change, which are expected to be geographically uneven and potentially profound.

7.3.3 Evaluating Sustainable Fisheries in Europe

Fishing within safe biological limits has improved substantially since the CFP's inception, but large differences between sea basins continue to pose challenges. While the number of jobs has fallen, in alignment with the objective to bring fishing capacities in line with biological fishing opportunities, the average salary per fisher has improved under the CFP. Although sustainable fisheries have not been reached for all fisheries and in all sea basins, I concluded – using a longitudinal approach – that the CFP has overall produced more sustainable fisheries, both with regard to fishing within safe biological limits and improving the livelihood of fishers despite the rigid fisheries governance structure.

The polycentric structure and processes (Chapter 7.1-7.2) of the EU fisheries governance system has overall produced more sustainable fisheries up to this point. I argue that this success is part of the problem when adapting to current and upcoming climate change effects. Reforms of the policy and institutional structure (Treaty of Lisbon) have been able to deliver sustainable fisheries without having to fundamentally alter the political structure of fisheries governance (Chapter 4.5). The core system rationale in which Member States compete for the biggest share of the pie has not changed. The climate driven changes to our oceans will test the CFP and make changes to the relative stability key almost inevitable. In times of a rapidly changing climate, the political dimension of fisheries governance in the EU could prove to be the linchpin. So far, the example of the Horse Mackerel (Chapter 4.5) has shown the political difficulty in adjusting management and scientific areas – even if this adjustment does not produce any real losers. Climate change driven biophysical changes to European waters, however, will almost certainly produce losers. Political changes to the CFP need to take place rather than just changes to how knowledge is produced (Chapter 2.3). So far, increased ecological knowledge and some changes to how knowledge is produced, have been sufficient in providing positive results. With the upcoming climate change driven migration of stocks and effects on species' life stages (Dahlke et al. 2020; Saborowski and Hünerlage 2022), changes to the distribution of fishing opportunities need to be made. Having concluded that, overall, European fisheries governance can produce sustainable fisheries, the question arises whether the current drastic decline in landings of the brown shrimp fisheries can be explained by and through polycentricity.

7.4 Polycentricity in the Brown Shrimp Fishery

Non-managed species such as brown shrimp constitute a distinctive governance challenge within the European fisheries framework. They fall outside EU fishing-effort and quota regulations and are, de facto, excluded from management considerations at the constitutional level (Chapter 5). Therefore, I ask: Is the brown shrimp fishery governance polycentric?

I argue that the lack of rules and regulations at the constitutional level, as well as feedback between self-management and constitutional level, play major roles in the currently unsustainable harvesting structure of the fishery. The fishery has been experiencing a 25% drop in landings compared to 2015. The self-management plan's fishing effort restrictions, harvest control rule or mesh size increases do not seem to be able to prevent a stock decline or, at the very least, a decline in landings (Chapter 6.2). A functioning system of self-organization relies on numerous feedback mechanisms across multiple hierarchical levels (Chapter 2.4.2). The outcomes of the interactions at different governance levels (constitutional, collective choice and operational level) are connected through feedback loops. Only through this interplay can sustainable self-governance emerge. Therefore, the functioning of self-governance systems rests on the interaction of feedback mechanisms embedded within a multi-level hierarchical structure (see Chapter 2.4.2). At the constitutional level, the brown shrimp fishery of the southern North Sea is subject neither to input nor output controls, but only to technical restrictions, along with Member State-specific entry limitations (see Chapter 5). The MSC assessment from October 2023 concluded that:

"The overarching CFP, EU nature conservation and GES Directives and the Member States national fisheries and nature conservation legislation combine to create effective national systems and organised and effective cooperation with other parties, where necessary, to deliver management outcomes consistent with MSC Principles 1 and 2, thereby meeting the SG 60 and SG 80." (MSC 2023, 210)

There are, however, no feedback mechanisms between the collective choice level and the constitutional level for the fishery. With the MSC certification, the EU regards the stock as being under sustainable management despite the recent drop in landings. The research informing the sustainability certification (e.g. Temming and Hufnagl 2015) of the MSC leads the EU not to impose a formal regulatory framework on the fishery. Therefore, the brown shrimp fishery is neither from a structural nor processual perspective governed by a polycentric system and therein lies the problem. Without rules at the constitutional level that go beyond technical restrictions but actually set a frame for sustainable fishing within the context of climate change, self-management plans will not be sustainable. The constitutional level needs to set guidelines for effort restrictions so that the fleets from the different Member States experience a level playfield. Without these rules at the constitutional level, large-scale exploitation of the resource ensues within the limits of formal governance restrictions. The EU needs to set more precise guidelines under which a self-management plan can be developed or, at the very least, a mechanism that comes into play when stocks decline.

7.5 Integrating Rigidity, Self-Management & Polycentricity in European Fisheries

I have shown in Chapters 4 through 7 that (1) the European and German fisheries are inflexible and therefore fundamentally ill-equipped to deal with climate change uncertainty (2), but only partially produce unsustainable fisheries as a result (H4). Governance structures at both the European and Member State level exhibit rigidity, making them ill-equipped at adapting to social-ecological changes. However, despite this institutional rigidity, the multi-level European governance system has managed to produce fisheries that could overall be considered more sustainable when compared to the early decades of the Common Fisheries Policy. Therefore, I reject the second part of Hypothesis 4 that rigid governance systems are unlikely to produce sustainable resource use, as postulated by Adaptive Governance Theory.

The systemic inflexibility of European and Member State governance highlights how rigid regulatory frameworks limit adaptive capacity to climate change. There is a reluctance to renegotiate old policy elements, marked by path-dependencies and institutional lock-ins. Although policy frameworks and institutional structures play a role in reinforcing system rigidity, resistance to change is primarily grounded in political considerations operating at both the EU and Member State levels. While political dynamics largely explain the rigidity of fisheries governance, they also provide the means for resolving it by negotiating clear and coherent processes that frame and facilitate adaptation. In the absence of these, climate change adaptation will continue to depend on case-by-case political negotiations, as the case of the horse mackerel highlights (Chapter 4). In Germany the missing political process becomes visible most prominently through a lack of fisheries' objectives, stifling its climate change adaptive capabilities. For non-managed species, such as the brown shrimp, for which there are effectively no constitutional level rules at either the Member State (Germany) or EU level, the need to negotiate clear and coherent adaptation frameworks becomes particularly important (see Chapter 6.1). Without such a framework, neither the EU nor Germany will be able to influence management decisions to the degree that is necessary (Chapter 5). However, there is little political willingness at either the European or Member State level to establish a framework for renegotiating existing processes, as such efforts are associated with substantial political costs by risking losing access to resources. After all, at its core, the CFP is a distributive policy. In its current form, the brown shrimp fishery's self-management fails to deliver sustainable outcomes, largely due to misalignments between harvesting rules and local conditions (Ostrom Principle 2). Foundational to this misalignment are missing constitutional level rules (Chapter 6.2).

A fishery that de facto relies on self-imposed rules does not meet sustainability objectives within the current fisheries governance system in Europe. The polycentricity of the EU's fisheries governance has enabled Europe to establish sustainable trajectories for its fisheries, although large regional differences exist. This polycentric power structure has so far been able to counteract the CFP's rigidity to a degree. However, within the context of climate change, I argue that this can pose a problem. The EU has been able to produce sustainable fisheries despite its rigidity. Climate change will, however, change the ecological makeup of oceans at a speed not seen before in European fisheries. While the system has been able to produce more or less satisfactory outcomes with respect to biological and social sustainability, at least from a longitudinal perspective, it is unlikely to be able to adapt at the speed necessary that climate change commands. Therein lies the problem that Europe has to face. A problem even more prominent for non-managed species because important polycentric components are missing. Through self-management, fishers and industry are more agile in adapting to a changing social-ecological oceanscape. However, this does not necessarily translate into sustainable management. Only through interconnected feedback mechanisms between different governance levels will sustainable harvesting practices emerge (Chapter 7). Without rules at the constitutional level the fishery is unlikely to become sustainable because of existing path-dependencies within the larger European fisheries governance system that entice and encourage the large-scale exploitation of fisheries resources.

8 Governance Rigidity and Institutional Path Dependencies: Large-Scale Exploitation in European Fisheries

Path-dependencies that result in the large-scale exploitation logic are foundational to European fisheries, from the EU through the Member States and self-management level. It examines the degree to which European multi-level governance systematically prioritizes the large-scale commodification of fisheries resources, favoring large-scale over small-scale fishing operations. Governance mechanisms, economic incentives, and institutional path dependencies collectively embed large-scale exploitation structures and limit adaptive responses. While European fisheries have become more sustainable over time (Chapter 7), the EU's fishing-opportunity allocation system (Chapter) is still embedded in institutional path-dependencies that systematically favor the large-scale sector. As a result of policy inertia (Chapter.3), the path-dependencies rooted in historical contingencies have largely withstood CFP reforms - keeping governments locked into former decisions and further institutionalizing large-scale exploitation. I hypothesize:

H5: The multi-level European political governance system is designed with the large-scale commodification of fisheries resources at its core, which favors and consequently produces large-scale compared to small-scale fishing operations.

This chapter explores how feedback loops, fueled by institutional path-dependencies, reinforce large-scale exploitation at every level of the governance system - the European, the Member State and the self-management level. Chapter 8.1 analyzes how European fisheries governance has an institutionalized preference for large-scale fisheries through key mechanisms such as quota allocation, locked in through a system of historical fishing rights, as well as market-based quota trading systems that work to the advantage of large-scale fleets – both at the Member State and the EU level. Chapter 8.2 examines how subsidies through European structural funds have primarily supported large-scale fishing, putting small-scale fishers at a comparative disadvantage. In addition, the chapter shows how EU and fuel tax exemptions disproportionally favor larger-scale fishing operations. Finally, Chapter 8.3 analyzes the large-scale exploitation within the brown shrimp fishery and shows how it exemplifies institutional inertia and structural barriers to a system of adaptive management.

8.1 Access to Fishing Opportunities

The EU's fisheries governance design has produced an institutionalized preference for large-scale fisheries. The current policy at the European and Member States level favors large capital investments and quota concentration that result in small-scale fishing operations being pushed out. The relative stability key, as the distributional mechanism of catch shares at the European level, as well as quota allocation within member states, plays a significant role in the large-scale commodification of marine stocks. Path-dependent institutional lock-ins have led to resistance to change and institutional rigidity that reinforce each other.

The Common Fisheries Policy has its origins in the early years of European integration and the treaties of Rome in 1957 (Peñas Lado 2016). The policy aimed to boost agricultural production - including fishery products, which were administratively classified as agricultural goods - and to enhance the livelihoods of those employed in the sector. At the same time, it sought to stabilize markets in order to secure supply and ensure that consumers had access to products at reasonable prices. The CFP was born out of and built around those core needs, which is important to remember. The EU introduced, in 1983, as part of the Common Fisheries Policy, fishing quotas to tackle overfishing that had grown to be a serious problem by the 1970's. The foundational mechanism for the EU's quota scheme is the system of relative stability and based on historical catch data from 1973 to 1978 (Chapter 4.1). Quotas were only established for commercially relevant species at the time, such as cod, herring and mackerel. Those nations, and fishing companies, were rewarded that had been able to set up the largest fishing operations in the mid to late 1970s (Peñas Lado 2019). This distribution agreement, based on historical fishing rights, institutionalized the access of large-scale fisheries and fleets, to the disadvantage of small-scale fleets. This is also of relevance within the context of climate change. The distributional key based on catches from the 1970's does not represent the ecosystem realities of today. The marine food web has changed, due to overfishing, pollution and climate change (Bastardie et al. 2022a; Möllmann et al. 2021; Predragovic et al. 2023; Sailley et al. 2025).

Another systemic advantage for large-scale fisheries was the introduction of a market-based quota trading system. Fishing companies have the ability to buy or swap quotas in Member States, leading to the private accumulation of quotas: "*Thanks to good contacts in Europe, we have been able to buy fishing companies with quotas. In most cases the reason was that the entrepreneur had no successor*" (Diek Parlevliet in Poulsen 2023). The current politics and institutional set-up at the EU level exacerbates the tendency towards large-scale commodification of stocks. The small-scale fishers association "LIFE" equates the process of negotiating TACs by the Council as a black box that benefits the large players (LIFE 2017).

The large-scale commodification of fishery resources is not only perpetuated at the EU, but also at the Member States level. While it holds true that the governance system at the EU level sustains the exploitation of resources by large-scale fishing companies, the 2013 CFP reform (CFP 2013) introduced

Article 17 through which the Member States can decide their national quota allocation on more than just historical catches:

"When allocating the fishing opportunities available to them, as referred to in Article 16, Member States shall use transparent and objective criteria including those of an environmental, social and economic nature. The criteria to be used may include, inter alia, the impact of fishing on the environment, the history of compliance, the contribution to the local economy and historic catch levels. Within the fishing opportunities allocated to them, Member States shall endeavour to provide incentives to fishing vessels deploying selective fishing gear or using fishing techniques with reduced environmental impact, such as reduced energy consumption or habitat damage." (CFP 2013, Article 17)

Article 17 gives Member States the ability to use the impact of fishing on the environment, history of compliance or contribution to the local economy as criteria complementing historic catch levels when allocating quotas. However, "*It is fundamentally ignored across Europe, to the detriment of a multitude of coastal communities. So, the status quo persists. The access is privatised, it goes to the person with the biggest pockets and therefore the most lobbying power*." (Poulsen 2023) Jerry Percy, general manager of the UK's New Under Ten Fishermen's Association (Nutfa)s says. The Low Impact Fishers of Europe, an organization for and by small-scale fishers, argues that the accumulation of quotas is to the disadvantage of small-scale fishers (LIFE 2017). The lobbying power and political influence of large-scale fisheries ensure the institutional lock-in towards large-scale exploitation. The Danish national audit office (Rigsrevisionen) concluded in a 2017 report that in the Danish fishing industry, too much quota was in the hands of too few people:

"It is Rigsrevisionen's overall assessment that, for a number of years, the ministry has estimated the ITQ concentration based on incomplete data, different methods of calculation and incorrect registrations of transfer and ownership of quotas. At the same time, international swapping of quotas has provided an option to swap quotas that should have been included in the calculation of quota concentration. As a result, neither the ministry nor the public has an accurate picture of the concentration of quota ownership… The ministry has asked the police to investigate the cases where Rigsrevisionen has found reason to suspect that a criminal offence has been committed." (Rigsrevisionen 2017, 3)

Once the total allowable catch is set and quotas are allocated to Member States, the management responsibility lies with the Member States. This is reiterated by the Commission*: "the way Article 17 is drafted does not give tools to [the] Commission to do anything drastic', leaving most of the interpretation to Member States" (Said et al. 2020, 2).* Member States can allocate their assigned quota at their discretion across their fleet segments. In essence, the distribution of quotas determines who gets access to fishery resources and, therefore, who is able to derive benefits from them (Carpenter und Kleinjans 2017). The following example from Denmark showcases that fleet capacity reduction plans and market-based quota trading systems disproportionately favor large-scale fisheries. Access to fishing opportunities is the outcome of processes that consist of access to decision making at various levels, access to capital and relationships with authorities of various kinds (Schuhbauer et al. 2020; Skerritt et al. 2020; Skerritt et al. 2023).

The introduction of the Vessel Quota Share (VQS) system in 2007 marked Denmark's shift toward a market-based management model - similar to individual transferable quotas - for its demersal fisheries, superseding the previous system of periodically distributed catch shares (Carpenter und Kleinjans 2017). Quotas were initially allocated based on historical catch records, with only vessel owners receiving quotas tied to their vessels. A few years earlier, an ITQ system had been implemented for the more capital-intensive pelagic fisheries. Both the ITQ and VQS systems were introduced after years of unsuccessful efforts to align the fleet's capacity with biological fishing opportunities and reduce overcapacity. Initially, the national organization representing demersal fishers opposed the ITQ system for the demersal fleet, but during political negotiations, the board's stance shifted (Said et al. 2020). To protect the small-scale fishing fleet under the new market-based management system, the Danish government introduced a "coastal fishing scheme" alongside the VQS system. Despite the introduction of the coastal fishing scheme, the VQS system has affected the stability of the small-scale fishing sector. According to official statistics, between 2003 and 2016, the small-scale segment experienced a 24% decrease in its share of the total value of fish landed. This decline was more pronounced for the smallest vessels (under 12 m), which saw a 33% reduction, while 'larger' small-scale vessels (under 18 m) saw a 20% decrease. In contrast, the large-scale segment (18 m and over) increased its share by 21%. They accounted for 64.6% of the total landing value in 2016, up from 53.3% in 2003. Additionally, within each vessel length category, the largest vessels have captured a greater share of the catch. Vessels primarily using gillnets, traditionally a hallmark of Danish small-scale fisheries, accounted for 14.4% of all landings in 2003, but this share dropped to 7.7% by 2016 (Said et al. 2020).

Vessel owners can withdraw from the scheme and sell their VQS on the open market. The scheme failed to prevent the loss of quotas from the small-scale, coastal fishing segment. While the decline of the small-scale fleet was already evident before the VQS system was introduced, it followed the overall trend of the entire Danish fleet. The implementation of the VQS system, however, accelerated these dynamics, putting unprecedented pressure on Danish coastal fishing. The system was explicitly designed to reduce overcapacity, and from the outset, it was expected to significantly decrease the fleet's collective capacity. The key issue became how this reduction would be distributed across different fleet segments, with access to external capital emerging as a crucial factor (Said et al. 2020). The VQS system allows vessel owners to use quotas as collateral for loans. However, large-scale operations usually have access to loans at lower interest rates than small-scale ones. (Said et al. 2020).

8.2 Subsidies in the EU

Policy elements such as the relative stability principle, TACs and market-based quota trading systems such as the ITQ have created path-dependent institutional lock-ins. The governance system that has emerged systematically favors large-scale fisheries, reflected in the distribution of EU structural-fund subsidies and in the provision of fuel-tax exemptions. Small-scale fisheries have received less support through the funds, facing economic and regulatory barriers in a fund that is geared towards supporting industrial fisheries (Skerritt et al. 2020).

The European Maritime, Fisheries and Aquaculture Fund has a budget of approximately €6.1 billion in the 2021-2027 management period. Around 87% of the fund is managed in collaboration with Member States, meaning national operational programs are defined and then approved by the European Commission. The allocation of the EMFAF budget is based on the size of each Member State's fisheries and aquaculture sectors, with the four largest beneficiaries—Spain (21%), France (11%), Italy (10%), and Poland (10%)—receiving nearly half of the total funds. National funding complements EU support, with Member States increasing the EU budget by an average of 40% through co-financing in the previous programming period (2014-2020) (EU Parliament 2022).

Over the years, funding from the EU budget for fleet support has decreased, shifting to other areas like control measures, environmental initiatives, marine research, and activity diversification. While the EMFAF includes some fleet support measures for vessels up to 24 meters, such as assistance for young fishers purchasing second-hand vessels and engine modernization, strict conditions are in place to avoid contributing to overcapacities or overfishing. These conditions require that new or modernized engines do not exceed the power of the engines being replaced and that vessels must belong to segments in balance with available fishing opportunities (EU Parliament 2022). The EMFAF also permits support for the temporary or permanent cessation of fishing activities, subject to a national ceiling set to be no higher than €6 million or 15% of the Member State’s budget allocation. Certain capacity-enhancing operations are explicitly prohibited, such as acquiring equipment to increase fishing capacity or transferring vessels to third countries (EU Parliament 2022).

The German program for the planned national implementation of the EMFAF was approved by the Commission in November of 2022. This means that around €211.8 million in EU funds are available during the program period to promote the German fisheries and aquaculture sector - in total, €302.6 million will be available (BMEL 2025). The German EMFAF program aims to contribute to achieving European objectives. In the context of the implementation of the EMFAF in Germany, the following areas are particularly supported according to the federal government (BMEL 2025):

- A sustainable, competitive, and knowledge-based fisheries and aquaculture sector, including the marketing and processing of fishery and aquaculture products,
- Measures for stock conservation, protection of the marine environment and restoration of aquatic biodiversity,
- Effective fisheries supervision and control, as well as data collection and analysis,
- Sustainable development of fishery areas along the coast and inland and
- Promotion of innovations in fisheries and aquaculture.

Of the program's budget, 49 % (103.6 million) will be allocated to sustainable fisheries, while 33 % (69 million) will be invested in sustainable aquaculture, processing, and marketing. 10 % or 21.7 million will support the sustainable blue economy in coastal and inland regions, 6 % (11.9 million) technical assistance and 2 % (5.2 million) will be directed towards enhancing international ocean governance with the goal to contribute to the EU's environmental and climate objectives (BMEL 2025). Additionally, the EMFAF will promote innovation, emphasizing energy efficiency and CO_2 reduction through knowledge sharing and transfer between research organizations and the fisheries and aquaculture sectors (EU COM 2022). It is too early to see if the funds will be spent on small- or large-scale fisheries and beyond the scope of this work to do an in-depth analysis on the allocation of funds in the past (EMFF and EFF). Looking at the EMFAF funds spent EU wide between 2014 and 2021, only 20 % were spent on the small-scale sector, while 80 % were spent on the large-scale fishing fleet (ClientEarth 2023). A study by Seas at Risk (2020) shows the concentration of funding in industrialized fishing harbors where large companies are located and the difficulty for small harbors to gain access to these funds in France. These numbers highlight the prevalence of EU funds to go to large-scale fishing operations both in terms of the support for fleet segments and harbor locations[10].

Besides the financial support through the EMFAF, another critical support measure for the EU fisheries sector is the exemption from fuel taxes. In 2020, the EU fleet consumed 1.9 billion liters of fuel, costing an estimated €700 million and representing 12.6% of operating costs. The tax exemption applies to fuel used for navigation within EU waters, and its value depends on Member States' fuel duties and fluctuating prices. A study by the NGO OurFish (2023) shows the different impacts that a fuel tax would have on the large- and the small-scale sector. The study showed that, retrospectively, the median profitability of the small-scale sector under three tax scenarios. As shown in Figure 22, in tax scenario 1 (€0.036/L), scenario 2 (€0.33/L) and scenario 3 (€0.67/L) the small-scale sector showed higher and upward trending profitability when compared to the large-scale sector.

10 There is an argument to be made that this distribution of subsidies is fair as the large-scale fisheries land the vast majority of fisheries resources, contributing 74% of total EU fleet landings and 67% of the value of these landings (Chapter 7.3.2). Exploring these discourses is, however, beyond the scope of this dissertation.

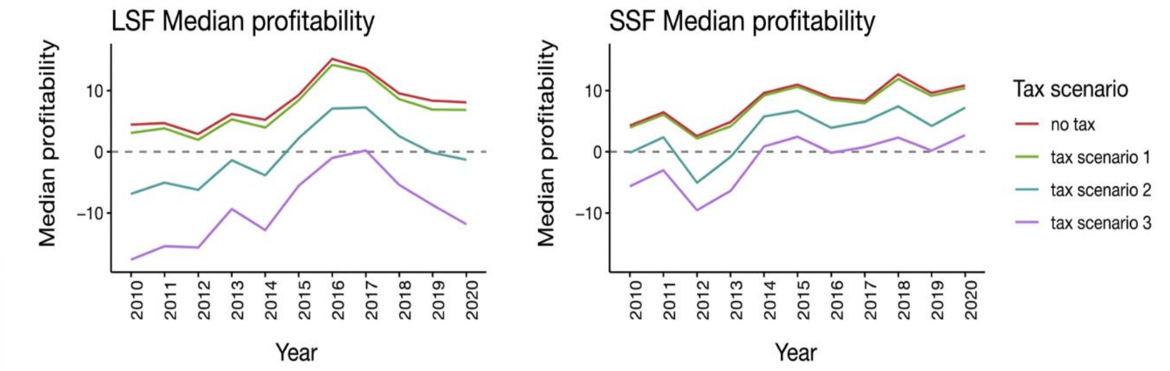

Figure 22: Profitability of the small-scale vs. large-scale sector under three different tax scenarios - (€0.036/L), scenario 2 (€0.33/L) and scenario 3 (€0.67/L) (adapted from OurFish 2023)

Important to highlight is the fact that the profitability for small- as well as the large-scale sector is not drastically impacted by the lowest tax scenario. Especially for the small-scale sector, the impact of median profitability seems to be almost non-existent. Even this lowest tax scenario of €0.036/L would have generated about €74 million in 2019 (OurFish 2023). Currently, the European Commission is revising the Energy Tax Directive (ETD), proposing to end the exemption and introduce a small nominal tax for shipping within EU waters to promote fairer distribution of environmental costs (EU Parliament 2022).

There is also a significant difference in the cost of fuel for the large- and small-scale segments (STECF 2023). A closer look at beam trawls in the North Atlantic shows that the average price for fuel was €0.45/L with an energy efficiency (fuel cost/revenue) of 24.7 %. This makes it one of the highest proportions of revenue required to cover fuel costs within the entire EU fleet. In Germany, beam trawlers are categorized into three fleet segments: 12-18 m, 18-24 m and > 24 m. When looking at the German brown shrimp fisheries, the segments 12-18 m and 18 -24 m are of relevance. For the first segment, the fuel price was €0.59/L with an energy efficiency of 14 %. For the 18-24m segment, the fuel price was €0.55/L with an energy efficiency of 19 % (STECF 2023). This shows that larger vessels have a relative advantage at least in the price of fuel, although their energy efficiency is lower. There are, however, some German brown shrimp fishers who think that diesel prices are too low and, in turn, incentivize unsustainable fishing practices – seeing in them one of the reasons for the current drop in landings (fisher 2022, personal communication).

8.3 Large-Scale Exploitation in the Brown Shrimp Fishery

Access to fishing opportunities, subsidies and fuel tax exemptions all work to disproportionately benefit large-scale fishing operations in the EU and reinforce this institutional lock-in at the European and Member States' level.

The EU has implemented several policy changes and enacted regulations with the intention of eliminating overfishing and protecting marine habitats - e.g., MSY or multi-annual fishing plans (Chapter 4). These changes, however, have always been reactionary. They were implemented when the problem of overfishing got too big to ignore and the pressure from a changing European electorate left little other options open (Chapter 4.4.1). Despite these policy changes, the CFP's foundation is still one of large-scale exploitation of resources as shown in Chapter 8.1 and 8.2. In what follows, the brown shrimp fishery serves as a case through which to examine the reversed application of the precautionary principle within EU governance of non-managed species.

The precautionary principle has been a formalized part of the CFP since the 2002 reform, reinforcing economic efficiency as a priority over ecological concerns. The reform emphasized sustainable exploitation of living aquatic resources and the precautionary principle was officially introduced as a guiding element, especially in instances where scientific evidence about stocks and ecosystem impacts was uncertain. With the 2013 reform, the precautionary principle was further formalized and became a core element of fisheries management (Fitzmaurice and Rosello 2020). The reformed policy set out to manage stocks at MSY, with an explicit focus on implementing the precautionary principle and an ecosystem-based approach to fisheries management:

"[The precautionary approach] means an approach according to which the absence of adequate scientific information should not justify postponing or failing to take management measures to conserve target species, associated or dependent species and non-target species and their environment". (CFP 2013, Article 4(8))

The precautionary approach in EU fisheries governance has its foundations in the United Nations Fish Stocks Agreement, which the EU is party to. The Treaty on the Functioning of the European Union in Article 191(2) ("*Union policy on the environment shall aim at a high level of protection…. It shall be based on the precautionary principle and on the principles that preventive action should be taken…*" (TFEU 2012, Article 191(2)) enshrines the precautionary approach into EU law. The UN Fish Stocks Agreement requires contracting parties to (ClientEarth 2020):

- be cautious in case information is inadequate, unreliable or uncertain

- to set reference points based on scientific information, to ensure actions to be taken if those reference points are approached and appropriate actions if those reference points are exceeded and
- take into account uncertainties.

While the precautionary principle is a formalized part of EU policy, it has not always been implemented to the extent necessary. TACs have regularly been set above the scientific advice provided (Froese et al. 2021; Möllmann et al. 2021). A glaring example of the non-use of the precautionary principle are non-quota species.

Non-quota species may have regional socio-economic importance, but do not play a significant enough role EU wide. They are not subject to TACs and the relative stability key. Additionally, fisheries governance in the EU is not only dictated by the CFP but operates in league with other European policies. The ruling against the trilateral agreement on restricting brown shrimp supply on grounds of infringements against the European competition law is one such example. The Dutch Authority for Consumer Protection and Markets ruled that the absence of a TAC on brown shrimp suggested that the limitation of catches was not within the management responsibilities of the producer organizations. The same was the case for claims by the industry that catch limitations were in part a tool for the conservation of the shrimp stock (Chapter 4.3.4).

Despite all of its detail oriented rules and regulations (Peñas Lado 2019; Peñas Lado 2016), and its formalized focus on the precautionary principle (Fitzmaurice and Rosello 2020), there are no clear mechanisms regarding the sustainable harvesting of non-managed species in the CFP. This leads to two interconnect outcomes. For one, once a "mainstream" species, such as the plaice, is no longer profitable to harvest, the fisheries move on to find other species. Non-managed species are an attractive alternative because of the absence of quotas. These fisheries are relatively easy to enter and pose the opportunity for high profits because of few restrictions (Chapter 5.1.1). Secondly, the lack of quotas and fishing effort restrictions means a race for large-scale harvesting quantities within the non-managed fishery. Exactly this has taken place in the brown shrimp fishery. Large Dutch flatfish vessels, so-called Euro-Cutters, have been entering the fishery over the last few decades. From the 1990's on, there has been a trend of ever higher landing quantities, larger vessels, and in the last few years, higher fishing effort – especially in winter (Temming et al. 2022b). Today, the fishery is in a potentially critical condition with no telling if the situation is going to get better, stabilize or get worse. A detailed analysis of the potential contributors to a collapse will be done in Chapter 9.

Rather than working pre-emptively to protect the over-exploitation of yet another species, the reverse use of the precautionary principles means that the necessity of conservation measures first has to be scientifically proven before they can be implemented - as illustrated by the ruling regarding the fisheries' self-management in 2003 (Steenbergen et al. 2017). While calls for "greener" policies in the EU's fishery governance are getting louder and more prominent, tackling the issues related to non-managed species is being avoided following a pattern of institutional rigidity (Chapter 4), a reluctance to change that is the result of lock-ins. The results are politically driven proposals that have little policy value and do not try to fundamentally change the underlying problem of European fisheries governance. The EU action plan (Chapter 4.3.2) is an example of the overarching problem that is non-managed species. Rather than renegotiating the existing governance systems, it perpetuates existing problems by encouraging fishers to move to exploit other stocks. Using this dissertation's research epistemology of interweaving knowledge types, I will show that the EU action plan is an example of a policy proposal that further encourages large-scale exploitation of fisheries resources based on the brown shrimp fishery.

On February 21st 2023, the EU proposed an Action Plan to ban all mobile bottom fishing in Marine Protected Areas in European waters with the stated aim to (1) *achieve biodiversity conservation* and (2) *climate change mitigation targets* (EU Action Plan 2023). Although not binding, the Commission encouraged the member states to develop plans, adopt national measures by March 2024 and pass legislation that phases out all mobile bottom fishing in marine protected areas. In Germany, this led to widespread outrage in the industry and a demonstration by brown shrimp fishers in February and March of 2023. A ban of mobile bottom trawling in MPAs would have meant an end to the German brown shrimp fishery as the most significant part of the inshore fishing grounds are located within the national parks of Schleswig-Holstein or Lower Saxony (Örey et al. 2025). Werner Schwarz (CDU) and

Figure 23: fishers demonstrating against the EU Action Plan in March 2023, photo by author

Miriam Staudte (Grüne), the ministers of agriculture from Schleswig-Holstein and from Lower Saxony, respectively, as well as the federal minister of agriculture Cem Özdemir (Grüne) renounced the action plan at the demonstration in Büsum, Germany (23.03.2023, personal attendance). They assured fishers that a German inshore fishery was wanted and promised their support, showing unity across the political spectrum. They, however, offered no clear intentions beyond a broad commitment to fisheries, which was met with skepticism and disbelief (Figure 23).

In the action plan, the Commission calls on its member states to ensure a "fair and just transition" for fishers through various financial schemes. The plan, seemingly based just on explicit knowledge (Chapter 2.2) without much practitioners' input, shows at best a simplistic and naïve view of fishing and marine ecologies. One of the only concrete, actionable recommendations is that:

"The impacts can range from small shifts in fishing operations that can be easily absorbed to larger changes in operations that would require mitigation action to help fishers, their communities and operators throughout the supply chain to adjust to broader, structural changes. Impacts could be partially offset by moving fishing activity to other fishing areas where this is possible." (EU Action Plan 2023, 12)

This two-sentence recommendation reveals a limited understanding of how fishing operations work. Switching from one fishing technique to another, as suggested, is not a "small shift" but requires a significant amount of practical knowledge that is not easily acquired nor practiced. This kind of knowledge cannot be preserved through communication and explicit knowledge alone. Switching fishing gear and targeting a different species is difficult and done by obtaining tacit knowledge, as one fisher put it:

> *"da wüsste doch heute gar keiner, wie das geht, die würden ihre Schiffe dreimal in sich selbst einwickeln in die Netze und brauchen 'nen Rettungskreuzer, um nach Hause zu kommen, nicht?" (RTB 2, Pos. 999)*
>
> *"Nowadays, nobody would even know how to do that. They'd wrap their ships up in their own nets three times over and need a rescue cruiser just to make it back home, right?" (RTB 2, Pos. 999)*

Using specialized gear is something that needs to be learned, something that is passed on from one fisher to the next. Therefore, moving from one fishing technique to another is by necessity part of larger changes rather than "small shifts in fishing operations".

There are several reasons why even larger changes, as imagined in the action plan, are difficult to implement. The North Sea inshore fleet almost exclusively targets brown shrimp. Other species, with some exceptions, are not available to harvest anymore - either because of overfishing, northward stock movements or lack of quotas (Temming et al. 2022b; COFAD 2020). Moving harvesting activities to other fishing areas is therefore not that simple. One reason is the large size of the MPAs and, in comparison, the relatively small size of the vessels. With some exceptions, such as the major shipping routes of the Elbe and Weser estuary, MPAs cover the entire German coastline from Sylt in Schleswig-Holstein to the East Frisian Islands in Lower Saxony (MSC 2023). Another is that the average vessel of the German inshore fleet is too small to fish outside of the MPAs all year round (fisher 2022, personal communication). However, even if this were possible, it would mean the entry of these fishers into a different fishery, creating over-capacities and with them the potential of overfishing of other species that this increased concentration could bring about. This, in turn, perpetuates longstanding challenges in non-managed fisheries such as the brown shrimp fishery. It effectively incentivizes continued large-scale exploitation—albeit of different, often non-managed species, which remain the easiest to access. As most fishers lack quotas for commercially valuable stocks, participation in other fisheries depends not merely on vessel characteristics and gear, but also on policy and administrative constraints. A non-quota species in the southern North Sea that does not require bottom-trawling gear is the European lobster (*Homarus gammarus*). Nonetheless, substantial investment in vessels and gear would be necessary to target lobster, and shifting the entire fleet into this fishery would place excessive pressure on the population. For this reason, many fishers—regardless of the action plan—saw lobster fishing as an alternative for a select few, but not a viable option for most of the fleet:

> *„Ich sehe vielleicht, ich höre das ja immer nur von links und rechts, einige diversifizieren sich noch mal. Ich glaube […] auf - auf - auf …] Hummer. […]Und was ist, wenn das jetzt noch zehn Schiffe mehr machen? […]Dann stehen wir vor demselben Problem." (RTB 2, Pos. 785-796)*

> *"I might see it, I only ever hear about it from left and right—some are diversifying again. I think... on... on... on... lobster. And what if ten more ships start doing the same? Then we're facing the same problem as we are today." (RTB 2, Pos. 785-796)*

Rather than solving an existing issue of European fisheries governance, the action plan would introduce a new policy that simply pushes the problem into another arena.

8.4 Integrating Rigidity, Path-Dependencies & Large-Scale Exploitation in European Fisheries

From an Adaptive Governance Theory and complex adaptive systems perspective, European fisheries governance is a rigid and path-dependent system, shaped by an economic efficiency logic and institutional inertia. The governance of European fisheries is structured by a framework that systematically prioritizes large-scale fisheries. It is marked by institutional rigidity and lock-ins as a result of historical policy choices that, through institutional path dependencies, still frame the fisheries of today. Both at the European and the Member States' level, quota allocation schemes based on historical catches and market-based resource allocation mechanisms favor large-scale operations

(Chapter 8.1). An example is subsidy structures that further entrench the dominant position that the large-scale sector is in, creating self-reinforcing feedback loops (Chapter 8.2). This can be seen not only in the European and Member State but also at the self-management level. As a non-managed fishery, the brown shrimp fishery exemplifies these dynamics. Without quota or fishing effort restrictions, self-management leads to ever increasing landings and higher fishing effort, potentially leading to a collapse of the fishery. A major reason for these dynamics is the reverse use of the precautionary principle. The analysis of the Commission's action plan has shown that path-dependency continues to foster policy inertia, leading to the neglect of underlying governance problems (Chapter 8.3). Therefore, I conclude that the multi-level European political governance system is designed with the large-scale commodification of fisheries resources at its core, which favors and consequently produces large-scale operations (H5).

The existence and persistence of large-scale dominance in fisheries management is not an unintended outcome but an intended product of a fisheries governance system that has its roots in economic efficiency. Without fundamental structural shifts that involve the redistribution of access rights and the restructuring of subsidy mechanisms, fisheries governance will continue to reinforce large-scale commodification of marine resources. The inability to break historical path dependencies raises questions about the adaptive capacity to climate change uncertainties and, with it, the long-term sustainability of Europe's fisheries.

9 The Threat of a Brown Shrimp Fishery Collapse

The question of Europe's fisheries sustainability in the future, extensively marked by climate change uncertainty, is very relevant today. The analyses in this dissertation have shown that the multi-level European fisheries governance system is not flexible and therefore ill-equipped at adapting to climate change uncertainty (Chapter 4-5). However, despite this rigidity, the EU has managed to develop an overall sustainable fisheries trajectory (Chapter 7). Institutional path-dependencies have enshrined a system of large-scale exploitation visible in the governance approach to non-managed species, which has produced unsustainable harvesting practices (Chapter 8). Therefore, I hypothesize:

(H6) Non-managed species, such as brown shrimp, incentivize overcapacity through unregulated harvesting quantities which, when combined with limited biological information and climate-change uncertainty, threaten both ecological and social units within marine social-ecological systems in the EU.

The analyses of the previous chapters have been retrospective. Here, by contrast, a prospective approach is adopted in order to assess the potential for a brown shrimp fishery collapse in the future, drawing on the Social-Ecological Action Situation Framework (Chapter 3.1) and the Social-Ecological Systems Framework for Benthic Fisheries (Basurto et al. 2013). The threat of a brown shrimp fishery collapse in the near-, mid- and long-term future is assessed by examining the constituent parts of the social-ecological system and the patterns of processes that gave rise to them using a beyond harvesting approach (Chapter 2.4.2). The analysis is based on the descriptive system's analysis of the fisheries governance at the European, Member State and self-management level (Chapter 4, 5, 6.1), the inferential analysis of the self-management plan (Chapter 6.2) as well as the role of polycentricity in brown shrimp fisheries (Chapter 7) and large-scale exploitation in European fisheries (Chapter 8). Methodologically, the analysis of the brown shrimp fishery is based on Basurto et al.'s (2013) adaptation of the Bloomington School's social-ecological systems framework for benthic fisheries in combination with Schlüter et al.'s (2019) Social-Ecological Action Situation Framework (Chapter 3.1). To the best of my knowledge, there are two novelties in my analytical adoption of these analytical frameworks: First, it is the first time that these frameworks are explicitly combined in an analysis. Additionally, it is the first time the Social-Ecological Action Situation Framework is used in a prospective instead of a retrospective analysis.

The boundary conditions for this analysis are as follows: the analysis is done within the context of climate change driven biophysical as well as social changes to the southern North Sea in the German brown shrimp fishery. Processes are identified that, alone or in concert with each other, are not only possible but plausible to lead to a brown shrimp fishery collapse in the future. The constituent parts and processes that are analyzed are not the only ones influencing the fishery, but the ones that were identified as most relevant based on the Adaptive Governance Theoretical approach that was developed (Chapter 2) and the empirical analyses done (Chapter 4-8). Whereas this chapter analyzes the threats that could lead to a future fishery collapse, Chapter 10 discusses plausible adaptation options.

9.1 Social-Ecological System: Structure and Processes

The relevant ecological as well as the social, economic and political structure and processes within which the brown shrimp fishery operates will be identified using Basurto et al.'s (2013) benthic fisheries framework – e.g., RS1.1 (Table 3). It is the conceptual foundation on which the empirical analysis of the brown shrimp fishery within the Social-Ecological Action Situation Framework is based. Brown shrimp are crustaceans with a maximum size of 6-9 cm and a life expectancy of 2-3 years. Females carry fertilized eggs up to three times per year on their abdomen for 3-10 weeks. The planktonic larvae go through five molts before they start living epibenthically in their post-larval stage. Although brown shrimp are classified as benthic organisms, they have been shown to be present throughout the water column (Campos 2009; Saathoff 2023). The animals have pigment cells in their subcutaneous tissue, which give them the ability to mimic the color of the substrate that they are moving on. To avoid predators, the shrimp bury themselves in sand with only their compound eyes and antennae visible above the substrate. To escape from predators, the animals flip their tail, which quickly propels them upward (Temming et al. 2022b). Brown shrimp have a distributional range from the White Sea to the coast of Morocco, the Baltic Sea as well as the Mediterranean and Black Sea (RS1.1). However, the only part of their range in which brown shrimp are caught on a large-scale is the southern North Sea, more specifically the Wadden Sea from the Dutch Islands to Skallingen in Denmark (RS3) (Campos 2009). Fishers only harvest on sandy substrate without larger rocks, mussel banks or vegetation at a depth of up to 20 m, depending on the size of their vessel (RS2) (fisher 2022, personal communication). There are two storage characteristics that are used in the fishery. One, the sieving process on-board flushes almost all of the undersized shrimps back into the ocean with the aim of harvesting them when they have grown to size (RS7.1). Large-scale cold storage is possible when the supply of shrimp exceeds the demand. The wholesalers have a network of cold storage facilities across Europe that enables them to quickly react to market fluctuations. Cold storage transport trucks are also in use that pick up the shrimp from any harbor along the coastline (RS7.2) (COFAD 2020).

Water temperatures affect the shrimp in multiple ways (Reiser et al. 2016; Reiser et al. 2014). With colder water temperatures later in the year, the shrimp migrate out of the mudflats to deeper water with more consistent temperatures and higher salinity than the shallow coastal areas (RS9) (Campos 2009). Temperatures also have an effect on the egg development and growth rate of a shrimp cohort (Saathoff 2023). Climate-induced warming of seawater influences the survival of planktonic larvae: egg development accelerates with temperature, yet the phototrophic plankton on which larvae rely follow light-dependent cycles. As a result, mismatches between brown shrimp hatching times and plankton blooms may occur, potentially increasing larval mortality and decreasing adult recruitment (RS4.2) (Saborowski and Hünerlage 2022). This is particularly relevant because brown shrimp in the Wadden Sea appear to form one interconnected stock. Egg-bearing females migrate south in winter, and northern areas, such as those around Denmark, depend in part on drifting cohorts originating from the south. The return migration to northern areas for egg release typically occurs in March and April. Chapter 9.2 offers a more detailed explanation of this process (RS8) (Respondek et al. 2022).

Despite a very high biomass of up to 82 animals per m^2 and a high reproduction rate (Hünerlage et al. 2019), brown shrimp landings have declined sharply since 2016. Since the 1990's, landings continuously increased and from 2003 to 2015 averaged around 35 000t. Since 2016, average landings have dropped to around 25 000t, roughly a 25% decrease. A notable anomaly in that trend, which will be analyzed later on, was the 2018 season with about 47 000t landed shrimp – the highest landings on record (RS4.1) (ICES 2025).

In addition to the decrease in landings, the brown shrimp fishery is affected by changes in its social, economic and political setting. The COVID-19 pandemic, with the accompanying world-wide economic downturn, Russia's invasion of Ukraine and high inflation, has left consumers willing to pay less money for the delicacy brown shrimp (S1). With sustainability and biodiversity conservation at the forefront of many societal discourses, green policies have become mainstream ideas in established parties, with the result that bottom trawling has come under scrutiny in the EU. Since the German brown shrimp fishery is exclusively using mobile bottom trawling gear and operating for the most part in marine protected areas, eNGOs have repeatedly called for a ban of the fishery – as did the EU action report (Chapter 8.3). The last parliamentary election in the EU, as well as in the Netherlands and Germany, have seen the influence of far-right parties grow and with them an anti-green agenda. Established conservative parties are already moving away from supporting green policies. How this moving political landscape is going to play out for the German brown shrimp fishers is yet to be seen (Chapter 4.4). However, inter-reform periods in the past have been precursors for future reforms and a move away from stock and biodiversity conservation seems unlikely in the political reality of today's European

Union (Chapter 4.3.2). More likely than not, brown shrimp fishers are going to face tightened conservation and increased climate change mitigation measures (S3).
The emergent phenomenon under investigation is the risk of a brown shrimp fishery collapse within the context of climate change. The point of analytic departure is the risk associated with plateaued brown shrimp landings at current levels or a further drop in future landings. A collapse of the fishery would most likely be a result of the interplay of various factors, such as the market organization, policy framework, self-management capacities and perception of the brown shrimp social-ecological fisheries system by fishers. This makes a beyond harvesting approach empirically relevant and useful from an adaptation perspective (Chapter 2.4). Figure 24 shows the social-ecological systems understanding of the German brown shrimp fishery using the Social-Ecological Action Situation Framework. Depicted are the social and ecological processes and structures identified to be theoretically and empirically relevant through the analyses done so far. Climate change driven temperature increases, as well as climate change mitigation and biodiversity loss prevention, are treated as external factors influencing the social-ecological system, as is the entry of Dutch Euro cutters (Figure 24, the red squares). Collectively, the social (Figure 24, red circles) and ecological (Figure 24, yellow circles) action situation processes, through interconnections (Figure 24, arrows), give rise to the social-ecological action situation event "Harvesting" (Figure 24, blue circles) - out of which the phenomenon under investigation "threat of a brown shrimp fishery collapse" emerges (Figure 24, grey square). A direct influence can be exerted from one action situation process of the same type to another (social to social), but only indirectly through a social-ecological action situation event if it is of another type (social to ecological). Self-organization and polycentricity are the main governance analytical elements of this analysis through the action situation processes of "EU", "Germany" and "Self-Management". Institutional diversity as a principle is represented by including "Market Organization". Interweaving knowledge types as an important concept is included through the action situation process of "Perception" (of fishers) while interdisciplinarity is practiced through the ecological action situation process "Population Dynamics", for which four important ecological processes are highlighted (Figure 24, yellow square).

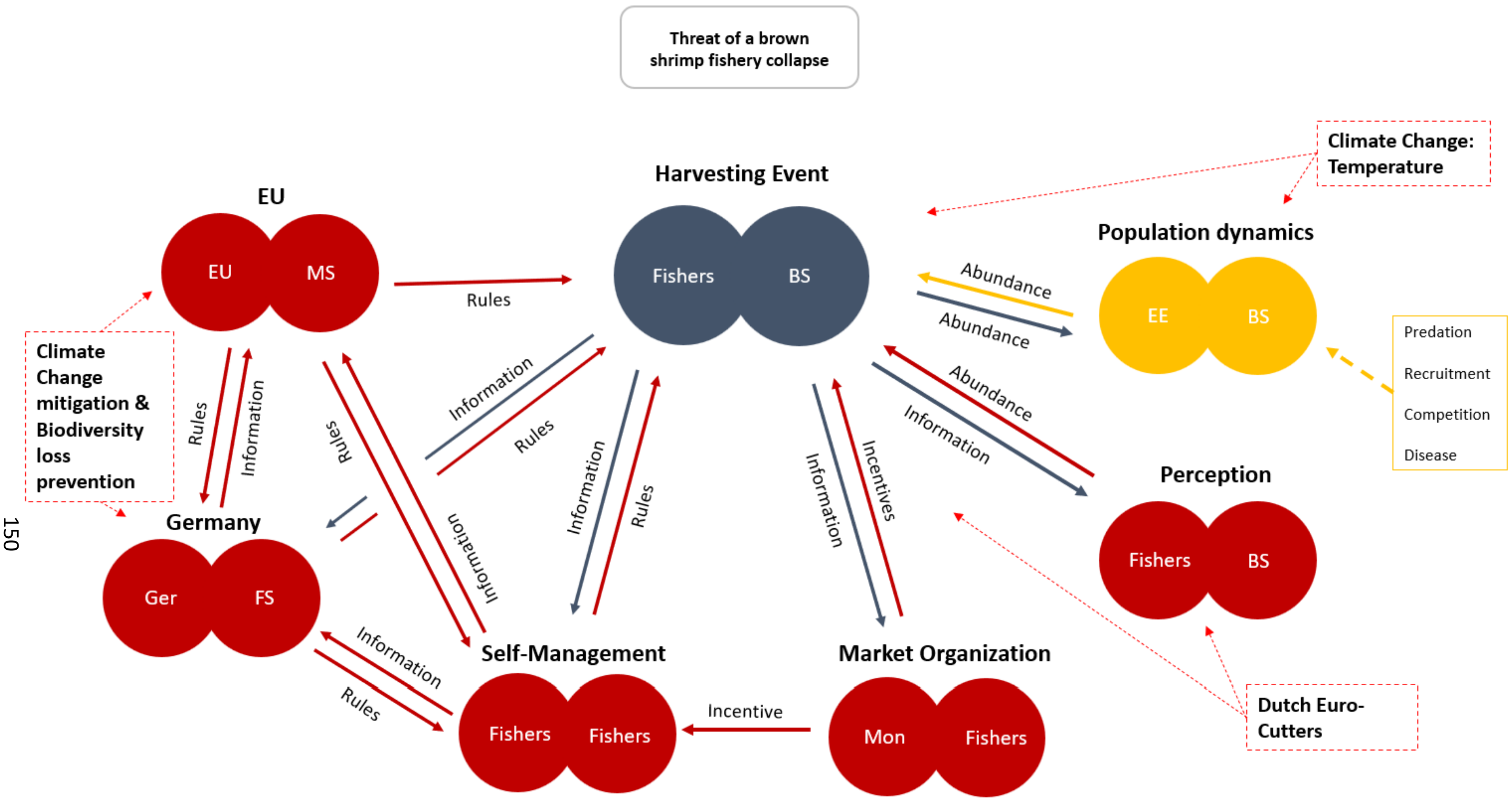

Figure 24: A system's understanding of the German brown shrimp fishery using the Social-Ecological Action Situation Framework. The red circles are the social action situations; the yellow one is the ecological action situation and the blue on is the social-ecological action situation. The red dotted squares are external factors influencing the system and the yellow square are ecological processes of influence within the ecological action situation "Population Dynamics". The arrows, in their respective colors, are the processes under analysis and direction of influence. The grey box at the top is the emergent phenomenon under investigation "Threat of a brown shrimp fishery collapse". EU = European Union, MS = Member States, Ger = Germany, FS = Federal States, Fishers = Brown Shrimp Fishers, BS = Brown Shrimp, Mon = Monopsony, EE = Ecological Elements

9.2 Population Dynamics

Population dynamics determine the abundance of brown shrimp and, therefore, are one important component that influences the harvesting potential for fishers. Climate change, through warming water temperatures, has a direct effect on the population dynamics of brown shrimp by influencing predation, recruitment and prevalence of disease.

Due to their high abundance and biomass, brown shrimp play a critical role in the coastal ecology of the Wadden Sea. They are a major predator of in- and epifauna in intertidal areas, controlling bivalve and plaice recruitment and are themselves an important food source for gadoids (Campos 2009; Saathoff 2023). The increased fishing pressure on brown shrimp and overfishing of predators in the North Sea led researchers to conclude that the fishery is now the main mortality source for adult brown shrimp (Temming and Hufnagl 2015). Overfishing of predators, like cod, and their simultaneous climate change driven northward movement (EEA 2024b) toward colder waters has implications for the predation of shrimp – now and in the future. Rising water temperatures (EEA 2025b) result in the northward movement of stocks and make it unlikely that they will recover to the abundance of the 1990's, even without as much fishing related mortality. However, the question is if this gap might be filled by species such as the whiting (*Merlangius merlangus*) which is reported by fishers to have drastically increased in abundance in the last few years:

> *„…wir sehen Veränderungen jetzt in punkto Klimawandel, Fisch, der Wittling, die Alten haben früher immer gesagt, ein Jahr, dann geht der erst mal wieder. Bleibt auch weg für ein paar Jahre. Jetzt ist es so, der bleibt sieben Jahre und ist vielleicht mal ein Jahr weg." (I4, Pos. 110)*

> *"...we are now seeing changes in terms of climate change. Fish, the whiting—older generations always used to say that it would stay for a year and then disappear again for a while. It would be gone for a few years. Now, it stays for seven years and might only be gone for one year." (I4, Pos. 110)*

An increase in predation would certainly have a negative effect on a fishery that is already experiencing high fishing pressure and low landings.

Climate change induced water temperature changes can also influence the recruitment of brown shrimp. Shrimp larvae are reported to be present almost the entire year in the German Bight as well as in estuaries of major river systems (Hünerlage et al. 2019). While spawning happens continuously from October until September of the following year, the peak of the spawning activity is in May in the coastal areas of the southern North Sea. The absence of ovigerous females in September and October is thought to be caused by endocrine regulation of vitellogenesis (Saborowski and Hünerlage 2022). The relationship between temperature and the duration of embryogenesis has been explored since the middle of the 20th century (Tiews 1970), with the development of eggs being dependent on water temperature. After cold winters, hatching happens later compared to warm winters. Temperatures below ~4◦C lead to a delay in egg development, with hatchlings appearing after five months. Consequently, cold winters (0 ◦C) result in a larval peak in early June while warm winters (6 ◦C) lead to the earliest larval hatches in January/February (Saborowski and Hünerlage 2022). Freshly hatched shrimp larvae lack significant energy reserves, thus making immediate feeding crucial for their survival. These larvae primarily consume micro-zooplankton, which appear in tandem with the spring phytoplankton bloom. Unlike the embryogenesis of brown shrimp, the spring phytoplankton bloom is most likely linked to photoperiodism (Hünerlage et al. 2019). In the North Sea, the phytoplankton bloom, and consequently the food availability for shrimp larvae, is relatively stable and minimally influenced by climate variability (Wiltshire et al. 2015). At 4°C, embryogenesis exceeds 160 days, at 8◦C 63 days and at 18°C 21 days. As a result, few or no shrimp larvae are likely to appear during cold winters and the following cold spring months. Additionally, the developmental pause in eggs laid during winter, combined with the rising proportion of ovigerous females during this period, leads to a pronounced concentration effect - culminating in a sharp hatching peak of approximately three weeks in June. A second, narrower hatching event is expected in July (Saborowski and Hünerlage 2022). In years with more moderate temperature ranges (3–18°C) the proportion of winter larvae increases slightly, though their total numbers remain minimal. The peak spawning period shifts approximately three weeks earlier, extending over a broader window from mid-May to mid-June. In the following weeks, hatching activity remains elevated but gradually declines toward August. The second hatching peak begins in late June and continues into July, with the interval between the first and second hatching peaks becoming shorter (Saborowski and Hünerlage 2022). Warm winters (6–18°C) lead to an increase in winter larvae, with their presence extending across much of the winter and spring. However, their numbers remain negligible compared to the primary hatching peak in late spring. The hatching maximum occurs around mid-May, though it is broad, with high larval production spanning from April to August. The second hatch from the early spawners may begin as early as April, resulting in the simultaneous presence of larvae from both the first and second hatches. Consequently, the peaks of the two hatches overlap and merge (Saborowski and Hünerlage 2022). At constant summer, but increasing winter temperatures, the mismatch between the larvae hatched and the phytoplankton bloom increases from about 5 % at a 2°C increase to about 20 % at a 6°C increase. For increasing summer and winter temperatures, the mismatch is even more pronounced at a 6°C increase, with about a 22% difference. A mismatch between the larvae hatchlings and the phytoplankton bloom may result in increased competition between individuals in their larval stage (Saborowski and Hünerlage 2022). Temperature dependent and climate change related influences on reproduction have also been identified with *crangon hakodatei* in the East Sea of Korea (Lee et al. 2025).

Temperature increases are also important drivers of disease in crustaceans. Temperature changes can affect both the host and the pathogen or parasite. A migration of pathogens and parasites due to lasting water temperature changes has the potential to lead to new diseases (Rowley and Coates 2023). Shell disease is a broad term encompassing various forms of melanized necrotic lesions, erosions, and tissue disintegration in crustaceans, including conditions like classical or endemic shell disease as well as epizootic shell disease. The proximate causes of shell disease involve various chitinolytic and lipolytic bacteria. These microorganisms are common in marine environments and are typically found on the cuticle of healthy crustaceans without affecting the host. However, under stressful environmental conditions—such as increased temperatures, chemical pollution, or mechanical damage—they can degrade the cuticle, creating entry points for additional pathogens. Shell disease is thus considered a maladaptive response to environmental changes, leading to reduced immune competence and weakened defenses against pathogens (Castro et al. 2012; Segelken-Voigt et al. 2018; Feinman et al. 2017). The condition can become lethal when secondary pathogens invade the epidermis and underlying tissues, causing sepsis or impairing critical functions such as locomotion and feeding. In ectothermic organisms like the brown shrimp, temperature influences vital processes, including embryogenesis, growth, molting frequency and reproduction. Rising water temperatures can increase physiological stress, reducing immune defenses and heightening susceptibility to shell disease (Tlusty et al. 2007; Segelken-Voigt et al. 2018). Additionally, higher water temperatures promote bacterial proliferation, further increasing the risk of infection. Segelken-Voigt et al. (2018) concluded in their study that higher seawater temperatures may have an effect on the growth and deposition of the cuticle and increase the bacterial load in the water. A combination of these factors might influence the infection rate and course of infections in brown shrimp. Their experiments suggested that shell disease affected the respiratory function of brown shrimp. Crustaceans have no adaptive immune system and therefore hemocytes have an important role in encapsulating bacteria and foreign particles as well as phagocytosis (Segelken-Voigt et al. 2018).

The effects of climate change induced seawater temperature increase on predation, recruitment, competition and disease susceptibility are likely to negatively influence the abundance of brown shrimp. The current harvesting practices that are leading to growth and recruitment overfishing are going to be exacerbated by these effects. This is going to have a negative influence on a fishery that is already struggling with a drop in landings. However, climate change effects on the brown shrimp population dynamics are not the main or major threat to the fishery in and by itself. They will not bring the population near a point of collapse but could prove detrimental to fishery because of the way that the market structure is set up.

9.3 Market Organization

Two major companies control the brown shrimp market, effectively creating a monopsony (Goti-Aralucea et al. 2021). These companies, Heiploeg and Klaas Puul (both Dutch), now dominate the market. Previously, the market was shared among at least four companies, including Stührk and Kok International Seafood, alongside Heiploeg and Klaas Puul. This consolidation increased efficiency by reducing transaction costs but also diminished the redundancy of actors, reduced diversity, and limited opportunities for experimentation with alternative sales channels. A factor that could be critical in adapting to climate change driven market shocks and foster competition. Following an EU cartel investigation that resulted in fines for several firms, only Heiploeg (the largest) and Klaas Puul (which filed the complaint and avoided fines) remained active. Together, they control 80–90% of the market share. Heiploeg was subsequently acquired by the Dutch fisheries conglomerate Parlevliet & Van der Plas, while Klaas Puul was sold to a private equity group (Tallaksen and Seaman 2014). Both companies also manage shrimp processing and operate peeling factories in Morocco (Goti-Aralucea et al. 2021). This market structure makes fishers completely dependent on these two companies, making them ”pseudo self-employed” as one fisher put it:

> *„sein eigener Chef sein, wir sind eigentlich alles nur noch Scheinselbstständige. Weil da oben steht nur Heiploeg. Und Heiploeg sagt, was wir machen.“* (RTB2, Pos. 227)

> "*Being your own boss, in reality, we're all just pseudo self-employed. Because up there, is only Heiploeg. And Heiploeg decides what we do.*" (RTB2, Pos. 227)

Subsidiaries of Parlevliet and Van der Plas are, among others, Deutsche See (DeutscheSee 2018). Fishers who hold contracts with these processing companies benefit from guaranteed sales of their catch but have little opportunity to pursue alternative market options. The value chain has become highly centralized, with the catching sector feeding directly into vertically integrated operations that manage collection, processing, and marketing within a single entity. This efficiency primarily benefits the intermediate firms, leaving fishing enterprises less connected to the broader economic and social network. Additionally, an asymmetry of information exists between German and Dutch vessels, as the companies are vertically integrated with some Dutch fleets, creating a competitive imbalance (Goti-Aralucea et al. 2021) as observed by German fishers:

> *„Da war aber das Komische, 2016 haben die Holländer bei sich ein Rekordjahr gehabt. So. Und da haben wir dann nachher schon flächendeckend Preise von 15, 16 Euro gekriegt. Und da haben wir uns auch schon gefragt, wenn wir jetzt die Menge hier gefangen hätten und die Holländer nichts gefangen hätten, hätten wir niemals diese Preise bekommen. Niemals! So, ne? Und das war schon so'n - so'n kleiner Wermutstropfen und da sind Betriebe gewesen, die - die haben da im Monat*

auch in der Woche das umgesetzt, was wir in den Jahren wirklich dann im Jahr durch … so - so im Durchschnittsjahr hatten, was wir da umgesetzt haben."(I25, Pos. 99)

"But the strange thing was, in 2016, the Dutch had a record year. Right. And then we were already getting prices of 15, 16 euros across the board. And we were wondering—if we had caught that amount here while the Dutch had caught nothing, we would never have gotten those prices. Never! Right? And that was a bit of a bitter pill to swallow. There were businesses that in a month, in a week made what we would make in a whole year…what we gross in an average year." (I25, Pos. 99)

The current market structure enables the wholesalers to dictate prices and conditions to fishers, based on seasonal supply. While the supply is high during peak harvesting season, prices are low, while prices are high in winter when the supply is low. Moreover, fishers are informed of the price for their catch only in retrospect, leaving them without prior certainty:

„früher war es so, da haben wir am Freitag die Preise gekriegt für die kommende Woche. Mittlerweile ist das so, jetzt kriegen wir Freitag die Preise für die vergangene Woche." (I23, Pos. 144)

"It used to be that we got the prices on Friday for the coming week. Nowadays, we get the prices on Friday for the past week." (I23, Pos. 144)

There is consensus among most fishers that one of the biggest and most pressing issues of the moment is adequate prices for their catch:

„Das Dringendste wären adäquate Erzeugerpreise für unsere Krabben. Adäquate Erzeugerpreise, dass wir wieder gut … oder dass wir davon leben können, dass wir unsere Betriebe bezahlen können, dass wir modernisieren können. Das wäre … das … also das wäre eigentlich der größte Wunsch, den ich im Moment hätte, dass wir alle wieder in wirtschaftlich normales Fahrwasser kommen." (I23, Pos. 263)

"The most urgent thing would be adequate producer prices for our shrimp. Adequate prices so that we can again make a decent…that we can live off of them, pay for our businesses, that we can modernize. That would be... that would actually be the biggest wish, that I have at the moment – that we all return to financially normal channels." (I23, Pos. 263)

However, there are differences in opinion about a vision of the general structure of the market. Some fishers prefer for the system function to remain as it is. They identify low prices—not the structure of the system—as the source of the problem:

„[…] den Luxus, den wir jetzt genießen mit den Krabbenfirmen, dass die mit ihren Lkws kommen, den Kram abholen, das - das … also das, was wir machen, ist ja … wird … ist ja … ist ja kaufmännisch betrachtet Arbeiten für Bescheuerte. Wir fischen, geben den Fang ab und bekommen die Woche drauf unser Geld. Einfacher geht's ja gar nicht. Also jeder Selbstständige würde sich da die Finger nach lecken, nach so einer Betreuung, ne? [Ein] Handwerksmeister, der - der im Büro sitzt und

Angebote schreibt und dann wird ein - ein Bruchteil davon nur angenommen oder … das - das Problem haben wir hier nicht, ne? Und das ist ja auch irgendwo ein gewisser Luxus, den man hat, so." (I26, Pos. 52)

"[...] The luxury we have now with the shrimp whole salers—that they come with their trucks, pick up the catch—that... I mean, what we do, is…well…is…from a business perspective, is basically work for fools. We fish, hand over the catch, and get paid the following week. It couldn't be easier. Any self-employed person would jump at such a setup, right? [A]master craftsman, who – who is sitting in his office and is writing offers and then only a – a fraction of them is accepted or… that's —that's not a problem we have here, right? And in a way, that is a certain kind of luxury we have." (I26, Pos. 52)

Others, however, see deeper structural issues within the system that go beyond price points:

"Also das ist keine richtige Schwankung mehr. Das ist eigentlich so'n - so'n Durchschnittspreis übers Jahr, was da sich wahrscheinlich so gesetzt hat, das ist nur eine Vermutung, was er so ausgeben will. Und weiß natürlich auch, dass wir gezwungen sind loszufahren, also das ist eigentlich völlig egal, welchen Preis er zahlt, denn normal ist es so gewesen, im Winter zog der Preis dann auch mal um einen Euro an oder 50 Cent, aber dann auch wöchentlich, ne, sodass du dann spätestens Anfang Januar, Mitte Januar auch wirklich einen vernünftigen adäquaten Preis gekriegt hast, mit dem man arbeiten konnte. Und dann, wenn dann alle irgendwie Mitte, Ende März wieder angefangen sind, dann ist das wieder langsam nach unten gegangen, aber du konntest davon noch gut fischen. So, und das hat sich einfach verändert. Also aus unserer Sicht regelt - regelt die Menge nicht mehr den - den Preis und die Nachfrage, das ist alles ein bisschen aus dem Gleichgewicht gekommen." (I25, Pos. 93)

"So, there is really no fluctuation anymore. It's more like an average price that has probably settled over the year—just a guess—based on what he's willing to pay. And of course, he knows that we are forced to go out fishing, so it doesn't really matter what price he pays. Normally, in winter, the price would go up by a euro or 50 cents, but on a weekly basis, so that by early to mid-January, you would get a reasonable, adequate price you could work with. And then, when everyone started fishing again around mid to late March, the price would gradually go down, but you could still fish profitably. But that has changed. From our perspective, the supply doesn't determine the – the price and the demand, it's all become a bit unbalanced." (I25, Pos. 93)

Therefore, while one group attributes low prices to underlying structural issues, the other treats the prices themselves as the problem and advocates maintaining the current market structure. This difference in vision exemplifies one of the fundamental problems in the fisheries sector.

Most fishers nevertheless recognize, either explicitly or implicitly, that they themselves bear some responsibility for the current market structure. Their collective actions—and inactions—have facilitated the development of a monopsonistic market:

„ja, leider Gottes durch die Vermarktungsstruktur, die sich geändert hat, früher gab es in jedem Hafen eine Genossenschaft, eine EO, da wurden die Krabben gesichtet, da waren mehrere kleinere Händler auf dem Markt […] Die ganzen kleinen Genossenschaften, die kleinen Siebstellen in den

Häfen sind alle weg. Die sind alle … ja, über die Jahre pleite gegangen, weil natürlich die Fischer auch, das muss man auch so sagen, ja, der Holländer hat mit dem Geld gewunken oder mit den Euros, und dann sind natürlich ein Großteil der Fischer abgewandert […] und dadurch hat sich das dazu entwickelt, dass wir nur noch nicht mal … ja, vielleicht gerade mal eine Hand voll Händler am Markt haben. Und das ist natürlich fürs Preisgefüge natürlich nicht unbedingt gerade so positiv. Also da kommen … diese normalen Marktmechanismen, Angebot und Nachfrage regeln den Preis, gibt es nicht mehr." (I23, Pos. 79)

"Yes, unfortunately, due to marketing structure that have changed, In the past, every harbor had a cooperative, an EO, where the shrimp were sorted, and there were several smaller traders on the market. [...] All those small cooperatives, the small sorting stations in the harbors are gone. All of them…well, over the years, they all went bankrupt because, all the fishers, to be fair, the Dutch came waving with their money, waving their euros, and a large part of the fishers switched over. [...] as a result, we now have not even…well, maybe barely even a handful of traders left in the market. And that's obviously not great for price dynamics. Well and than…the usual market mechanisms, supply and demand determining the price, just don't exist anymore." (I23, Pos. 79)

A step towards changing both the market structure and raising the price point was taken by the largest brown shrimp Producer Organization in Germany (Erzeugergemeinschaft der Deutschen Krabbenfischer) by negotiating a minimum price for shrimp. There are differing opinions among fishers about the usefulness of this minimum price. One group sees this as an accomplishment and proof of at least some leverage that fishers have over the wholesalers:

„Ja. Ich - ich sehe also, das - das ist eine riesige Verbesserung für uns. Wir haben diesen Minimalpreis, also da haben wir jetzt ja in wochenlangen Verhandlungen mit … oder auch nicht nur Verhandlungen, sondern auch ganz einfach Gespräche mit den großen Abnehmern, die eigentlich den Markt beherrschen, die sehen es auch ein, dass unsere Unkosten immer weiter steigen, Energiekosten steigen, unsere Unkosten steigen immer weiter" (I3, Pos. 99)

"Yes. I - see this- this as a huge improvement for us. We now have this minimum price, which we achieved after weeks of negotiations… well not just negotiations, but also simply discussions with the major buyers who basically control the market, they also recognize that our costs keep rising, energy costs are increasing, and our expenses continue to go up." (I3, Pos. 99)

Other fishers are more skeptical of the real-life improvements that this minimum price is going to bring:

„Ja, aber ein Mindestpreis, das ist ja so - so eine Sache, so am - am … wie soll ich das sagen? Am grünen Tisch, oder wie nennt man das, nicht? Mindestpreis hängt ja auch immer damit zusammen, was gefangen wird. Mindestpreis, ich weiß jetzt nicht, was das war, 4,50 oder was er jetzt gesagt hatte, oder 4, ist auch scheißegal. Wenn du nichts fängst, dann kannst du 10 Euro kriegen, du musst deinen Preis auch mit Kilos multiplizieren. Letztendlich muss es der Markt- und Fanglage angemessen sein. Und deswegen ist das ein sehr … eine sehr oberflächliche Sache. Wir hatten irgendwann mal, vor Jahren, da hatten wir da 3 Euro irgendwie ausgehandelt und so was. Und da waren alle glücklich. Nur, da haben wir, weiß ich was, fünf, acht … fünf Jahre oder acht Jahre drauf verhandelt und rumgestritten, bis wir das dann hatten. Aber die Zeit war weitergegangen. Der

Gasölpreis, die Werkstattkosten, die Sozialabgaben, alles das, was uns richtig drückt, als diese 3 Euro dann sich so langsam dann so festgesetzt hatten, waren die 3 Euro schon - schon wieder … für uns schon wieder ein Katastrophenpreis, nicht?“ (I27, Pos. 152)

"Yes, but a minimum price is a, a tricky thing, how ahm- ahm…how should I put it? Decided at the green table, or whatever you call it, right? A minimum price always depends on what is being caught. A minimum price, I don't know what it was, 4.50 or whatever he said, or 4, it doesn't really matter. If you're not catching anything, you can get 10 euros, but you still have to multiply that price by the kilos you catch. In the end, it has to be appropriate to the market and the catch situation. That's why it's a very…a very superficial thing. We once negotiated, years ago, we negotiated 3 euros or something like that. And everyone was happy. But we negotiated and fought over it for five, maybe eight years before we finally got it. And by then, time had moved on. The price of fuel, repair costs, social contributions, everything that really puts pressure on us kept rising, by the time those 3 euros were finally established, these 3 Euros they were- were again… already a disaster price for us, right?" (I27, Pos. 152)

Most fishers, however, agree that the current market system will not be easily changed, if at all:

„Über Nacht war es Heiploeg. Die sind als mehrfache Millionäre ausgeschieden […]. Keine Vorgespräche, nichts. Durch eine Indiskretion kam das Mitte Februar raus, sechs Wochen nach der Übernahme, nicht, da war natürlich hier Großalarm, nicht, war aber ja nichts zu ändern mehr, nicht? War dann eben so. Nur so - so arbeitet der Markt, so - so laufen diese Dinge, nicht? Entweder wirst du … wird dir der Saft so abgedreht, dass du eingehst, oder du wirst komplett übernommen. Aber die Großen, die sich ihren Markt erarbeitet haben und die ihre Großabnehmer haben, da lassen die sich nicht zwischengrätschen“ (I27, Pos. 198)

"Overnight, it was Heiploeg. They walked away as multimillionaires[…]. No prior discussions, nothing. It only came to light in mid-February through a leak, six weeks after the takeover, right, naturally there was a major alarm here, but there was nothing we could do anymore, right? That's how it was. That's how - that's just how the market works—that's how these things go, right? Either you… they squeeze you out until you go under, or you get completely taken over. But the big players, the ones who have built up their market and secured their major buyers, they don't let anyone get in their way." (I27, Pos. 198)

What almost all fishers also agree is that self-organizing processes, or the lack thereof, are a major reason for their inability to apply pressure on the wholesalers and change prices or system structures:

“als ich anfing zu fischen, da hatten - hatten wir gefühlt … hatten wir … konnten wir Druck auf den Handel ausüben und sagen, wir waren irgendwie eine geschlossene Gemeinschaft, die gesagt hat, so, bis hierhin und nicht weiter. Unter - unter 3 Euro, da fahren wir einfach nicht los. So, und jetzt ist es aber der Handel, der Druck auf uns ausübt. Da finde ich, ist die … ist die dollste Veränderung, also die extremste Veränderung von allen, dass wir es nicht mehr schaffen, eine Gruppe zu bilden, die sagt, unter dem und dem Preis fahre ich einfach nicht los. Das schaffen wir irgendwie nicht mehr. Weil natürlich, es gibt immer diese einzelnen Kollegen, die ausscheren.“ (I26, Pos. 94)

"When I started fishing, we had – it felt like … we had….we could apply pressure on the wholesalers and say, we were a united group that stood firm, saying, this far and no further. Below – below 3

Euros we are not gonna go out. But now, it's the wholesalers that puts pressure on us. I think that's the…that's the biggest change, the most extreme change of all, that we no longer manage to form a group that says, I won't go out for less than this price. We just can't manage do it anymore. Because, of course, there are always some colleagues who break away." (I26, Pos. 94)

Opinions about the market structure and the minimum price are influenced by each fisher's business structure, which is heavily dependent on the type of vessel they own. Fishers who recently acquired a vessel and have corresponding debt cannot take a lot of risk in setting up new market structures but need dependable wholesalers that buy their catch. Owners of Euro-Cutters have a different business structure than owners in the 17-18 m cutter range. In order to be profitable, Euro-Cutters have to fish much more to cover the higher expenses related to fuel and maintenance of their vessel. These different business realities all influence how the market system is viewed and show that fishers envision a market structure of the future, making it more difficult to find a common ground (fisher 2023, personal communication).

The current market system structure has the benefit for fishers that wholesalers are managing collection, processing, distribution and marketing. The fishers, or their respective Producer Organizations, do not have to spend time and effort setting these structures up themselves. A danger to the future of the fishery is the low prices that fishers are getting for their catch compared to the high expenses that they have. The combination of low landing volumes, high expenses and comparatively low prices incentivizes fishers to increase their fishing effort. This could lead to a feedback mechanism in which an increased fishing effort due to low prices and landings volumes leads to falling landing volumes in the next year.

9.4 Governance: Self-Management

Fragmentation within the community of fishers has a significant impact on both the Producer Organizations and the MSC self-management (GS5.2.1). Producer Organizations operate at the collective choice level (GS6.3) while the Marine Stewardship Council works in its applied form at the operational level (GS6.2). While POs are mostly responsible for monitoring the social part of the fishery, the responsibility of the MSC is to monitor the condition of the brown shrimp (GS9.2). I begin by examining the fragmentation both within the current structure and arising from it and subsequently analyze how this fragmentation affects the MSC self-management plan.

The German brown shrimp fishery is characterized by institutional fragmentation and by internal disagreement over the fishery's future (Chapter 6.2). Some fishers consider fewer representative institutions to be the solution to fragmentation, whereas others argue that strengthening larger organizations—such as the “*Erzeugergemeinschaft Deutscher Krabbenfischer”*—is equally problematic and unlikely to resolve fragmentation within the community:

> *“Wir haben einmal im Jahr eine Hauptversammlung da sitzen wir dann mit den hundert Mann da zusammen, von Ditzum bis - bis Husum, das ist eine Jahreshauptversammlung, wo du überschwemmt wirst mit Zahlen und Berichten vom Jahr, und das, was eigentlich sein müsste, dieser Austausch, was du ansprichst, der findet da nicht mehr statt“ (I27, Pos. 220)*

> *"We have a general meeting once a year, where we all sit together with a hundred people, from Ditzum to Husum. It's an annual general meeting where you're overwhelmed with numbers and reports from the year. But what actually should happen – the exchange you’re talking about – doesn’t take place there anymore." (I27, Pos. 220)*

From an Adaptive Governance perspective, one challenge associated with forming larger institutions is the reduction of institutional diversity, which in turn diminishes redundancies at lower governance levels. When multiple institutions independently experiment with different strategies for marketing shrimp, the risk of a system-wide failure declines, as the collapse of one strategy does not threaten the entire fleet. This dynamic is further complicated by the geographical dispersion of fishers along the North Sea coast. Multiple, regionally based institutions allow for regular interaction, thereby strengthening personal relationships within the organization. With large institutions whose members are distributed over large distances, impromptu meetings are not possible.

I, however, do not see structure related matters of the institutional landscape as the only problem at the self-management level. Relevant are also existing communication flows and the willingness to work within the existing institutions. One example is that it is difficult to find fishers who to be in a leading position in representative institutions:

> *„Also da - da war natürlich … dass ich das gemacht hab, war gut, Kuh war vom Eis, aber es wurde gleich unterm Tisch nachgetreten, wa- wa- wart ab, wir werden dir schon zeigen, wo … was du da zu machen hast, nicht? Also diese Sache, also dass da Nachwuchs rangeführt wird, und - und - und da muss man eine breite […] also erst mal wieder, ja, nur für ein Jahr, mal sehen, ob sich dann einer findet. Was ein Blödsinn, kein Mensch meldet sich dafür, nicht? Wenn do so'n Posten an der Backe hast, da kannst du … kannst du echt in Rente mit gehen, ne?“ (RTD2, Pos. 554)*

> *"Well, of course... it was good that I did it, the problem was solved, but then there was an immediate kick under the table – ‘Just wait, we’ll show you what you’re supposed to do,’ right? So this whole thing, bringing in new people... and then they say, ‘Well, just for a year, let’s see if someone steps up after that.’ What nonsense! No one volunteers for that, right? If you take on a position like that, you might as well retire with it, you know?" (RTD2, Pos. 554)*

Fishers are individualists at heart who engage with each other in a sort of cooperative competition. The brown shrimp fishery is a classic common pool resource problem, where if one fisher does not fish, the other can harvest the catch. The fragmentation in Germany makes it difficult for fishers to unite as a collective against the wind park and nature conservation lobby, arguably one of the most imminent existential threats. In the absence of a unified position, fishers are unlikely to secure the fishing grounds they presently hold. This weakness is tied to the persistent lack of organized lobbying efforts and adequate legal representation. Up to this point, not enough fishers have been willing to work collectively within the institutions already in place. While consolidating current institutions could help resolve the shortage of fishers willing to take on leadership roles, I remain unconvinced that it would promote the collective cohesion required for unified action.

This fragmentation also influences the plausibility of changes to the MSC self-management rules and system, which Chapter 6.2 has shown to be unsustainable in its current form. The self-management plan is based on two pillars: the harvest control rule and mesh size increases (GS6.1.2). These two pillars, however, do not seem to be able to ensure a sustainable fishery. Implementation guidelines for the harvest control rule are vague, and the rule is rarely applied, even with the pronounced decrease in landings. Regulations to prevent growth overfishing have also been loosened—for instance, a 22.1 mm mesh may be legally counted as 24 mm (Chapter 6.2). In addition, MSC requirements effectively support continued large-scale exploitation by allowing Euro-Cutters—whose beam weights and annual fishing effort far exceed historical norms—to obtain MSC sustainability certification. Moreover, as discussed in Chapter 8, the MSC framework does not meaningfully limit the fishing operations of any vessels.

Therefore, I argue that the MSC rules and the institution's structure are major issues when it comes to the short- as well as long-term sustainability of the fishery. However, it is unlikely that the MSC rules will be renegotiated in the near future. The actors involved are interested in the large-scale harvesting of shrimp, and, for some, their business model is set up to do so. Euro Cutters, which entered the fishery from the flat-fish sector, are dependent on a year-round fishing, as mentioned by multiple fishers:

> *Weil letztendlich wird es immer dadurch kaputt gemacht, dass der Aufwand übertrieben wird. Ob du dem Pfahlzug misst, also hier Schleppkraft, ob du das in Geschirrschwere machst, ob du das in … die Stunden müssen runter. Weil - weil dadurch auch der Anreiz genommen wird für immer größere Schiffe, weil - weil das ist ja mit - mit ein Auslöser dafür. Ich weiß nicht, die letzten vier Jahre, da sind bestimmt wieder, weiß ich nicht, fünf, sechs neue holländische Krabbenkutter angepasst der Situation zwischen irgendwie so 22 und 24 Meter tiefgehend, schlank, stark, leistungsfähig, also auch das hat man weiter verfeinert. Man muss nicht mehr die 24 Meter unbedingt haben für dieselbe Leistungsfähigkeit, man kann das auch aus Energie- und Kostengründen die Rümpfe etwas anders machen, dass sie ein bisschen besser durch die See gehen. Die haben sich darauf eingestellt. Diese Schiffe, die kosten 2,2 bis 2,5 Millionen. Aber unter 150 Tonnen Jahresfangmenge, da fangen die gar nicht erst an zu rechnen. (I27, Pos. 530)*

> *"Because in the end, it always gets ruined by excessive effort. Whether you measure it by bollard pull, meaning towing power, by gear weight, or whatever – the hours need to be reduced. Because that also removes the incentive for building ever-larger ships, which is one of the driving factors*

behind it. I don't know, but in the last four years, there have probably been five or six new Dutch shrimp cutters designed to fit the situation—somewhere between 22 and 24 meters in length, deep-drafted, sleek, strong, and powerful. They've refined that even further. You don't necessarily need 24 meters anymore for the same performance. For energy and cost reasons, the hulls can be designed slightly differently to move more efficiently through the sea. They've adapted to that. These ships cost between 2.2 and 2.5 million. But if they're catching less than 150 tons per year, they don't even start doing the math." (I27, Pos. 530)

Without a revision of the current rules and uniform application of the ones that are currently in place (Chapter 6.2), I think that a sustainable fishing practice that meets the structural demands of the brown shrimp market (Chapter 9.3) will be hard to achieve. A revision of the current structures does not seem likely with a divided fishing community that cannot decide on a vision of the future (fishers 2025, personal communication).

Therefore, it is crucial that the self-management plan rests within a set of constitutional level rules that govern and determine sustainable fishing practice. Currently, the brown shrimp fishery is not operating within a polycentric governance system (Chapter 7.4). Without rules and mechanisms at the constitutional level, the fishery is effectively asked to police itself, given the structure of the MSC certification (Chapter 6.2).

How Member States position themselves towards the fishery through their implementation of the CFP and national fisheries regulations has a direct and significant effect on the sector. Despite the collective MSC certification, different rules apply for fishing in Member States' exclusive economic zones – e.g., weekend closures (Chapter 5.1.1).

9.5 Governance: Germany

On the German governance level, the principal threats to a potential collapse of the fishery are posed by nature conservation and wind-park lobbies advocating area closures (GS5.1), as well as by the fragmentation of the German brown shrimp sector, which has led to an almost complete absence of lobbying capacity. In the following, I am first going to examine the impact of offshore the wind energy and then the nature conservation sector before analyzing the German brown shrimp sector's response.

Although the vast majority of wind parks are not located in fishing grounds, they are indirectly affecting the brown shrimp fishery. Not only the physical wind parks that affect the fishery, but also processes that are involved in their construction or infrastructure, such as cables running to the mainland:

„Also jetzt die … direkt die Windmühlen nicht, die sind alle nördlicher. Also so weit nördlich betreibt man keine Krabbenfischerei […]Aber natürlich die ganzen Kabel, die sind ja südlich und gehen bis

an Land. Und das ist natürlich für uns ein großes Thema. Weil das wird ja sicher … die wollen das glaube ich verzwanzigfachen, die Leistung da auf See. Und dann kann man sich ja vorstellen, was da noch kommt". (I2, Pos. 102-103)

"So, now the... not directly the windmills, those are all farther north. That far north you don't do shrimp fishing [...] But of course, all the cables are south and extend all the way to land. And that's definitely a big issue for us. Because that for sure… they're planning to increase the capacity at sea by, I think, twenty times. And then you can imagine what's coming next." (I2, Pos. 102-103)

There is a general unease within the community about the future of the fishery, driven by uncertainty over how wind-park development may lead to further area closures and potentially impact the brown shrimp itself:

„Weil du kannst nicht einfach in so ein Strömungsgebiet da Pfeiler reinhauen, das verändert Strömungen. Ich weiß jetzt inzwischen, dass es auch von der … dass Schall Erosionen im Unterboden, allein der Flügelschlag, diese Rotation, dadurch hast du Aufwinde vor diesen Windparks, sprich, warme Luftstrukturen ziehen nach oben. Du greifst da direkt ein, und das ist ja nicht mehr, da stehen ein, zwei Windparks […] Die Nordsee ist ja zugepflastert und wir fangen ja weiterhin an, das Ding zuzupflastern. Da kann mir keiner erzählen, dass das keinen Einfluss auf unseren Lebensraum Nordsee Wattenmeer hat." (I4, Pos. 140)

"Because you can't just drive pillars into a current area like that – it changes the currents. By now, I also know that sound causes erosion in the seabed. Just the beating of the blades, that rotation, creates updrafts in front of these wind farms, meaning warm air structures rise. You're directly interfering there, and it's not just one or two wind farms anymore […] The North Sea is plastered with them, and we're still adding more. No one can tell me that this has no impact on our habitat, the North Sea Wadden Sea." (I4, Pos. 140)

Nature conservation is another factor that is significantly influencing German brown shrimp fisheries with environmental NGOs calling for an end to bottom trawling in the North Sea MPAs (Oceana 2024; Seas at Risk 2025). While both Lower-Saxony and Schleswig-Holstein, as well as the federal government, have committed to preserving small-scale inshore fishing, their actual response has been limited (Chapter 8.3). Moreover, there seems to be a difference between Lower-Saxony and Schleswig-Holstein in how the subject is approached, as one person involved in the process said:

„Es ist ein … es ist ein Spannungsfeld in Schleswig-Holstein, muss man einfach so sehen. Das ist in Niedersachsen nicht so. Wir sind hier jetzt zweimal schon eingeladen worden von dem Leiter des Nationalparks, einfach nur uns mal wieder auszutauschen. Und das finde ich auch in Ordnung." (I11, Pos. 836)

"It's a... it's a field of tension in Schleswig-Holstein, you have to see it that way. It's not like that in Lower Saxony. Here, we've already been invited twice by the head of the national park, just to exchange ideas. And I think that's good." (I11, Pos. 836)

Both offshore wind parks and conservation measures result in loss of fishing grounds and, consequently, in higher concentrations of fishers in the grounds that remain.

„Es ist ganz klar, mit Ausbau von Naturschutz, aber eben auch Offshore-Windenergie kommt es zu Konzentrationseffekten in den verbliebenen Gebieten. Und wenn man sich den neuen Raumordnungsplan anguckt, dann ist da nicht mehr so viel freie Fläche übrig, wo man irgendwo noch wirtschaften kann.“ (I19, Pos. 19)

"It is clear that with the expansion of nature conservation, but also the offshore wind energy, concentration effects are occurring in the remaining areas. And if you look at the new spatial planning plan, there isn't much free space left where you can still operate economically." (I19, Pos. 19)

Competition for areas in the Wadden Sea with both the wind park industry and the nature conservation lobby is unlikely to stop in the future. To avoid losing crucial fishing grounds, the brown shrimp sector would need to proactively engage with politicians and environmental NGOs to secure continued access to the areas currently available for fishing:

“Und da habe ich immer wieder das Problem, dass die Fischer überhaupt nicht handlungsbereit sind, selbst nicht bei den Bereichen, wo ich ganz klar sage, die Trockenfallgebiete, was ist damit? Gebt die doch weg. Ihr könnt sie doch weggeben ohne Schmerzen. Gebt sie weg, dass man das Gefühl hat, ihr wollt irgendwo mitarbeiten und nicht … nee! Und das ist leider … kommt nicht durch, ne? Wir geben keinen – keinen Millimeter weg und das ist Quatsch. Ich sage, wenn ihr nicht weggebt, dann kommen Leute und nehmen euch was weg. Und die fragen nicht, was ihr brauchen könnt und nicht. Die machen einen Strich hin. Also es sind gravierende Auswirkungen zu erwarten, finde ich.“ (I8, Pos. 47)

"And I keep having the problem that the fishermen are not willing to act at all, not even in areas where I clearly say, the tidal flats that fall dry, what about them? Just give them up. You can give them up without any pain. Give them up, so it feels like you're willing to cooperate and not... no! And unfortunately…that doesn't get through, right? We’re not giving up a single – single millimeter, and that’s nonsense. I say, if you don't up areas, then others will come and take them from you. And they won’t ask what you might need or what not need. They’ll just draw a line. So, I think there will be serious consequences." (I8, Pos. 47)

Some fishers recognize the importance of proactively engaging with eNGOs and political actors on issues of nature conservation and the increasing likelihood of fishing-ground closures:

„Ob das jetzt der Umgang mit Naturschutz ist, sich nach außen zu präsentieren, als hier … wir wollen die Natur schützen, das ist unser größtes Anliegen. So, und – und ganz einfach gesagt, wenn du deinen Feind nicht besiegen kannst, musst du ihn halt umarmen. Dir bleibt nichts anderes übrig mehr. So, und – und wir – wir wollen im – im Konsens sein mit den Naturschutzverbänden, mit der Politik und, und, und, aber es muss halt ein … es müssen Gespräche auf Augenhöhe sein. So, und – und das Gefühl haben wir nicht zurzeit. So, das ist … und das macht für mich einen modernen, zukunftsorientierten Fischer aus, der nicht nur an Gewinne, Gewinne, Gewinne denkt, sondern auch an das, was danach noch kommt. Mensch, wir haben hier ein Erbe zu vergeben, das – das lohnt … wo es sich lohnt weiterzugeben. Und – und das offen zu kommunizieren, ist für mich … für mich die einzigste Möglichkeit, zukunftsorientiert zu arbeiten, ne?“ (I26, Pos. 24)

"Whether it's dealing with nature conservation, presenting a public image, as here…We want to protect nature, that's our biggest concern. And – and simply put, if you can't defeat your enemy, you have to embrace them. You have any other choice. So and - and we – we want to be - be in consensus with the conservation organizations, with politic and, and so on, but it has to be... there need to be conversations on equal footing. And, and right now, we don't have that feeling. So that's... and for me, that's what makes a modern, future-oriented fisher, someone who doesn't just think about profits, profits, profits, but also about what comes after. Look, we have a heritage to pass on here, that's – that's worth… something worth passing on. And – and to openly communicate this, is for me... for me the only way to work in a future-oriented manner, right?" (I26, Pos. 24)

There are, however, many others who believe that making concessions by voluntarily giving up areas would lead to worse outcomes in the future:

„Also ich sage mal, ja, also auf eine Weise nein, klipp und klar, und zwar, weil die andere Seite mit – mit solchen abstrusen Forderungen kommt und mit solchen sachfremden Vorstellungen, da kommst du nicht aufeinander mit. Das Problem ist, wenn man denen ein kleines Zugeständnis macht, die wollen ja dann sofort das Doppelte als Nachschlag, nicht?" (I27, Pos. 308)

"So, I'd say, yes, in a way, point-blank, no, and that's because the other side comes with such abstruse demands and such off the subject ideas that you can't find common ground. The problem is, if you make them a small concession, they immediately want double the amount as a follow-up, right?" (I27, Pos. 308)

Without political action, it is hard to imagine the German brown shrimp fishery not significantly shrinking or even collapsing if the EU action plan to stop all bottom trawling in marine protected areas is implemented. The industry needs to professionalize its efforts in order to be able to counter lobbying done by environmental NGOs and others.

In the long-term, the lack of a national fisheries strategy will negatively influence the sustainability of the sector. With the EU further implementing regionalization (Chapter 4.3), Germany needs to develop and implement constitutional level objectives in order to prevent a collapse of the fishery in the long-term.

9.6 Governance: EU

Climate change mitigation and nature conservation policy at the EU level could have a direct impact on the brown shrimp fishery and probably poses the most immediate threat to it, currently in the form of the Commission's action plan (Chapter 4.3.2). In Germany, the action plan has been criticized by the industry as well as politicians of various parties and levels – from the federal minister for food and agriculture Cem Özdemir to the MEP Niclas Herbst (CDU). While there has been stark criticism, the EU action plan to ban mobile bottom trawling gear in all MPAs is not dead yet. Inter-reform periods of the past have shown that they can function as precursors of CFP reforms to come (Chapter 4.3.2). The policy proposal(s) of the current action plan have a low chance of being implemented in their current form, but their implementation cannot be ruled out. The changed and changing make-up of the European political landscape is a major factor. The EU parliament and its committee on fisheries have more right-wing members than in past legislative periods and the EEP is softening its stance on so-called green policies (Chapter 4.3.3), which lowers the chances of an all-out ban. However, even if this current proposal is not implemented, I believe that nature and biodiversity protection legislation is going to continue to become more prominent in the future, both nationally and in Europe. One reason is the electoral advantage that dispersed groups have under proportional representation systems in comparison to geographically concentrated ones, such as the fishing industry (Chapter 4.4.1).

The medium- to long-term structural problem that I see concerning the brown shrimp fishery is institutional diversity and feedback loops. The current brown shrimp harvesting framework, born out of the MSC certification process, does seem to ensure biologically sustainable harvesting quantities. The EU, apart from some technical restrictions (e.g. Plaice-Box), is not further involved in brown shrimp fishery governance - even after a steep decrease in landings since 2016. The brown shrimp fishery is de facto not governed by a polycentric system and therefore lacks institutional diversity. A sustainable harvesting structure cannot exist with rules at the constitutional level (Chapter 2.4.2). Constitutional level rules need to be designed both at the Member States and at the EU level to act as a backstop.

9.7 Perception

The perception of actors has a significant influence on how they behave within the system and consequently, the system itself. In the following, I explore how climate change is perceived within the community of fishers and how their perception influences the social-ecological system.

There is a range in perceptions of climate change within the community of fishers, similar to society at large. Some fishers see climate change as man-made and undeniable:

“Der Klimawandel ist da und den können wir nicht wegquatschen“ (I26, Pos. 20)

“Climate change is here, and we can’t just talk it away.” (I26, Pos. 20)

While some fishers accept that climate change is real and human-induced, they do not perceive it as a significant issue in their daily lives. Others contend that long-term temperature variability has always been a natural characteristic of ecosystems (fisher 2023, personal communication). A recurring argument is that the North Sea has always exhibited shifts in species composition, which many use to conclude that climate change does not significantly — or disproportionately — affect their lives as fishers. Their own lifeworld serves as a reference category to judge whether or not climate change is real, or at least perceived to be of major influence.

Fishers perceive local climate change in their lifeworld in various forms, such as meteorological phenomena, shifting seasons as well as changes in flora and fauna. These changes were also not always perceived as negative. A number of fishers said that they were not sure if climate change, through warming water temperatures and longer fishing seasons, could even have a positive effect on the brown shrimp and consequently the fishery:

> *„Ich sehe das eher positiv, weil die Winter nicht mehr so kalt sind. Du kannst jetzt das ganze Jahr fischen.“ (I12, Pos. 101)*
>
> *"I see it more as a positive, because the winters are no longer as cold. You can now fish all year round." (I12, Pos. 101)*

Another group, however, sees the potential downside of a year-round fishery:

> *[…] also […] zu fischen im Winter halte ich sowieso irgendwie für - für mich nicht so zielführend, weil man da wirklich die Laich-Krabben auch dann … weil man dann schon fast zwölf Monate auf die Biester losgeht. (I1, Pos. 126)*
>
> *"[…] So […] fishing in the winter, I don’t really consider it – for me its not so productive, because you're really targeting the spawning shrimp then... because you're almost going after those creatures for twelve months straight." (I1, Pos. 126)*

Even so, a considerable number of fishers regard climate change as having a positive effect on the fishery. This belief is fueled by the perception of the brown shrimp as a “Wundertier” that can cope with any environmental conditions in the Wadden Sea (Chapter 9.2):

> *„Die Bestände 2018, Ende 2018 zum Herbst hin sind die explodiert. Wir hatten so viele Krabben wie noch nie. In dem letzten Quartal sind mehr Krabben gefangen wie sonst in einem ganzen Jahr. Also das ist … der Krabbenbestand ist ganz schwierig einzuschätzen. Das haben schon ganz viele versucht und sind damit auch kläglich gescheitert.“ (I4, Pos. 110)*
>
> *"The stocks in 2018, towards the end of 2018 in the fall, exploded. We had more shrimp than ever before. In the last quarter, more shrimp were caught than in an entire year. So that is… the shrimp stock is very difficult to assess. Many have tried and failed miserably." (I4, Pos. 110)*

The brown shrimp has an almost mythical status in the community. While it is acknowledged that the winter fishery has an influence on stock abundance, brown shrimp are seen as unpredictable in their abundance. The highest ever recorded landings in 2018 are time and again brought up as an example and proof of that. It serves as a constant motivation and lifeworld anchor: while landings are bad at the moment, they could increase next season or even next week. A firm belief in the next big catch in combination with high, ongoing expenses related to owning a vessel drives some fishers to fish as much as possible. If they are successful, other fishers take notice and themselves go out to fish.

9.8 Harvesting

Climate change influences the harvesting of shrimp in multiple ways, from bio-physical effects on the brown shrimp to the ability of fishers to leave the harbor and fish. The most relevant to my research question will be analyzed in the following. First, I will examine the effect of rising temperatures on discard shrimp mortality rates, drawing on a biological field study conducted on-board commercial brown shrimp vessels. Then I will explore the effect of a winter fishery on the brown shrimp.

In the brown shrimp fishery, discard shrimp are flushed back into the North Sea in order to ensure a higher future fishing yield by letting undersized shrimp grow to commercial size and to reduce the likelihood of growth overfishing. My research has shown that:

1. The rate of immediate discard mortality in the commercial brown shrimp fishery is higher than previously thought and
2. That temperature has an influence on the survival rate of discard brown shrimp in the commercial fishery.

In 51 hauls from six different commercial fishing trips, 4936 shrimps under 55 mm were analyzed with respect to their rate of immediate mortality. The rate of immediate mortality for discard shrimp was on average 17.8 % (± 10%) per haul, while 10.5 % (± 6%) of the discard shrimp were alive but unable to carry out their escape response – tail flipping (vitality class, 2 Figure 25). 71.7 % (± 13%) of discard shrimp were alive and able to carry out their escape response (vitality class 1, Figure 25).

Immediate mortality varies substantially between fishing trips, seasons and hauls within a trip. In summer months, such as August 2021 and July 2022, immediate mortality varied more strongly between hauls than in cooler months, such as November and April of 2021. For example, in the second haul in August, the rate of immediate mortality was 54 % while in the tenth haul it was 11 %. The average immediate rate of mortality in the summer months July, August and September, was with 21.0 %, 25.7 %, 22.7 %, respectively, notably higher than in October, November or April, with 17.5 %, 9.1 %, and 14.4 %, respectively. A significant correlation between the months during which the fishing trips took place and the temperature at fishing depth was observed (spearman's rank correlation = 0.63, p-value < 0.0001), connecting the seasonal variability in the rates of immediate mortality to water temperature (Figure 26).

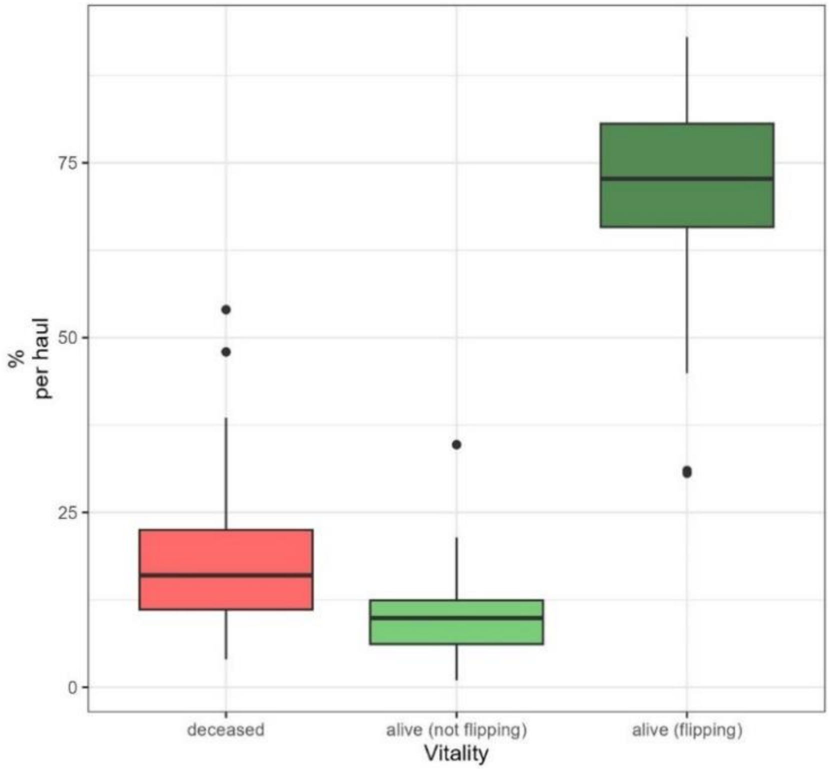

Figure 26: The distribution of vitality classes per haul (%) of discard brown shrimps pooled from all fishing trips

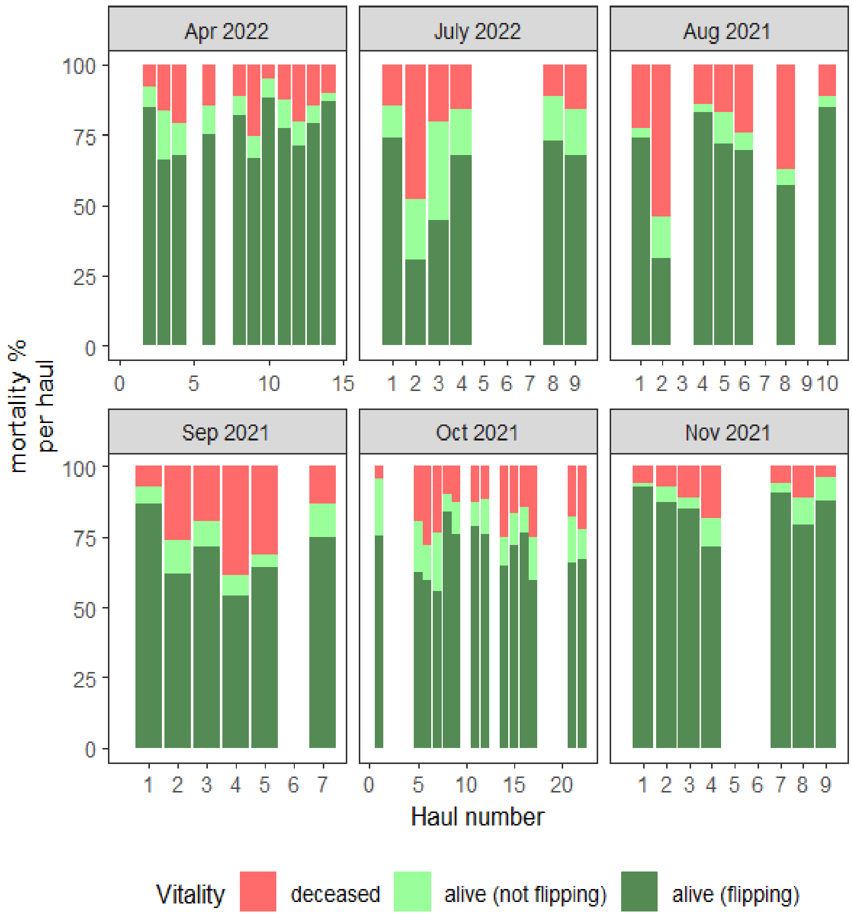

Figure 25: Mortality per haul (%) for every haul sampled and grouped by fishing trip

For the analysis of temperature on the survival of brown shrimp, the data from April 2022 (cruise 6) was excluded because it is incomplete due to an error in the recording of values. Therefore, the analysis was based on 3497 brown shrimp. A weak monotonic relationship between water temperature and survival likelihood exists (Spearman's $\rho = -0.1241$, $p < 0.001$). Although the effect size was small, the correlation was significant and suggests that higher water temperatures are associated with lower survival. Figure 27 shows that between 9 and 10 °C, the likelihood of immediate mortality was between 7 and 8 %. With increasing water temperatures, the likelihood of immediate mortality increased to 23 % between 17 and 18 °C. Moreover, with increasing temperatures, the variance in the likelihood of immediate mortality between hauls approximately triple. A notable difference between daylight and non-daylight catches was, however, not observed.

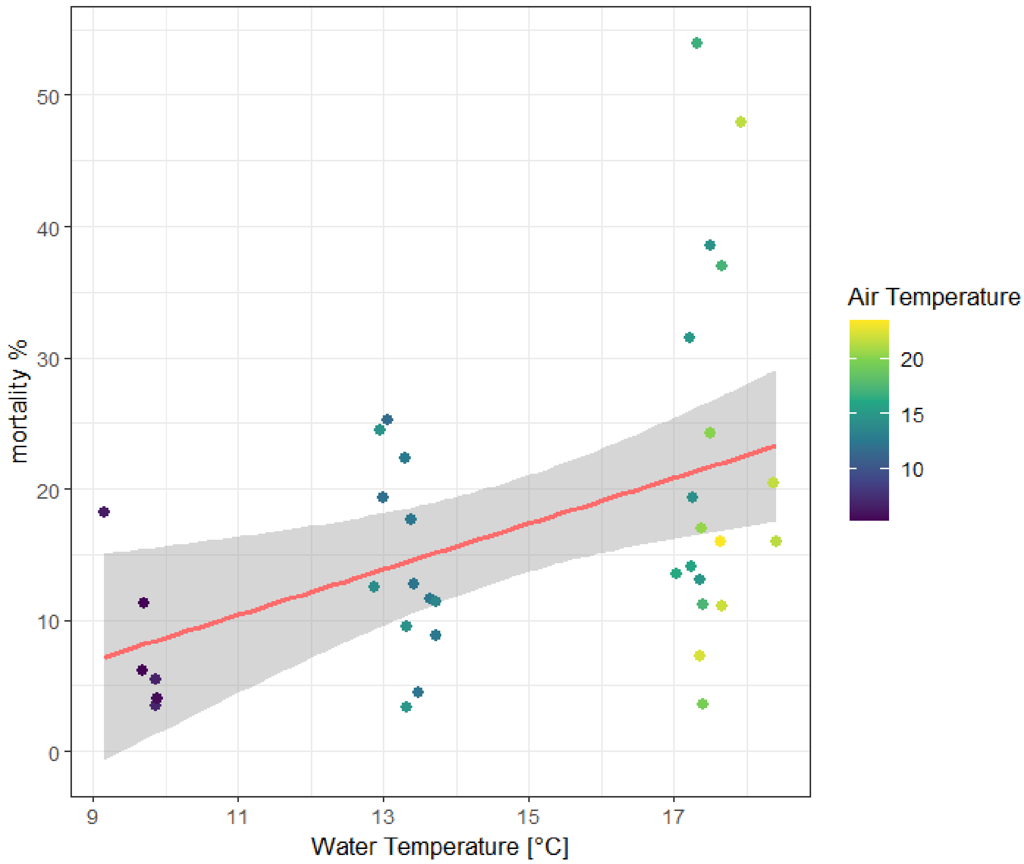

Figure 27: The likelihood of immediate mortality of discard brown shrimp (%) in correlation to median water temperatures. Colors indicate the air temperature. All temperature values are given in °C.

The binary logistic regression analysis of 3497 discard brown shrimp (Table 9) shows the influence of temperature on the survival likelihood. When controlling for the other predictors in the model, the odds of a brown shrimp experiencing immediate mortality increases by 27 % with every degree Celsius (odds ratio = 1.27, $p = 0.000$) increase in water temperature. This translates to an increase in absolute mortality risk from 17.8% to 21.6%. A 3.8 percentage point increase in absolute risk per 1°C increase in water temperature. While the logistic regression offers many additional insights, I will not explore them further in this point, as they fall outside the scope of this dissertation. For further details on methodology and results, see Müller et al. (in prep.).

Table 8:The logistic regression table for discard brown shrimp showing the predictors with their predictor categories as well as the respective odds ratio, confidence intervals and p-value. Significant p-values are highlighted in bold.

Predictors	Predictor Categories	Odds Ratio	Lower 95%	Upper 95%	p-value
Intercept		0.0025	0.0012	0.0050	**0.000**
Water Temperature		1.275	1.221	1.332	**0.000**
Sorting Process	(Beginning)				
	End	2.341	1.939	2.827	**0.000**
Carapace	(Hard)				
	Medium	2.377	1.881	3.004	**0.000**
	Soft	22.188	14.570	33.789	**0.000**
Haul Volume	(868 - 1358 L)				
	<868 L	0.741	0.455	1.207	0.229
	>1358 L	1.519	1.118	2.064	**0.008**
Haul Time	(2-3 h)				
	<2 h	0.291	0.198	0.428	**0.000**
	>3 h	1.200	0.867	1.660	0.270
Length	(40-50 mm)				
	<30 mm	2.034	1.179	3.508	**0.011**
	30-40 mm	1.167	0.939	1.449	0.162
	>50 mm	1.099	0.792	1.525	0.569
Haul Volume:Haul Time	(868-1358 L: 2-3 h)				
	<868 L : <2 h	1.101	0.543	2.233	0.788
	>1358 L : <2 h	2.734	1.575	4.748	**0.000**
	<868 L : >3 h	0.809	0.444	1.471	0.488
	>1358 L : <2 h	0.850	0.495	1.459	0.557

The logistic regression shows that continued increases in temperature are going to affect the odds of survival for discard shrimp. Using this regression model, a prediction was run (Chapter 3.5.3) on the likelihood of survival of discard brown shrimp under water temperatures from 10 to 23 °C. Across the most frequently observed combination of biological and operational conditions in the dataset—medium-sized brown shrimp (40–50 mm), hard carapaces, moderate haul durations (2–3 h), intermediate haul volumes (868–1358 L), and individuals sampled at the beginning of the sorting process—the logistic regression model revealed a monotonic increase in the probability of immediate mortality with rising water temperature. When predictions were generated for a broader temperature range to capture both spring and summer conditions, mortality probabilities increased sharply from 2.8% at 10 °C to 4.4% at 13 °C, 7.0% at 15 °C, and 13.6% at 17 °C, indicating a rapid escalation already at moderate temperatures. At 18–19 °C, predicted mortality rose further to 16.7% and 20.3%, respectively. The steepest increases occurred within the upper ranges of the temperature range: mortality reached 24.6% at 20 °C, 29.3% at 21 °C, 34.6% at 22 °C, and ultimately 40.3% at 23 °C, representing more than a fourteen-fold increase relative to the lowest observed temperatures. This temperature–mortality gradient highlights an accelerating, nonlinear thermal sensitivity, whereby each incremental rise in temperature disproportionately increases the likelihood of mortality. Because the predictor settings used here reflect the common, robust biological states (hard shelled, medium long individuals) and standard operational conditions in the fishery, these temperature-dependent estimates likely approximate typical discard outcomes during routine commercial practices rather than reflecting extreme scenarios. Collectively, the results demonstrate that high temperatures exert a strong negative effect on post-capture survival.

With the current mesh sizes used in the brown shrimp fishery, approximately 60% of all caught shrimp are discarded, representing roughly 40% of the total catch weight (Temming et al. 2022b; Temming et al. 2022a). Given average annual landings of about 25,000 t in the southern North Sea between 2016 and 2024, this corresponds to nearly 17,000 t of undersized shrimp being returned to the Wadden Sea each year. In the context of climate change, with (marine) heatwaves projected to become more frequent and severe, such temperature dependent mortality dynamics imply that an increasingly large proportion of the substantial discard fraction will die in the sorting process. Consequently, the potential economic impacts are likely to intensify, underscoring the need for alternative management rules.

Climate change affects not only brown shrimp directly but also the fishers who depend on them. Higher winter temperatures, the absence of harbor ice, and the increasing use of larger vessels have collectively extended the fishing season. The winter fishery is now dominated by larger vessels capable of operating under harsher weather conditions (fishers 2022, personal communication). The introduction of Dutch Euro-Cutters in particular has significantly altered harvesting practices and impacted shrimp stocks. These vessels can operate in weather conditions and at depths that were previously inaccessible to the traditional small-vessel fleet (Chapter 8.3). Before their arrival, a winter fishery was virtually absent as shrimp retreat to deeper waters as temperatures drop, making them inaccessible to smaller vessels. This shift is especially important because the deeper-water migration includes egg-bearing females (Chapter 9.2). Respondek et al. (2022) hypothesize an aggregation area of ovigerous females off the eastern Dutch coast during January and February. From these deeper habitats, females migrate toward coastal spawning areas in March–April, where larvae are released and subsequently carried northward by prevailing currents.

A winter fishery in combination with these migration and drift patterns can have a significant impact on the shrimp stock. The impact of the winter fishery on landings can be shown through fishing effort in the winter and Landings Per Unit Effort (LPUE) in the summer fishing season. There is a significant correlation between fishing effort in winter (January – February) and LPUE in the following summer fishing season (July-August). Notable is the negative correlation between winter fishing effort of the eastern Dutch coast and summer LPUE in Lower-Saxony (Germany South) and Schleswig-Holstein (Germany North). Data from the years 2009-2020 show the significant negative correlation between winter fishing of the eastern Dutch coast and summer LPUE from Lower-Saxony, Schleswig-Holstein and southern Denmark, as shown in Figure 28.

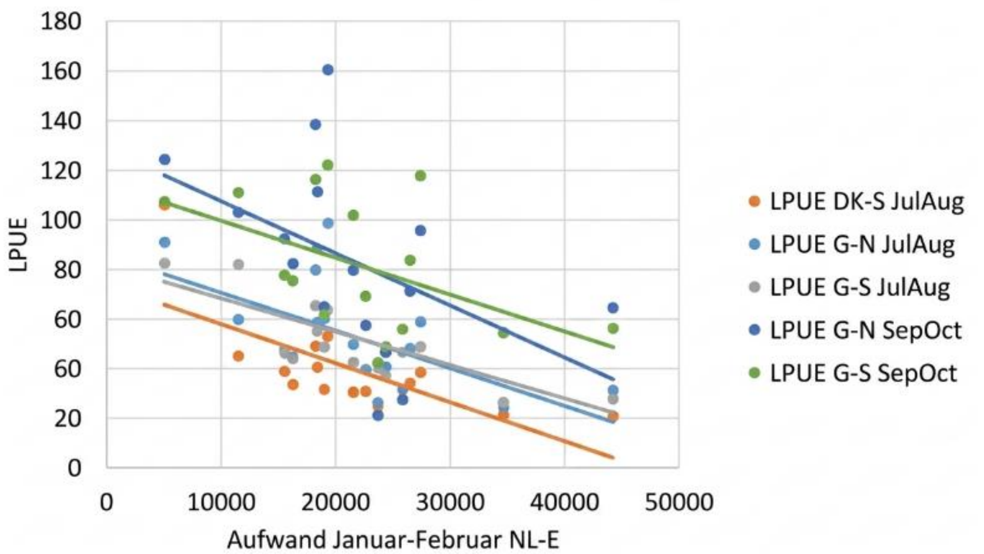

Figure 28: Linear regression between fishing effort in January–February off the eastern coast of the Netherlands (NL-E) and LPUE (kg h^{-1}) in July–August and September–October in the northern (G-N) and southern (G-S) German Bight and the southern Danish coast (DK-S) (Temming et al. 2022,12).

Temming et al. (2022b) have also shown that the total effort off the eastern Dutch coast has increased by 12 % in the four year period from 2014-2018 when compared to 2009-2013. Fishing effort in Germany and Denmark was largely unchanged from 2014 to 2018 compared with the reference period, whereas both western and eastern Dutch waters experienced increases. Consequently, the majority of the effort increase occurred in Dutch waters. Over the same period, landings declined by 9% relative to 2009–2013, with particularly notable reductions in Denmark, Lower Saxony, and most strongly in Schleswig-Holstein (Temming et al. 2022b).

Climate change induced warming temperatures, in combination with the entry of Dutch Euro Cutters, are two external factors that directly influence the harvesting of brown shrimp. Higher average and extreme summer temperatures will lead to higher rates of immediate mortality of discard shrimp and therefore larger forgone fishing yields. Higher average winter temperatures and a reduced frequency of extreme cold events will likely make winter fishing even more attractive to fishers in the future if no regulatory measures are introduced. These dynamics are not mutually exclusive, rather, their effects may reinforce one another through a positive feedback loop. Increased forgone fishing yield stimulates a larger winter fishery, which in turn results in lower LPUEs in the following season.

9.9 Evaluating the Threat of a Fisheries Collapse

This chapter has shown that the German brown shrimp fishery faces non-trivial short-, medium- and long-term systemic risks that carry a high likelihood to result in a fisheries collapse. It highlights how non-quota fisheries in the EU's multi-level governance system incentivize overcapacities and unsustainable harvesting practices that lead to social-ecological vulnerabilities in the system. These vulnerabilities are further exacerbated by limited biological information of non-managed species and climate change uncertainty (H6).

Focusing on the governance system, problems at every level contribute to the risk of collapse, although to varying degrees. The most pressing problems to be solved in the short-term are at the self-management level. Current harvesting rules do not prevent the unsustainable harvesting of brown shrimp, but together with the current market organizational structure and the absence of constitutional level rules, produce self-reinforcing loops of over-exploitation. Therefore, the self-management plan needs to be renegotiated to account for the present situation, tightening the rules that are supposed to prevent growth and recruitment overfishing. If current harvesting practices persist, landings will likely stagnate at present levels or decline further, which would almost certainly result in the closure of many fishing businesses. While the resilience of brown shrimp may buffer many short-term climate change impacts from becoming readily apparent, in years of low landings, elevated discard mortality will still reduce profit margins. However, any attempt to renegotiate the self-management system will face considerable obstacles. Even within the German fishing community, consensus will be difficult to reach because fragmentation persists, driven not only by entrenched grievances but also by divergent business models and competing visions for a future fishery. Bridging these divides is, however, necessary not only for the short- but also for the medium- and long-term.

In the short to medium term, fishers will need to work collectively to counter the lobbying efforts of the offshore wind industry and environmental NGOs, both pushing for reduced access to fishing grounds. Should bottom trawling be banned in marine protected areas, as proposed in the Commission's action plan, the German brown shrimp fishery would almost certainly collapse - as its current market organization is built around processing large quantities of shrimp.

In the medium- to long-run, effective feedback loops from the self-management level to the constitutional level need to be created, alongside constitutional-level regulations that provide the structural framework necessary for a sustainable fishery. Without rules at the constitutional level, the risk of a fishery collapse in the future is high. The absence of strict catch limits and effort restrictions fosters a market-driven exploitation, creating conditions for feedback loops of over-exploitation. The past has shown that low landings can create high fishing effort in the next season. Climate change could exacerbate this tendency if it leads to recruitment failures in the future.

This analysis has shown that non-quota species, such as brown shrimp, create structural incentives for unsustainable exploitation resulting from a lack of fishing effort restriction or legal catch limits coupled with a market-driven harvesting system. Using and applying the Social-Ecological Action Situation Framework revealed critical areas that foster the risk of a fishery collapse through inflexible governance institutions that are not set up to manage uncertainty and integrate environmental feedback into decision making. Furthermore, non-managed fisheries lack accountability structures at the constitutional level and therefore are prone to over-exploitation. If building resilience to climate change uncertainties is the goal, Europe's fisheries governance must transform towards adaptive structures that can respond dynamically to ecological and social changes. Without these, non-quota fisheries in particular, but many European inshore fisheries, will remain at great risk from climate change.

10 Adapting the EU's Fisheries Governance to Climate Change Uncertainty

This third analytical part sets out to identify and discuss the adaptation capacities of the EU's multi-level fisheries governance system within the context of climate change, with adaptation options being developed at every governance level. I ask the research question:

(Q3) How should governance structures be adapted to climate change uncertainty to enable the social and ecological sustainability of the German inshore brown shrimp fishery?

This chapter combines the empirical governance shortfalls identified in part two (Chapter 4-9) with the Adaptive Governance theoretical insights from part one (Chapter 2) to develop plausible adaptation options that are needed for a socially and ecologically sustainable European fishery with a focus on non-managed species (Whitney et al. 2017). While there are a multitude of topics to be addressed, these adaptation options specifically relate to governance within the context of Adaptive Governance theory. Therefore, the focus lies on different governance levels and the interplay between them. Chapter 10.1 addresses adaptation options at the European level with a focus on regionalization and fishing opportunities, while Chapter 10.2 discusses adaptation options at the constitutional level specific to Germany. Chapter 10.3 considers adaptation options to the brown shrimp management from the constitutional to the self-management level and obstacles to Climate Change resilience.

10.1 Adaptations to European Governance

While there are many adaptations that could or need to take place[11] at the European level, I am going to focus on two aspects related to Adaptive Governance theory and the empirical analysis of Chapters 4 through 9. First, I argue that the participation of diverse actors and the subsequent inclusion of different knowledge systems within the context of regionalization are important in order to successfully adapt to climate change challenges. Second, while European fisheries policy is often criticized, I assert that it is the politics and institutional structure (polity) that are going to be a challenge for a sustainable European fishery, rather than the policy itself.

[11] See the EU's "Climate change and the Common Fisheries Policy: adaptation and building resilience to the effects of climate change on fisheries and reducing emissions of greenhouse gases from fishing" report for a comprehensive overview.

10.1.1 Regionalization

Regionalization of the EU's fisheries governance is an important tool in adapting to climate change challenges. It will, however, only yield meaningful positive results if local actors are involved in decision making. This local knowledge can serve to complement scientific knowledge in developing adaptation scenarios (Thornton and Scheer 2012; Cinner et al. 2018). By bringing together different knowledge systems, EU fisheries can best adapt to rapidly changing local ecological and socio-economic circumstances. The inclusion of different knowledge types, this "analytic deliberation" as Dietz et al. (2003) put it, is central to a successful local adaptation. However, the inclusion of different knowledge systems must extend beyond a normative concept. This means that it is not sufficient to merely consult local actors; their knowledge and understanding must be integrated from the outset rather than treated as an add-on at the end. It is about integrating their knowledge into the whole process of searching for a solution rather than adding that knowledge to a solution that has already been decided on (Chapter 2.2.2).

The Commission, in its communication "The common fisheries policy today and tomorrow", sees the move towards greater regionalization as successful by involving actors more directly in decision-making and allowing for more tailored fisheries management measures at the regional level. The report outlines future directions and sets priorities for enhancing sustainability: supporting small-scale fisheries, innovation in fisheries and strengthening regionalization (COM 2023c). However, continued regionalization that is based on a meaningful involvement of fishers, bringing together different knowledge systems, is still not applied comprehensively within the EU. A striking example is the "EU Action Plan: Protecting and restoring marine ecosystems for sustainable and resilient fisheries". It exemplifies how the failure to integrate local social-ecological knowledge results in misinformed and unrealistic policy proposals (Chapter 8.3). Rather than proposing objectives to be met by Member States, the action plan calls for a blanket ban on bottom-trawling activities within marine protected areas in EU waters. Not only does this plan not adhere to the spirit of regionalization, but it is also obvious that practitioners were not meaningfully consulted when drafting the plan.

The CFP is a supranational policy that tries to balance the interests of Member States with differing priorities based on the role that the fisheries sector plays. Rather than attempting to create a level playing field by negotiating technical details at the European level, the focus should be on formulating objectives that must be achieved. Member States would then be responsible for negotiating and developing plans outlining how these objectives will be met. Even in a changing political landscape, both at the European level and within the Member States, which see the strengthening of far-right movements (Chapter 4.4), regionalization is likely to be supported by a broad political spectrum. While these far-right actors seek to halt, or at the very least stifle, the continued European integration, regionalization in fisheries can serve at least as a symbolic victory for them. The Brexit negotiations demonstrated that fisheries can become a focal point of public controversy, notwithstanding the sector's limited economic significance (Peñas Lado 2019). Pushing for more regional decision-making power should be in the far-right's interest and be seen as a political win. Incidentally, moving regionalization forward will enhance the system's capacity to adapt to climate change by mitigating existing institutional rigidities (Chapter 4). However, the far-right's nation-centric stance on other key issues, such as the renegotiation of fishing opportunities, is likely to hinder the development of climate-change-resilient fisheries.

10.1.2 Renegotiation of Fishing Opportunities

The policy dimension of EU fisheries governance is often criticized as an obstacle to the ecological sustainability of fisheries. However, it is not as much the policy itself that is curtailing Europe's ability to adapt to a changing climate but the political dimensions involved in its implementation (ClientEarth 2024; Oceana 2025). As a supranational policy, the CFP is the common regulation for Member States with different objectives. Fisheries governance is often talked about as an exclusively European competence, but at its core, the CFP is a distributional policy and its evolution is dependent on the interests of the Member States. The relative stability key is the major distribution mechanism of fishing opportunities for a large number of commercially relevant species (chap Chapter ter 4). Climate change induced ocean warming has led to a northward geographical shift for many species (EEA 2024a), leading to a potential mismatch between scientific and management areas. The historical catches of the 1970's, on which the relative stability key is based on, do not reflect the reality of the future of Europe's fisheries (Chapter 4.1) with two potential consequences: renegotiation of the relative stability key and adjustment of scientific and management areas.

However, Member States and industry are not interested in renegotiating the relative stability key and the practice of setting TACs, as doing so could result in reduced quota shares for them (Chapter 4.4). The process of renegotiating the alignment of scientific and management areas for the horse mackerel shows the difficulty inherent in these negotiations. Geographical stock shifts would involve a true re-distribution of quotas and likely result in even more challenging negotiations (Chapter 4.4.1). At the Member State level, the CFP allows — through Article 17 — the allocation of quotas based on a range of criteria, of which historical catch levels are only one. However, in practice, both at the European and Member State levels, historical catches remain the dominant criterion for allocating fishing opportunities. The EU lacks a transparent mechanism for resolving mismatches between scientific and management areas. Adjustments are decided upon on a case-by-case basis rather than through a fixed process. The continued right-wing electoral success is likely going to have a different effect on renegotiating fishing opportunities than it will on regionalization. While continued regionalization can be seen as a success for nationalist forces within the EU, renegotiating fishing opportunities is likely going to be seen as politically too risky – especially in Member States like Italy, France or the Netherlands where fisheries play a significant role (Chapter 4.4).

Renegotiating how Europe is going to distribute fishing opportunities would need to entail a change in the way that fisheries are seen - a change in ontology rather than just epistemology. A transition of this kind would require adopting complex adaptive systems thinking — highlighting non-linear, non-equilibrium dynamics — while placing greater emphasis on a precautionary approach (Chapter 2.5). Rather than focusing on efficiency, the emphasis needs to be on building resilience to climate change disturbances with a process ontological focus. Preserving European inshore fisheries in times of rapid change requires a focus on diversifying target species and adopting a broader, beyond-fishing approach. All this means renegotiating what fishing means in the European Union. An example of the need for such a shift is non-managed species such as the brown shrimp. Currently, the logic of large-scale exploitation results in the practice of fishing down the food web: once it is no longer profitable to fish a species, the fleet moves on to the next one (Chapter 8.3). Especially for non-managed species, the precautionary approach is not applied, if anything, the reverse is the case. Conservation interventions occur only after unsustainable practices have been conclusively demonstrated (Chapter 4.3.4).

10.2 Adaptations to German Governance

Some researchers (e.g. Carpenter und Kleinjans 2017) , as well as almost all German brown shrimp fishers, criticize Germany for not articulating fisheries objectives beyond those of the CFP. Although this criticism is comprehensible, I would argue that Germany does not require objectives that exceed those already established. What is needed is a coherent implementation strategy that adapts the CFP's objectives to the specific cultural, economic, social, and ecological contexts of Germany's sea basins—the North Sea and the Baltic Sea. Both sea basins have distinct fisheries and operate within very different path dependencies. A continued European push for regionalization makes national goals and accompanying strategies necessary for sustainable German inshore fisheries.

A national strategy based on medium- and long-term goals is needed for setting guide rails in decision making processes. Without a strategy that is tailored towards national goals, European directives are going to be implemented to the letter for lack of alternatives. Brown shrimp fishers are criticizing politicians for implementing and following European rules and regulations precisely, while Member States like the Netherlands are far less meticulous. A changing climate will increase the need for a national strategy, with the current European fisheries governance system leading to conflicts when scientific and management areas are misaligned. A national strategy is needed that focuses on the resilience of the German North Sea inshore fishery rather than short-term efficiency. Short-term efficiency has been the driving force of the current self-management system (Chapter 8) and seems not to be a viable option in the long run.

Concrete actions within such a strategy could include establishing a fixed and diverse set of quotas for inshore fishers in the North Sea. This would create opportunities for diversifying target species and could reduce pressure on the brown shrimp stock. In doing so, it would support the fishery by enhancing diversification and redundancy in target species, while simultaneously benefiting the brown shrimp population through potentially lower exploitation rates—provided that alternative species are available. Additionally, funds could be used to finance weekend or seasonal closures, which could be framed as a shared win with environmental NGOs.

10.3 Adaptations to Brown Shrimp Governance and Management

The brown shrimp fishery is already experiencing climate-change impacts: directly through the emergence of a winter fishery and rising discard mortality and indirectly through spatial closures linked to offshore wind-park expansion. Landings have fallen by 25% since 2016, and additional declines could precipitate the collapse of most of the fleet (Chapter 9). Sustaining the fishery socially and ecologically will therefore require coordinated adaptations at higher and lower governance levels, as well as more effective integration of fishers into governance processes.

10.3.1 The Constitutional Level

A key obstacle to achieving sustainability in the brown shrimp fishery is the lack of constitutional-level quota or effort limitations. With management de facto confined to the self-management plan, the decline in landings indicates that current measures are insufficient for ensuring sustainability (Chapter 6.2).

Sustainable self-organization relies on multiple feedback mechanisms functioning across various hierarchical levels, only through this interplay can sustainable self-governance emerge. As a non-managed species fishery, such feedback mechanisms are absent for the brown shrimp fishery. The EU needs to construct a framework for non-managed species, and by extension, the brown shrimp fishery, that further controls self-management. This framework needs to follow a precautionary directive with a threshold approach that triggers EU rules for sustainable fishing practices. Currently, there are no feedback mechanisms put in place. How sustainability is defined in a brown shrimp fishery is de facto outsourced to a non-state actor, the Marine Stewardship Council. This can prove to be a problem in the future if no state actor is positioned to decide whether a fishery is sustainable or not.

The other constitutional level actor apart from the EU is the Member States. While the Danish, Dutch and German brown shrimp fisheries are MSC certified together, they operate under different national fisheries acts. The fleets have the same self-management plan, but not an equal playing field because of differences in national policies and fisheries management practices. The Trilateral Wadden Sea Cooperation is a formal government-level collaboration between Denmark, the Netherlands and Germany. Its purpose is to protect and conserve the Wadden Sea region as an ecological as well as a cultural entity through common policies and management. As an already established institution, it could function as a platform for creating a more equitable playing field and for formulating nationally grounded rules that could frame the self-management plan. Such an approach may enable more rapid development of constitutional-level rules than the slower process of amending EU legislation. Although this may offer a practical solution for the brown shrimp fishery, addressing the overarching governance challenges associated with non-managed species will require changes at the EU level.

10.3.2 The Self-Management Plan

Effective governance systems are comparable to a co-evolutionary race. The set of rules that fits a particular set of social-ecological conditions may lose its effectiveness as systematic changes occur and users learn how to evade rules. Successful commons governance requires rules to evolve with the system (Haider et al. 2021). Consequently, the self-management plan must be reoriented to align with the current situation in the brown shrimp fishery. The plan was established at a time when landings were increasing or at least plateauing at high levels. With these conditions having shifted, the self-management framework must also evolve. This requires changes to both the harvesting rules and the broader institutional arrangements through which these rules are designed.

The research project “CRANMAN” by the University of Hamburg and the Thünen-Institute studied the biology of the brown shrimp and the functioning of its fisheries within the sector’s self-management system. It recommended further measures to reduce growth overfishing. An increase in mesh sizes to 26mm (without rounding effects) would be an effective measure to avoid bycatch of undersized shrimp (Temming et al. 2022b). As an alternative, a reduction in fishing effort could be an option. To achieve a comparable increase in yield, the annual effort would need to be effectively reduced by 12% compared to the long-term average (Temming et al. 2022b). Especially considering the higher than expected discard mortality measures (Chapter 9.8), a fishing effort reduction or complete stop during summer months could be beneficial to both brown shrimp and fishers.

The harvest control rule in its current form cannot effectively prevent further increases or, at the very least, very high levels of fishing effort in areas with low shrimp stocks. This is particularly the case in the winter months, where current harvesting practices can lead to recruitment overfishing. Furthermore, current regulations leave room for additional increases in fishing effort, despite the introduction of harvest control rule restrictions. Thus, in addition to revising the reference values, strict control of actual effort is necessary. The CRANMAN project also identified the regionalization of the harvest control rule as one possible solution to prevent overfishing, even though fishers largely oppose a regionalization of it in surveys (Temming et al. 2022b).

Beyond the need for revising specific rules, I regard the MSC structure itself as a major obstacle to the short- and long-term sustainability of the fishery. Although the MSC framework does not appear to prevent overfishing of the brown shrimp stock, it is unlikely that these standards will be renegotiated in the near future. The entire brown shrimp system is currently oriented toward large-scale harvesting and prioritizes efficiency over resilience. While some actors in Germany support changing this system, the degree of fragmentation within the community is too great to generate meaningful reform. Without a revision of the current rules and uniform application of the ones that are currently in place (Chapter 6.1), I think that sustainable fishing practices that meet the structural demands of the brown shrimp market (Chapter 9.3) will be hard to achieve. This strengthens calls for constitutional level rules not to replace the current self-management system but to give it a frame in which it can work to develop sustainable fishing practices.

10.3.3 An Obstacle to Climate Change Resilience

Unsustainable fishing simplifies food chains and, like aquaculture, can lead to dependence on a few economically valuable species. This reduced diversity heightens the risk of ecological and economic instability (Steneck et al. 2011). I hypothesize that the interplay between a species' high ecological resilience and its high economic value obstructs the development of resilience to climate change. This dynamic can be observed in the brown shrimp fishery as well as in the New England lobster fishery. Each represents a gilded trap: a social-ecological trap in which attractive economic opportunities conceal or overshadow significant social and environmental risks (Fisher et al. 2021). The promise of substantial financial gain reinforces the trap, making it harder to break. Escaping or preventing gilded traps requires fostering both biological and economic diversity, but this is challenging when strong financial incentives support the status quo (Steneck et al. 2011). In the long run, fisheries management must shift from a single-species focus to a more integrated social-ecological approach that promotes diverse ecosystems, societies, and economies (Mason et al. 2023; Boonstra and Boer 2014).

The brown shrimp are highly abundant and have a high biomass in the Wadden Sea. They have a short lifecycle, reproduce at least once a year and have a high tolerance for temperature and salinity changes due to the natural fluctuations in their habitat (Chapter 9.2). Remarkably, I observed that even while confined in the net, they fed on dead bycatch, including the carcasses of other brown shrimp. These attributes make them a resilient and reliable target species and a highly valuable target species, in fact, the third most important species in value landed in the region (STECF 2023). The combination of these attributes with the fact that no quota or effort restrictions apply results in the prioritization of efficiency over resilience to external stressors. The situation in the North Sea is similar to the lobster fishery in the Gulf of Maine. Intense fishing in the North Sea has led to the depletion of most commercially important species, such as the cod and has led to a simplification of the food web, a situation where the fishing mortality for brown shrimp is higher than the mortality from. Centuries of intense fishing have wiped out most apex predators in the Gulf of Maine, leading to a near-monoculture of American lobster (*Homarus americanus*) (Steneck et al. 2011; Temming and Hufnagl 2015). In Maine, lobster fishers derive a median of 80% of their income from lobstering (Dayton and Tokunaga 2023), making them dependent in a similar manner as the brown shrimp fishers.

However, the Maine lobster fishery is often cited as a successful example of Elinor Ostrom's principles of self-management, showcasing how local communities can effectively govern and sustain common-pool resources (Barnett and Anderies 2014). Yet, the outcome emphasized in such assessments is efficiency rather than resilience—a distinction of considerable relevance. This is noteworthy, as efficiency is not synonymous with resilience—and conflating the two obscures important system vulnerabilities. The existing system acts as a gilded trap for brown shrimp fishers, necessitating strategies that build resilience rather than efficiency at all levels of governance—European (Chapter 10.1), German (Chapter 10.2), and within the self-management framework (Chapter 10.3.2).

11 Conclusion

It is indisputable that European fisheries are profoundly impacted by direct and indirect climate change impacts (Beaugrand et al. 2022; Bastardie et al. 2022b; Dahlke et al. 2020; UNCTAD; UNCTAD 2024). Beyond rising temperatures, climate change effects, such as more frequent and intense extreme weather events, can negatively affect fishing operations. Moreover, it is clearly increasing the speed at which social-ecological systems are changing and calls into question the institutional foundations governing these systems (Paniagua and Rayamajhee 2024; Elrick-Barr et al. 2024). Therefore, climate change is not only affecting European fishing activities but also the institutional structures and processes that govern them (Harte et al. 2019). This dissertation has analyzed and discussed the institutional impact of climate change on the European fisheries governance regime, focusing on non-managed species. It explored and developed plausible adaptation pathways through the case study of the brown shrimp fishery in the southern North Sea, using an interdisciplinary, mixed-methods research approach that integrated qualitative social science analysis with quantitative research on juvenile discard shrimp mortality rates. Through this integrative, multi-layered approach, disciplinary gaps were explored and bridged - providing a comprehensive understanding by addressing not only what was happening but also why and how. This, in turn, enabled me to develop adaptation options for European fisheries in general and the brown shrimp fishery in particular. A process-ontological approach (Hertz and García 2019) was fundamental in enabling a beyond-harvesting perspective (Basurto et al. 2020) , built on empirical analysis and theoretically anchored in complex adaptive systems thinking (Preiser et al. 2018). Central to this was the use of the brown shrimp as a boundary object (Star and Griesemer 1989), facilitating epistemological integration. The dissertation's epistemological orientation thus rested on the integration of scientific and practical knowledge systems and on interdisciplinary collaboration. I sought to identify and analyze the processes and structures that fishers themselves perceive as particularly pressing within the current fisheries-governance system in Germany. Methodologically, this was achieved through semi-structured interviews with actors involved in fisheries. Adaptive Governance Theory was used as the theoretical foundation of this dissertation. As an institutionalist theory, it highlights self-management capacities of communities, integrating knowledge of diverse actors, polycentric governance structures and social ecological fit. It aims to provide an adaptive governance system for the sustainable use of resources in social-ecological systems (Chaffin et al. 2014; Datta and Chaffin 2022).

This dissertation has aimed to understand the systemic problems and resulting failures of the multi-layered governance system that shapes the policy, polity and politics of the European fishery governance structure, focusing on inshore, non-managed fisheries with the case study of the German brown shrimp fishery. The analysis showed that the constitutional, collective action and operational governance layers should be considered when developing plausible adaptation options for the multi-level European fisheries governance system. The brown shrimp fishery case study showed that both the multi-layered political structure that determines fisheries governance in Germany and the practical knowledge of fishers need to be included in the analysis to get an integrated understanding of adaptation options. With this integrative, interdisciplinary approach, the multi-perspective conceptual framework was developed and allowed for a comprehensive analysis and understanding of the systematic problems of the governance system. A key piece in the methodological framework was the qualitative, mobile method of on-board interviews. The on-board interviews during commercial fishing trips gave key insight into the daily lifeworld of the fishers while also facilitating the biological field research on discard brown shrimp mortality rates. The combination of these methods led to novel insights, both from a social and natural science perspective. From a social-science perspective, this allowed me to situate the interviews within the life-world of the interviewees, while from a natural-science perspective, it enabled me to contextualize them within the realities of commercial fishing. In combination, the methods allowed for an integrated understanding and communication of the research agenda and its results. Using brown shrimp as the boundary object was paramount for bridging the disciplinary divide and creating an integrated research paradigm, but also allowed for and enabled communication across knowledge systems.

11.1 Summary

The dissertation was organized into three parts that addressed three interrelated research questions. Part 1 analyzed the potential contribution of Adaptive Governance Theory to improving climate-change adaptability within EU fisheries governance (Chapter 2). Part 2 investigated governance constraints in the EU fisheries system under climate change uncertainty, both in general terms and specifically for the German brown shrimp fishery, through retrospective and prospective analyses (Chapters 4–9). Part 3 then discussed adaptation pathways for European fisheries governance, informed by the findings of the previous parts and again illustrated through the brown shrimp case study (Chapter 10).

This first part (Q1) focused on Adaptive Governance Theory in EU fisheries governance within the context of climate change. I showed that future conceptions of Adaptive Governance Theory need to go beyond a normative concept in their implementation for the EU to engage with climate change uncertainties and adapt at scale (H1). Rather than using Adaptive Governance as a normatively intuitive concept, theoretical accuracy is required and intimate knowledge of its theoretical building blocks. Especially its conception as a critique of centralized expert management is vital for understanding the importance of the inclusion of diverse types of knowledge. Following Polanyi, the inclusion of practical knowledge on an individual and system level appears to be necessary for the EU to develop sustainable fisheries (Chapter 2.2). Moreover, I have shown that Adaptive Governance Theory implementation needs to entail incremental change in fisheries political governance rather than just a change in knowledge acquisition of fisheries - a move from epistemology to ontology (H2). It means that local social-ecological knowledge inclusion needs to come with a change in the way the governance system structurally functions and not just as a simple addition to the way knowledge about fisheries is generated. As Polanyi argues, bodily and mental modes of knowing are fundamentally interconnected and there is no true explicit knowledge. Combining insights taken from Polanyi's epistemology and process ontology hold the potential to form a framework for environmental policy development that might be able to show that not just a change in knowledge acquisition is needed, but a conceptual and structural change in fisheries governance is required. A beyond harvesting approach to fisheries, based on a process ontological complex adaptive system's understanding, yields such a change (Chapter 2.3).

Additionally, I have shown that Adaptive Governance Theory holds the potential to enable climate change adaptation through iterative learning, feedback and implementation processes at lower and higher levels of governance (H3). Feedback mechanisms at and between lower and higher levels of governance play a crucial role in the success of common pool resource governance systems. Polycentricity theory and Ostrom's Collective Action Theory, as the primary theoretical contributions to Adaptive Governance Theory, highlight the centrality of iterative learning and implementation processes at and between lower and higher levels of governance in institutions. Without feedback processes between the governance levels and regulatory intervention at the constitutional level, sustainable management of non-managed fisheries in the EU seems to be unlikely (Chapter 2.4).

The second part of the dissertation (Q2) focused on the constraints of the multi-level European fisheries governance system amid climate change conditions in general, with a focus on the German brown shrimp fishery. I have shown, through the use of the political dimensions polity, policy and politics, that European fisheries governance is characterized by rigidity (H4 part 1). The CFP is not only rigid, but it is also complicated and mistrust among Member States prevails, culminating in incredible regulatory detail. Decision-making processes have become so complicated and time consuming, that there is little willingness by politicians to react to emerging issues. Too much emphasis is put on negotiating technical details rather than overarching political questions - such as the renegotiation of e.g. relative stability. By sidestepping larger political questions and diving into technical details, the EU seems to be ill equipped to deal with the uncertainty that climate change brings (Chapter 4-5). However, despite the rigidity of the EU fisheries governance system, its polycentric structure can produce an overall fairly sustainable fisheries sector, if examined through a longitudinal perspective (H4 part 2). I argue that the success of the EU in developing fairly sustainable fisheries - despite its rigidity - will be to its detriment in a future with climate change uncertainty. It simply has no institutional structures and processes in place that hold the potential to facilitate adaptation processes, instead everything relies on case-by-case political negotiations (Chapter 7). A right-wing push in the European Parliament, but also in the Member States, may make such negotiations even more difficult. However, non-managed species occupy a unique position in fisheries governance, requiring distinct consideration. They are not subject to fishing effort or quota controls from the EU and are de facto non-managed at the constitutional level. My analysis of the brown shrimp fishery has shown that rules developed at the self-management level have not been sufficient in preventing drastic landing declines and given rise to serious doubts about the future viability of the fishery. I argue that the lack of governance from the constitutional level and feedback between the self-management and constitutional level play a major role in the current landings decline of the brown shrimp fishery. Without rules and regulations at the constitutional level, from a systems perspective (Chapter 2.4.2, Figure 12), it is unlikely that the fishery will sustainably self-manage in the long-term, as self-management relies on an architecture of multiple levels of second order feedback loops (Chapter 6.2). Apart from its structural and process rigidity, the EU's fisheries political governance system appears to be designed for the large-scale commodification of fisheries resources at its core (H5). This favors and consequently produces large-scale fishing operations. The conception and system setup of fishing opportunities in the EU at all governance levels is based on an ethos of large-scale exploitation, which has survived to a large extent the decadal CFP reforms. Current policy at the EU and Member States' level favors large-scale capital investments and quota concentration, while subsidies in the EU and fuel tax exemptions disproportionally favor larger-scale fishing operations (Chapter 8.1-2). The large-scale exploitation ethos even moves down to the self-management level. As a non-managed species, fishers are incentivized within the current constitutional governance system to harvest larger quantities and increase their fishing effort. This produces a positive feedback loop in which higher fishing effort leads to lower landings, which in turn produces an increase in fishing effort (Chapter 8.3).

The German brown shrimp fishery shows that non-quota species can incentivize over-capacities through unregulated harvesting quantities, which, coupled with limited biological information and climate change uncertainty, threatens both ecological and social units within marine social-ecological systems in the EU (H6). The fishery is confronted with substantial systemic problems in the short, medium, and long term, and addressing these challenges is essential to avoid a collapse of the fishery.

These systemic changes need to happen at various levels of the governance structure. The most pressing one is the renegotiation of the self-management plan and the tightening of the rules that are supposed to prevent growth and recruitment overfishing. If current harvesting practices continue the way that they are, landings will most likely stagnate at the current levels or decline even further, which could mean the end of many fishing businesses. The development of sustainable fisheries governance requires both medium- to long-term feedback from self-management to the constitutional level and the implementation of constitutional-level rules that define the overarching framework. At all levels, a shift needs to take place from focusing on efficiency to resilience (Chapter 9.9).

In the final part of this dissertation's empirical analysis (Q3), I discussed how political and self-management governance structures should be adapted to climate change uncertainty, focusing on the EU, German and self-management governance levels. This part’s focus was the practical policy implementation of the results of the analyses. At the European level, a continued push for regionalization would likely be helpful by making European fisheries more flexible in the face of varying climate change effects in its sea basins. However, while regional flexibility is a useful tool in building resilience, the EU needs to renegotiate its institutional foundations (e.g. relative stability) if it wants to have a functioning fisheries governance system with changing geographical stock concentrations. Europe needs to renegotiate its fisheries governance foundations if it wants to have sustainable fisheries, both ecologically and economically (Chapter 10.1). For Germany, adaptation would include, if not require, the development of a national fisheries strategy. Objectives beyond those of the CFP are not required, rather, it is essential to develop a strategy that implements these objectives in ways that reflect regional specificities and align with the social, economic, and ecological realities of its coastscapes (Chapter 10.2). In the case of the brown shrimp fishery, this implies a need to revise its self-governance system. Constitutional-level regulations are required both to establish clear sustainability standards and to ensure that action is taken when self-management no longer delivers sustainable outcomes (Chapter 10.3.1). Changes at the self-management level are equally essential. A management system is required that co-evolves with the ecological dynamics of the stock it manages. Present harvesting rules are failing to produce sustainable outcomes, making it necessary to renegotiate the harvest control rule, overall fishing effort, the winter fishery, and weekend closures. Without such adjustments, these rules will remain misaligned with contemporary realities and will likely contribute to a future collapse of the fishery (Chapter 10.3.2). The brown shrimp fishery needs to move away from prioritizing efficiency and towards resilience. I argue that the current situation is partly driven by the interplay between the brown shrimp’s ecological resilience and its substantial economic value, resulting in a gilded cage that inhibits the development of a resilient fishery under conditions of climate change (Chapter 10.3.3).

11.2 Limitations

While this study provides valuable theoretical, methodological and empirical insights into multi-level European fisheries governance under climate change uncertainties, several limitations must be acknowledged. Adaptive Governance Theory explains institutional rigidity and the importance and interplay of different governance levels. The theory's focus on polycentric governance was invaluable in analyzing the interplay between the EU, Member State and self-management level. Especially its focus on interweaving knowledge types helped to examine adaptive capacities within the context of climate change uncertainty. However, the theory is focused on iterative processes of learning at both the institutional and personal level, assuming that shifts in governance are possible through learning processes. This is a blind spot of the theory as it neglects, or at least downplays, power imbalances and does not explain their influence on adaptation or how to overcome them. In the multi-level EU fisheries, these imbalances, present at all governance levels, are inherently part of the system and create institutional resistance to adaptive reforms as analyzed in Chapter 8.

A mixed method approach was applied to generate data, consisting of document analysis, semi-structured interviews, roundtable discussions, and a binary logistic regression analysis of discard shrimp mortality rates. Combining qualitative and quantitative methods in an interdisciplinary manner provided an integrated and comprehensive understanding of the multi-level European governance system in general and an in-depth understanding of the brown shrimp fishery the social-ecological system. However, each of the methods had its limitations. While the semi-structured interviews provided in-depth data on actor perspectives, which included informal institutional barriers and power dynamics, they only allowed for insights by a limited number of interviewees. I was only able to capture the perceptions of those fishers who were willing to talk to a scientist, therefore possibly missing out on a diversity of other perspectives and opinions. Although other actors involved in fisheries, from politics and administrative personnel, were interviewed, the focus was on fishers, which could be seen as another limitation. The same is true for the roundtable discussions, which helped to instigate discussion and show agreement as well as contention within the community of fishers. Their participation was dominated by fishers I had previously interviewed and, therefore, I was possibly losing out on a diversity of other opinions. Furthermore, the study undertakes an interdisciplinary analysis of the brown shrimp fishery, yet the integration of social, economic, and ecological perspectives was challenging and only partially realized. This is especially true for the economic perspective. Another limitation is the discard mortality study and the corresponding climate change. The data used in the statistical analysis was operationalized to fit the reality of commercial fishery and should therefore be regarded more as tendencies than exact values.

While this dissertation has its theoretical and methodological limits, it represents a first in-depth and integrated analysis of the multi-level fisheries governance in Europe with a focus on non-managed species through the case study of the brown shrimp. The next chapter will reflect on future research based on the limitations of this study as well as the strengths and contributions of this dissertation.

11.3 Future Research & Final Thoughts

Achieving ecologically, economically and socially sustainable fisheries in the EU requires the ability of the sector to cope with and adapt to climate change (Eurich et al. 2024). The analysis reveals an absence of an objectives-based strategic framework for the German fisheries sector. Therefore, future research should focus on adaptive fisheries governance in Germany more broadly, addressing one of this dissertation's limitations by including a broader set of actors and assist in developing a concrete strategy. It should focus on the conceptual, structural, social and practical elements that are needed to build a climate change resilient German inshore fishery - moving from theory to implementation. While this is common for agriculture, it is very rare for fisheries, especially in the small-scale sector of inshore fisheries (Gelcich et al. 2019; Khan et al. 2022). Methodologically, this could involve the co-construction of ecologically and socially sustainable adaptation scenarios that are feasible to implement at local and regional governance levels. Following this dissertation's research epistemology, rather than providing possible adaptation scenarios, plausible ones should be developed in conjunction with administrative staff, fishers and ecologists, along with roadmaps based on which scenarios could or should be implemented. Their expertise is key in identifying bottlenecks and adjusting nodal points for a climate-smart transformation of the German North Sea inshore fishery, especially when addressing climate change mitigation or biodiversity conservation schemes that are in conflict with fisheries. While addressing limitations and future improvements, it is also important to highlight the contributions of this dissertation:

My research makes a significant contribution to the scientific literature by examining the role of non-managed species within the European fisheries governance system. It both contributes to the Adaptive Governance literature and develops actionable management proposals. In terms of contributions to Adaptive Governance literature, the study demonstrates that self-managed fisheries function effectively only within a nested, polycentric governance architecture, challenging assumptions that treat self-management as a normatively desirable state in itself. My research also sheds light on the challenges of transnational fisheries governance within the current system of MSC lead self-management, hopefully contributing to a discussion on policy harmonization and sustainability in

European fisheries management. These contributions were possible through a comprehensive, integrated and multi-perspective analysis on the basis of a mixed-method, interdisciplinary approach to research. Although time consuming, the on-board interviews and biological field study enabled me to gain a deeper, multi-perspective understanding of the brown shrimp fishery. Through the field study, I was able to use the brown shrimp as a boundary object, which was crucial not only for the interview process but also for the roundtable discussions with fishers. The research approach enabled me to integrate practical and scientific knowledge on various levels. While integrating different knowledge types is crucial for a comprehensive understanding and consequently the development of plausible adaptation options, this dissertation has also shown that more is needed. In order to adapt to climate change, there needs to be an incremental change in fisheries political governance and not just a change in how we produce knowledge about fisheries - a move from epistemology to ontology. Non-managed species serve as a prime example in that they reveal the large-scale exploitation logic of the CFP. If we do not take a beyond harvesting approach to fisheries, non-managed species will face a fishing down the governance web scenario in which, once a commercial stock is no longer viable, fleets move on to the next, least regulated fishery. Facing climate uncertainty, fisheries Governance in Europe needs structures and processes that empower resilience - rather than efficiency.

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